UL 2525

STANDARD FOR SAFETY

Two-Way Emergency Communications Systems for Rescue Assistance

UL Standard for Safety for Two-Way Emergency Communications Systems for Rescue Assistance, UL 2525

First Edition, Dated June 12, 2020

SUMMARY OF TOPICS

This is the first edition of ANSI/UL 2525, Standard for Two-Way Emergency Communications Systems for Rescue Assistance, and includes approval as an American National Standard.

The new requirements are substantially in accordance with Proposal(s) on this subject dated February 28, 2020 and May 8, 2020.

No Text on This Page

UL 2525

Standard for Two-Way Emergency Communications Systems for Rescue Assistance

First Edition

June 12, 2020

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 2525 as an American National Standard (ANSI) occurred on June 10, 2020. 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.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

OTHER TESTS

MANUFACTURING AND PRODUCTION-LINE TESTS

MARKINGS AND INSTRUCTIONS

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover:

a) Discrete electrical products for rescue assistance two-way emergency communication systems, e.g. remote communications stations, master control units and accessories.

b) Electrically- and electronically-operated amplifiers that provide speech communication and distinctive sounds in conjunction with rescue assistance two-way emergency communication systems; and

c) Commercial stationary and fixed power supplies for rescue assistance two-way emergency communication systems, having input and output ratings of not more than 600 V, direct- and alternating-current, (DC and AC).

1.2 These requirements cover products to be employed in accordance with the following Codes and Standards:

a) National Electrical Code, NFPA 70;

b) National Fire Alarm and Signaling Code, NFPA 72;

c) Life Safety Code, NFPA 101;

d) International Building Code (IBC)/International Fire Code (IFC);

e) Building Construction and Safety Code, NFPA 5000;

f) Fire Code, NFPA 1.

1.3 The products covered by this standard are intended to be used in combination with other devices to form a rescue assistance two-way emergency communication system. These products provide all monitoring, control, and indicating functions of the system. An installation document(s) provided with the product describes the various products needed to form a rescue assistance two-way emergency communication system and their intended use and installation. This standard includes systems used for emergency communication in the following situations:

a) Exit stairs, stairways, or stair landings (Stairway Communications Systems)

b) Elevator lobbies and landings (Elevator Landing Communications Systems)

c) Occupant evacuation elevator lobbies (Occupant Evacuation Elevator Lobby Communications Systems)

d) Area(s) of Rescue Assistance or Area(s) for Assisted Rescue Communications Systems

e) Area(s) of Refuge Communications Systems

f) Other similar two-way emergency communications systems

1.4 These requirements do not cover:

a) Other initiating devices; nor do they cover notification appliances not provided as part of the product.

b) Emergency Responder Communications Enhancement Systems, UL 2524,

c) Communication systems, which are covered by the Standard for Hospital Signaling and Nurse Call Equipment, UL 1069.

d) Communication systems covered by the Standard for Emergency Call Systems for Assisted Living and Independent Living Facilities, UL 2560.

e) Fire alarm, emergency voice/alarm communication systems, and two-way in-building wired emergency services communication systems covered by the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

1.5 These requirements do not include determination of compliance with regulations of the Federal Communications Commission (FCC). Should products covered by these requirements be required to comply with FCC regulations, a report of verification from the manufacturer is required as evidence of such compliance.

2 General

2.1 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

2.3 Undated references

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

3 Glossary

3.1 ACCESSORY – A device or appliance externally connected to a master control unit that is employed to assure proper operation of a system or to provide supplementary signaling and/or annunciation. Examples of master control unit accessories are annunciators, end-of-line resistors or diodes, auxiliary relays, remote switches, and the like.

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

3.3 ADDRESSABLE – Two-way emergency communication system with discrete identification of interconnected devices and/or appliances that can have their status individually identified or that is used to individually control other functions.

3.4 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.

3.5 AIR-HANDLING SPACE – Space used for environmental air-handling purposes other than ducts or plenums. The space over a hung ceiling used for environmental air-handling is an example.

3.6 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.

3.7 ATTENDANT NOTIFICATION APPLIANCE – A notification appliance intended to get the attention of the master control unit operator to indicate an emergency signal, or trouble condition.

3.8 ATTENDANT NOTIFICATION APPLIANCE CIRCUIT – A circuit or path directly connected to an attendant notification appliance.

3.9 AVERAGE VALUE – The sum of all instantaneous values of current (or voltage), averaged over one-half of an alternating cycle.

3.10 BATTERY CHARGER – A product intended to deliver sufficient current to maintain storage batteries in their fully-charged condition while the batteries are not connected to a load. The storage batteries are intended to provide a secondary source of operating power in response to failure of the primary source of operating power.

3.11 REMOTE COMMUNICATIONS STATION – A manually-operated device, the normal intended operation of which results in an emergency signal indication at the master control unit.

3.12 CIRCUIT CLASSIFICATIONS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 V 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 V alternating current (AC) rms, 42.4 V direct current (DC) or peak.

c) Power-Limited Circuit – A circuit wherein the power is limited as specified in Table 43.1 and Table 43.2.

3.13 COMBINATION SYSTEM – A two-way emergency communication system whose components might be used, in whole or in part, in common with non-emergency or other emergency signaling systems.

3.14 COMMUNICATION (S) CIRCUIT – Communications circuit between master control units and remote communications stations and networked master control units that carries voice, audio, data, and other signals.

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

3.16 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.

3.17 EMERGENCY SIGNAL – A signal indicating an emergency condition requiring immediate action such as a signal indicative of a need for rescue assistance.

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

3.19 EVACUATION – The withdrawal of occupants from a building.

3.20 EXTERNAL CIRCUITS – Circuits or wiring leaving the product.

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

3.22 FIELD WIRING – Conductors to be installed by others to connect a product to source(s) of supply, devices, other products, and loads.

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

3.24 GAGES – Wherever they appear in this standard, the abbreviations MSG, GSG, and AWG mean, respectively, Manufacturers' Standard Gage for Steel Sheets, Galvanized Sheet Gage, and American Wire Gage. Reference to sheet metal by gage number is intended only as auxiliary information. Sheet metal of the indicated gage number may not be used if the forming processes have reduced the thickness of the sheet to a point below the specified minimum thickness.

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

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

3.27 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.

3.28 INSTALLATION LOCATIONS: Dry – A location with a controlled ambient that is not subject to dampness or wetness.

3.29 LIFE SAFETY NETWORK – A combination system that carries other signals in addition to fire alarm or mass notification signals and is connected to a fire alarm or mass notification system.

3.30 MASTER CONTROL UNIT – The principal on-premise attended location where the status of the two-way emergency communication system is displayed and from which the system can be manually controlled.

3.31 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.

3.32 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.

3.33 NORMAL CONDITION – System, circuits, and components are operating as intended and no abnormal condition exists.

3.34 OFF-SITE COMMUNICATIONS LINKS – Physical media or wireless methodology for providing two-way voice, audio, data, and other signals between a two-way emergency communication system within a building and an off-site constantly attended monitoring location on contiguous or non-contiguous property.

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

3.36 OPERATOR – Individual(s) responsible to access and operate the product and/or system, but does not have access to portions of the product required for servicing and maintenance.

3.37 OPERATOR INTERFACE – Providing controls for manually operating the product/system.

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

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

3.40 POWER SUPPLY-BATTERY CHARGER – A power supply that serves the dual function of providing operating power and charging storage batteries. The power supply is usually permanently connected to storage batteries, and the power supply-battery combination is intended to provide all of the electrical operating power required by the equipment to which the combination is connected, when the equipment is operating in its intended manner.

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

3.42 RESCUE ASSISTANCE – Building occupants that need assistance during an emergency can request assistance by using a remote communications station that signals a master control unit.

3.43 RESET – A control function that attempts to return a system or device to its normal condition state.

3.44 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 Ω resistor connected across the potential exceeds 0.5 mA.

3.45 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 min of operation; or

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

3.46 SHORT-RANGE RADIO-FREQUENCY DEVICES – Any device that communicates with control/receiving equipment by low-power radio signals in accordance with the Code of Federal Regulations (CFR) 47.

3.47 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. For the purpose of this standard, software is one of two types:

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 Software – 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.

3.48 STANDBY POWER SOURCE – Provides power when the primary power source fails.

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

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

3.51 SUPERVISORY CIRCUIT – A circuit or path that monitors the status of other systems which must be maintained to prevent affecting normal system operation.

3.52 SUPERVISORY CONDITION – An abnormal condition related to the monitoring of other systems and/or equipment.

3.53 SUPERVISORY SIGNAL – A signal indicating the need of action in connection with the monitoring of other systems or equipment.

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

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

3.56 SUPPLEMENTARY-DEVICE CIRCUIT – A circuit provided by a product for controlling a device, the operation of which is supplementary to the primary functionality of the emergency communication system.

3.57 TRAINED SERVICE PERSONNEL – service personnel that are trained and have knowledge and experience of the maintenance for the equipment being serviced or maintained.

3.58 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 two-way emergency communications system.

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

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

4 Information Required for Assessment

4.1 The following documentation may be required to determine compliance:

a) Schematic diagrams of all circuits.

b) Where the product uses software, evidence of software integrity as described in 38.3.1 – 38.3.4.

c) Marking to be applied to the product as required in Markings, Section 67.

d) Installation wiring diagram/instructions as required in Installation Wiring Diagram/Instructions, Section 68.

e) Operating instructions as required in Operating Instructions, Section 69.

CONSTRUCTION

5 General

5.1 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.

5.2 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.

5.3 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.

5.4 The requirement in 5.3 applies also to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

5.5 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.

5.6 Products that currently meet all the requirements of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, UL 60065 or the Standard for Audio/Video, Information and Communication Technology Equipment – Safety Requirements – Part 1, UL 62368 need only be evaluated to the following sections with respect to the construction requirements: 6.1.1, 9.5, 11.1.1, 11.2, 12.1 – 12.3, 12.6, 14.4, 19, 23.1, 25.3, and 27.

6 Enclosures

6.1 General

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

6.2 Metallic material

6.2.1 An enclosure of metal shall have a minimum thickness as specified in Table 6.1, Table 6.2, or Table 6.3, or shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards, Section 57.

Table 6.1
Cast-metal electrical enclosures

Use, or dimensions of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal other than die-cast,	
	in	(mm)	in	(mm)
Area of 24 in^2 (155 cm^2) or less and having no dimension greater than 6 in (152 mm)	1/16	(1.6)	1/8	(3.2)
Area greater than 24 in^2 (155 cm^2) or having any dimension greater than 6 in (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 in (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

Table 6.2
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			
								Uncoated,		Metal coated,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		in	(mm)	in	(mm)
in	(cm)	in	(cm)	in	(cm)	in	(cm)	[MSG]		[GSG]	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	[24]	[24]		
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	[22]	[22]		
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	[20]	[20]		
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	[18]	[18]		
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	[16]	[16]		
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	[15]	[15]		
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	[14]	[14]		
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	[13]	[13]		
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	[12]	[12]		
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	[11]	[11]		
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	[10]	[10]		

Table 6.2 Continued on Next Page

Table 6.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
in	(cm)	in	(cm)	in	(cm)	in	(cm)	in [MSG]	(mm)	in [GSG]	(mm)

[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 in (12.7 mm) wide.

Table 6.3
Minimum thickness of sheet metal for electrical enclosures of aluminum, copper, or brass

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

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending

Table 6.3 Continued on Next Page

Table 6.3 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
in	(cm)	in	(cm)	in	(cm)	in	(cm)	in	(mm)
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 in (12.7 mm) wide.									

6.2.2 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.

6.2.3 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.

6.2.4 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 in (0.81 mm).

6.3 Polymeric materials

6.3.1 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.

6.3.2 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 6.4.

Table 6.4
Flammability characteristics of polymeric material

Polymeric material area/dimensions	Flammability rating
0.24 in^3 (4 cm^3) maximum and 2.4 in (61 mm) maximum length	None
Greater than 0.24 in^3 (4 cm^3) and less than 2 ft^2 (0.19 m^2), 6 ft (1.83 m) maximum length	HB, V-2, V-1, V-0, or 5V

Table 6.4 Continued on Next Page

Table 6.4 Continued

Polymeric material area/dimensions	Flammability rating
Greater than 2 ft^2 (0.19 m^2) and less than 10 ft^2 (0.93 m^2), 6 ft (1.83 m) maximum length	V-1, V-0, or 5V
Greater than 10 ft^2 (0.93 m^2), or longer than 6 ft (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

6.3.3 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.

6.3.4 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.

6.3.5 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.

6.4 Covers

6.4.1 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 emergency 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.

6.4.2 Normal operation referenced in 6.4.1 is determined to be operation of a switch for testing or for silencing an audible signal or operation of any other component of a unit which requires such action in connection with its intended performance.

6.4.3 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."

6.4.4 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 6.5.

Table 6.5
Thickness of glass covers

Maximum size of opening				Minimum thickness,	
Length or width,		Area,			
in	(mm)	in^2	(cm^2)	in	(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 in (3.2 mm) or more, depending upon the size, shape, and mounting of the glass panel.

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

6.4.6 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 6.3.2.

6.5 Battery compartments

6.5.1 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.

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

6.6 Enclosure openings – general

6.6.1 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 power-limited sources and controlling only power-limited loads.

6.6.2 The requirement in 6.6.1 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 in (6.75 mm) or an area greater than 0.055 ft^2 (35.5 mm^2); and

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

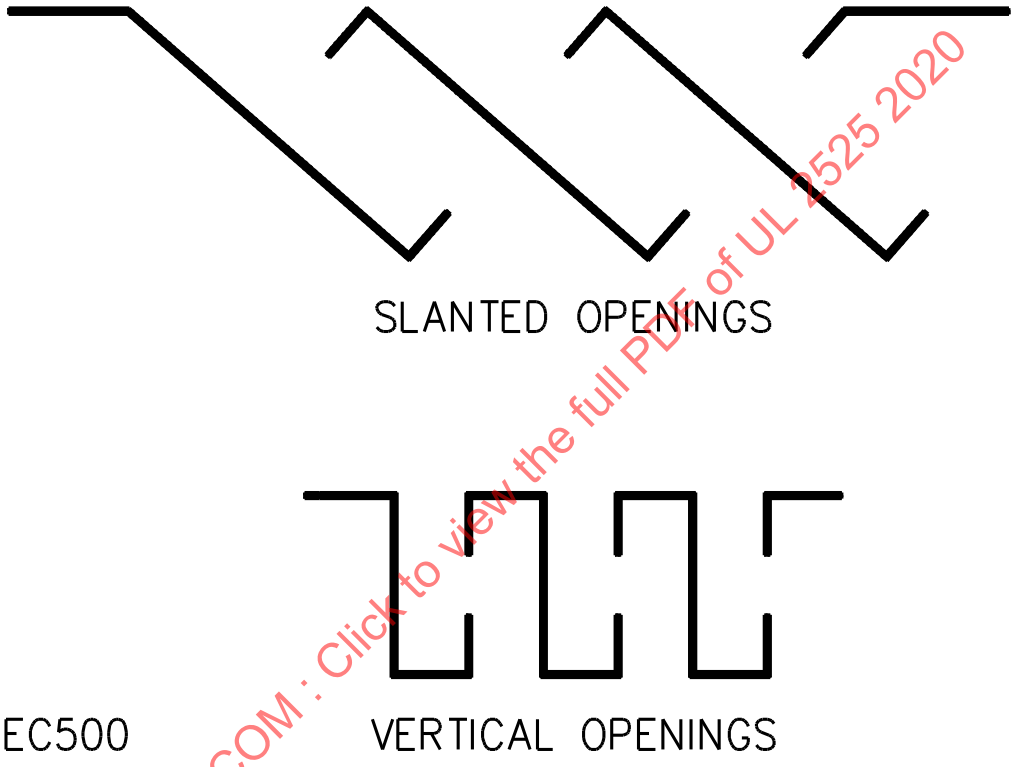
6.6.3 Acoustical openings for both the speaker and microphone shall be vandal-resistant by not providing direct access to any sound producing element, for example, a cone or diaphragm, by a rigid rod 0.8 mm (0.03 in) in diameter.

6.7 Enclosure top openings

6.7.1 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 in (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 6.1 for examples of top-cover designs complying with the intent of the requirement.

Figure 6.1

Cross-sections of top-cover designs



6.8 Enclosure side openings

6.8.1 An opening in the side of the enclosure shall:

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

b) Be provided with louvers shaped to deflect an external falling object outward (see Figure 6.2 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 6.3).

6.8.2 When a portion of a side panel falls within the area traced out by the 5° angle in Figure 6.4, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 6.9.1 – 6.9.3.

Figure 6.2

Louvers

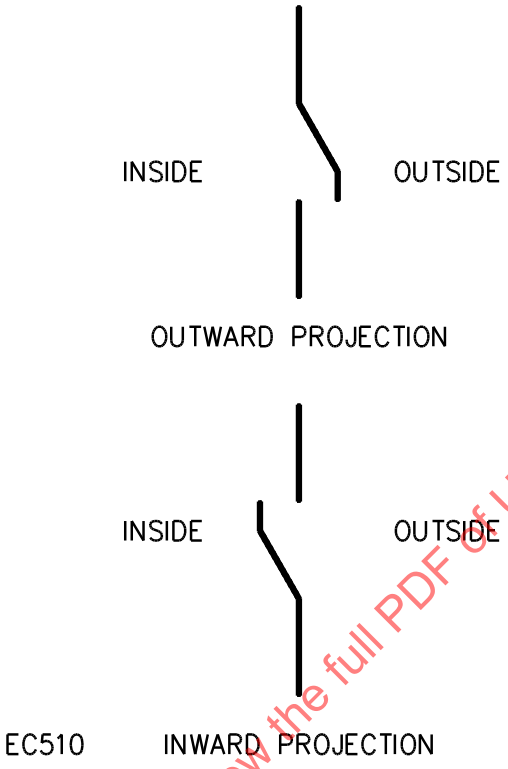
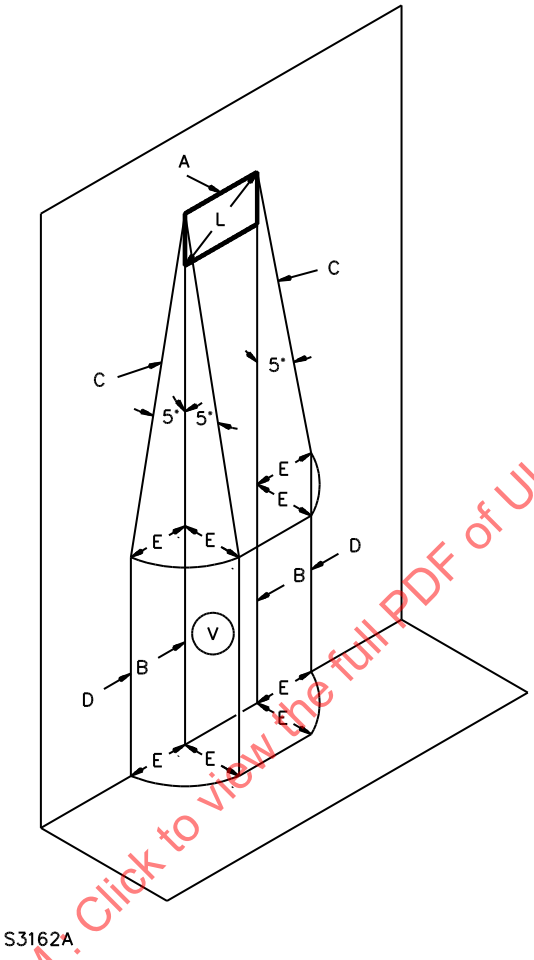


Figure 6.3

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° 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.

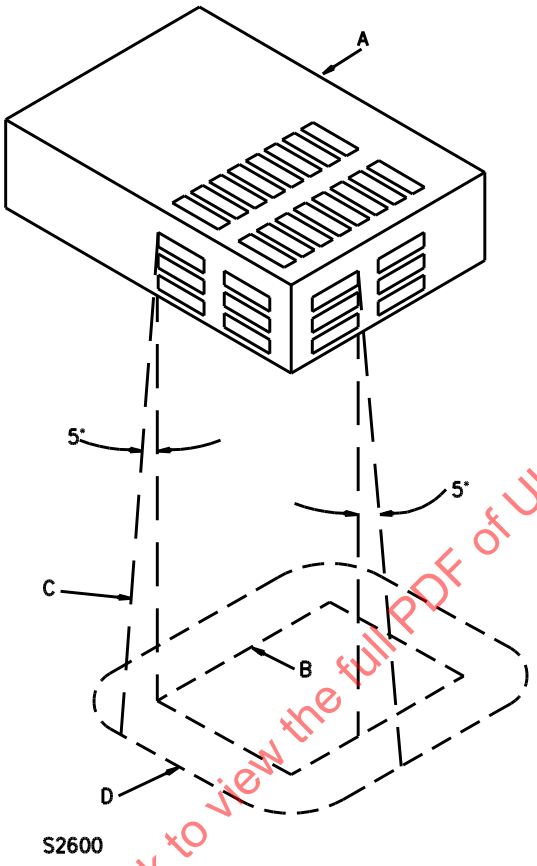
E – Projection of the opening (not to be greater than L).

L – Maximum dimension of the enclosure side opening.

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

Figure 6.4

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° 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° when the enclosure bottom contacts a vertical enclosure or side panel, or when the horizontal extension of the enclosure B to D exceeds 6 in (152 mm).

D – Minimum outline of the enclosure, except that the extension B to D is not required to exceed 6 in (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.

6.9 Enclosure bottom openings

6.9.1 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 6.4, that complies with the ventilation opening requirements in 6.9.2 and 6.9.3 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.

6.9.2 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 6.6, or a galvanized or stainless-steel screen having a 14 by 14 mesh per 1 in (25.4 mm) constructed of wire with a minimum diameter of 1/64 in (0.4 mm). Other constructions are to be used only when they comply with the Ignition Test Through Bottom-Panel Openings, Section 53.

Table 6.6
Perforated metal plates

Minimum thickness		Maximum diameter of holes		Minimum spacing of holes center-to-center	
in	(mm)	in	(mm)	in	(mm)
0.026	(0.66)	0.045	(1.14)	0.67 [233 holes per in^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 in^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)

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

7 Internal Materials

7.1 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.

7.2 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 in (12.5 mm) of air, or a solid

barrier of V-1 or less-flammable material from uninsulated electrical parts that involve a risk from electrical energy-high current levels:

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

b) Tubing for air or fluid systems, and 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.

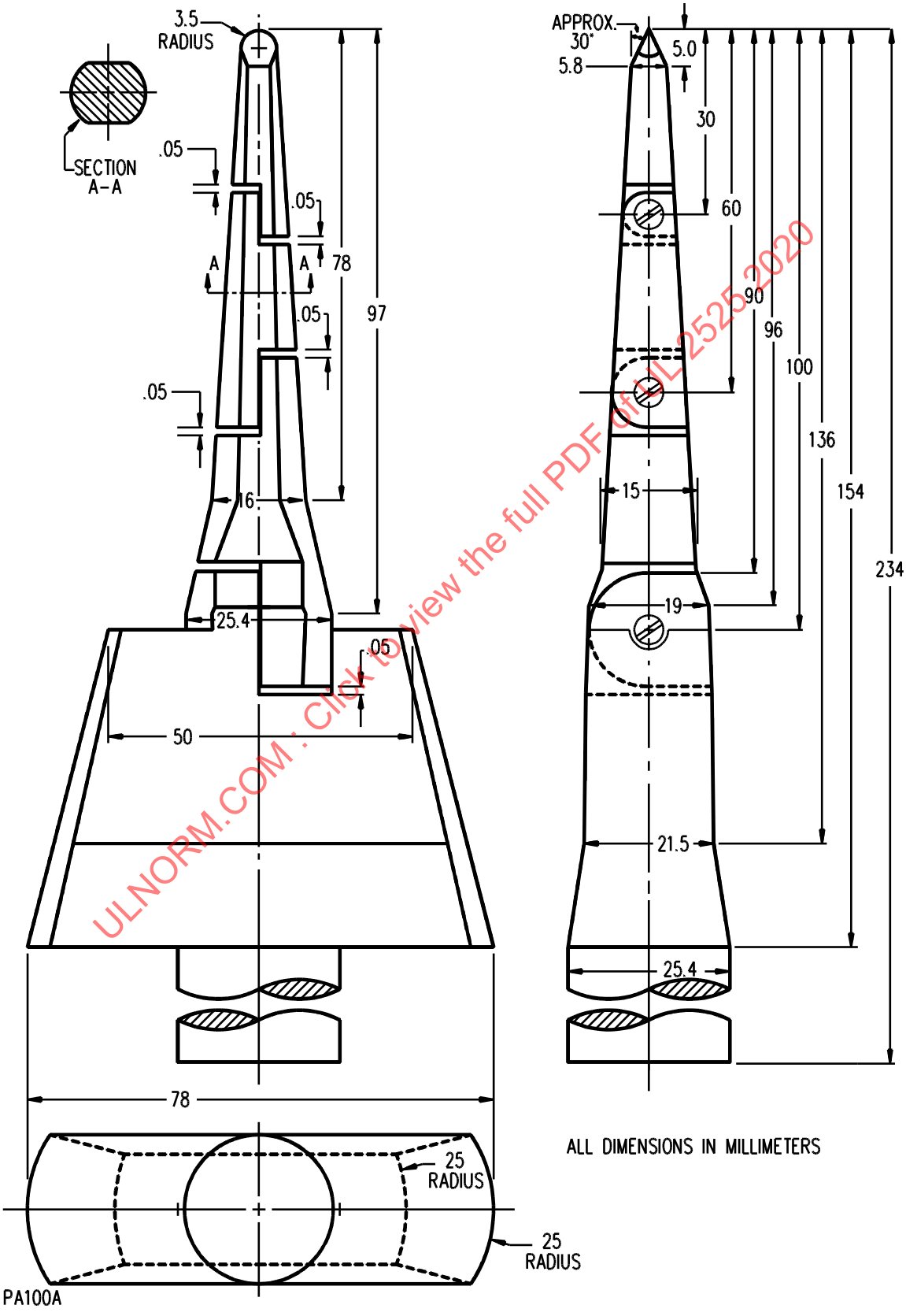
Exception No. 2: Combustible material used within an enclosure is not prohibited from being HB when the power sources to the enclosure meet the criteria for no risk of fire as defined in 3.45.

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

8.1 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 in (25.4 mm), and such a part or wire shall not be contacted by the probe illustrated in Figure 8.1.

Figure 8.1

Articulate probe with web stop



8.2 The probe illustrated in Figure 8.1 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 8.1 shall be applied in any possible configuration and, when necessary, the configuration shall be changed after insertion through the opening.

8.3 The probe illustrated in Figure 8.1 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.

8.4 During the examination of a product to determine whether it complies with the requirement in 8.1, 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.

9 Mechanical Assembly

9.1 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.

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

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

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

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

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

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

Exception No. 2: When rotation does not reduce spacings below the minimum required value, a lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, complies with the intent of the requirement.

9.3 Friction between surfaces shall not be used for securing the position of the parts specified in 9.2.

9.4 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.

9.5 All subassemblies, modules, and printed-wiring boards shall be held in their intended place in the product by mechanical means.

10 Protection Against Corrosion

10.1 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.

11 Branch-Circuit Connection

11.1 General

11.1.1 Products powered by the branch circuit supply shall be provided with a means for permanent connection to the branch-circuit supply.

Exception: Video display terminals, other operator interface products installed within a limited access room for authorized personnel only that may be repositioned for normal use or maintenance.

11.2 Permanently connected

11.2.1 General

11.2.1.1 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.

11.2.1.2 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 45, and not having qualifying marking as specified in 67.1.14, shall be sealed by welding or the equivalent or be permanently marked adjacent to the opening with: "Do Not Use".

11.2.2 Field-wiring compartment

11.2.2.1 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.

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

11.2.2.3 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.

11.2.2.4 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”.

11.2.2.5 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.

11.2.3 Field-wiring terminals and leads

11.2.3.1 A permanently connected product shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than 125% of the current input of the product when connected to a power-supply voltage in accordance with 30.1.1 – 30.1.6.

11.2.3.2 The free length of a lead inside a terminal box or compartment shall be 6 in (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 in (0.76 mm) minimum average and 0.027 in (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 in (150 mm) long when it is evident that the use of a longer lead results in a risk of fire or electric shock.

11.2.3.3 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.

11.2.3.4 A field-wiring terminal shall comply with the requirements in 12.4 for field-wiring terminals (general application) except a wire-binding screw shall not have a diameter smaller than No. 8 (4.2 mm).

11.2.4 Identified terminals and leads

11.2.4.1 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.

11.2.4.2 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.

11.2.4.3 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.

11.2.5 Strain relief

11.2.5.1 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.

11.2.5.2 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 min a pull of 10 lbs (4.54 kg) without any evidence of damage or of transmitting the stress to internal connections. The strain-relief means provided shall comply with the Strain-Relief Test, Section 62.

11.3 Cord-connected product

11.3.1 Cords and plugs

11.3.1.1 A product shall be provided with a length of 5 – 15 ft (1.5 – 4.5 m) flexible cord and a grounded attachment plug when intended for connection to a line voltage branch-circuit supply. See Table 11.1 and Table 11.2.

Exception No. 1: A length of flexible cord of Type S, or cord determined to be equivalent, not exceeding 25 ft (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 11.1
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 11.2
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

Table 11.2 Continued on Next Page

Table 11.2 Continued

Type of appliance	Type of cord
[a] A tinsel cord shall be used when all of the following conditions are met: 1) The cord is no longer than 8 ft (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 ft (1.5 m).	

11.3.1.2 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.

11.3.1.3 The flexible cord on a cord-connected unit shall be as indicated in Table 11.2 or shall be of a type at least as serviceable for the particular application. Table 11.3 specifies cord types determined to be equivalent to those specified in Table 11.2.

Table 11.3
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

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

11.3.1.5 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.

11.3.1.6 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.

11.3.2 Strain relief

11.3.2.1 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 62.

11.3.2.2 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.

11.3.2.3 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.

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

11.3.2.5 When tested in accordance with 62.1.1 – 62.1.3, the strain-relief means provided on the flexible cord shall be capable of withstanding for one min, a pull of 35 lbs (15.9 kg) applied to the cord, with no evidence of stress on the interior connections.

11.3.3 Bushings

11.3.3.1 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.

11.3.3.2 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.

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

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

11.3.3.5 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 in (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.

11.3.3.6 A bushing of any of the materials specified in 11.3.3.5 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.

11.3.3.7 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 in (1.6 mm) thick at the point where the cord passes through the enclosure.

11.3.3.8 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 in (0.8 mm) and completely fills the space between the grommet and the metal in which the grommet is mounted.

12 Other Field-Wiring Connections

12.1 General

12.1.1 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.

12.1.2 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.

12.1.3 Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits of products intended to be connected to non-addressable communication or attendant notification appliance circuits of a two-way emergency communication system; 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 68.11 shall be included in the installation wiring diagram/instructions.

12.2 Field-wiring compartment

12.2.1 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.

12.2.2 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.

12.2.3 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."

12.2.4 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.

12.3 Power-limited circuits

12.3.1 When the design of the product is such that the product either requires or permits power-limited circuit conductors to occupy the same enclosure as electric light, power, Class 1, or non-power-limited 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 power-limited conductors are segregated from electric light, power, Class 1 conductors, non-power-limited 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 in (6.4 mm) is provided between all power-limited conductors and all electric light, power, Class 1 conductors, non-power-limited signaling conductors, or medium-power network-powered broadband communications-circuit conductors, or

2) For circuit conductors operating at 150 V or less to ground where the power-limited conductors are installed using Types FPL, FPLR, FPLP, or equivalent cables, a minimum 1/4 in (6.4 mm) separation is provided between these power-limited cable conductors extending beyond the jacket and all electric light, power, Class 1 conductors, non-power-limited 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

12.4 Field-wiring terminals (general application)

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

a) 12.4.2 – 12.4.5;

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.

12.4.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm2) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 in (1.3 mm) thick. Securing screws of plated steel have been determined to meet the requirements.

12.4.3 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.

12.4.4 Terminal plates tapped for wire-binding screws shall:

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

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

12.4.5 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.

12.5 Field-wiring terminals (qualified application)

12.5.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 12.5.2 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; and

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

12.5.2 Any of the terminal configurations listed in 12.5.1 are appropriate for connection of field wiring provided all of the following indicated conditions are met.

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

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

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

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

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

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

12.6 Field-wiring leads

12.6.1 General

12.6.1.1 Leads provided for splice connections shall be minimum 6 in (153 mm) long.

Exception: The free-lead length is not prohibited from being less than 6 in 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.

12.6.1.2 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.

12.6.1.3 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 min a pull of 10 lbs (4.54 kg) without any evidence of damage or of transmitting the stress to internal connections. The strain-relief means provided shall comply with the Strain-Relief Test, Section 62.

12.6.2 High-voltage circuits

12.6.2.1 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 0.30 in (0.76 mm) minimum average and 0.027 in (0.69 mm) minimum at any point.

12.6.3 Power-limited circuits

12.6.3.1 A lead provided for field connection to a low-voltage, power-limited circuit shall be no smaller than 22 AWG (0.32 mm^2) and the insulation shall be a minimum of 1/64 in (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 amp for lengths up to 2 ft (61 cm) or 0.4 amp for lengths up to 10 ft (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 62; and

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

12.7 Cords and plugs

12.7.1 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.

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

13 Internal Wiring

13.1 General

13.1.1 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.

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

13.1.3 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.

13.1.4 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.

13.1.5 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.

13.1.6 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.

13.1.7 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.

13.1.8 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 in (0.8 mm) thick and no overall braid and

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

13.1.9 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.

13.1.10 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.

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

13.1.12 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.

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

13.2 Splices and connections

13.2.1 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.

13.2.2 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.

13.2.3 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.

13.2.4 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.

13.3 Connectors and receptacles

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

14 Protective Devices

14.1 A fuseholder, 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.

14.2 A fuseholder 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 V.

14.3 Fuseholders, fuses, and circuit breakers shall be rated for the application.

14.4 All external circuits intended to be connected to nonpower-limited 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 41.3.3.

15 Current-Carrying Parts

15.1 Except as noted in 15.2, current-carrying parts shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other nonferrous material intended for the application.

15.2 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.

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

16 Spacings

16.1 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 16.1.

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 55.8, 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 16.1
Minimum spacings

Point of application	Minimum spacings				
	Voltage range,	Through air,		Over surface,	
	V	in	(mm)	in	(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)
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)

Table 16.1 Continued on Next Page

Table 16.1 Continued

Point of application	Minimum spacings				
	Voltage range,	Through air,		Over surface,	
	V	in	(mm)	in	(mm)
	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.

16.2 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.

16.3 The spacing requirements in Table 16.1 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 16.1.

16.4 The "To-walls-of-enclosure" spacings indicated in Table 16.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

16.5 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 in (0.71 mm) thick; except that a liner or barrier that is minimum 0.013 in (0.33 mm) thick meets the intent when used in conjunction with a minimum of one-half of the through-air spacing required. The liner shall be located so that it will not be affected adversely by arcing.

16.6 Insulating material having a thickness less than that specified in 16.5 meets the intent when it has been determined to have equivalent mechanical and electrical properties.

16.7 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.

16.8 The spacings within snap switches, lampholders, and similar wiring devices supplied as part of a unit are determined under other requirements for such devices and is not required to comply with the requirements of Table 16.1. See General, Section 2.

17 Insulating Material

17.1 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.

17.2 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.

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

17.4 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.

18 Printed-Wiring Boards

18.1 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, 16. 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.

18.2 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.

19 End-of-Line Devices

19.1 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, such as a master control unit, or remote communications station:

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.

20 Voltage-Dropping Resistors

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

21 Coil Windings

21.1 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 Annex A).

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

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

22 Components

22.1 Switches

22.1.1 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.

22.2 Lampholders and lamps

22.2.1 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.

22.2.2 Except for circuits operating at 30 V, root-mean-square (rms), 42.4 V direct current (DC) or 42.4 V 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.

22.2.3 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.

22.3 Operating mechanisms

22.3.1 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.

22.3.2 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.

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

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

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

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

22.4 Across-the-line components

22.4.1 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 Annex A.

22.4.2 A component is considered to be across the high-voltage supply circuit when, in a shorted condition, a current of more than 1 amp 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 amp or less by a fixed impedance or a protective device rated 1 amp or less.

22.4.3 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.

23 Grounding for Products Containing High-Voltage Circuits

23.1 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 in) thick.

23.2 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.

23.3 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.

23.4 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 23.1.

23.5 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.

23.6 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 23.5 .

23.7 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 23.5.

23.8 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size specified in Table 23.1.

Table 23.1
Bonding wire conductor size

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

[a] Or equivalent cross-sectional area.

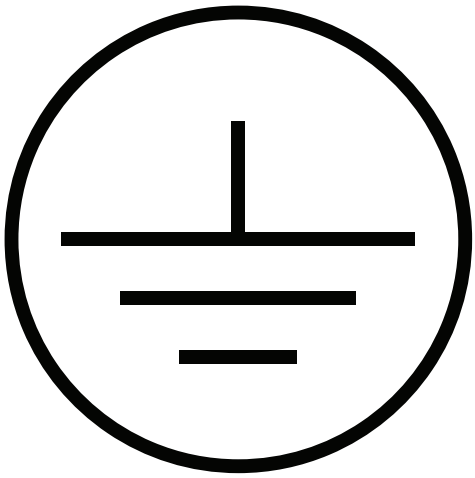
23.9 The size of a copper or aluminum conductor used to bond an electrical enclosure shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 23.1.

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

23.11 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 23.1, 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 23.1

International electrical symbol



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

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

23.14 When a means for grounding is provided on the product, even though it is not required, it shall comply with the requirements in 23.1 – 23.13.

23.15 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 amp from a power supply of not more than 12 V 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.

24 Batteries

24.1 Rechargeable storage-type used as standby 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. The maximum charging rate shall be identified per 68.4(b).

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 intended for emergency signaling, it shall meet the requirements of the Primary Batteries Tests, Section 61.

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 lb) 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 in) 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 non-rechargeable lithium battery shall be protected from abnormal charging currents during use and comply with the Standard for Lithium Batteries, UL 1642.

Exception: A non-rechargeable lithium battery complying with UL 1642 and serving as the sole power source is not required to be subjected to the abnormal charging current requirements in UL 1642.

24.3.3 A rechargeable lithium battery shall be protected from abnormal charging currents during use and comply with the Standard for Lithium Batteries, UL 1642.

24.3.4 A non-rechargeable lithium battery pack (multiple cells) shall be protected from abnormal charging currents during use and comply with the Standard for Household and Commercial Batteries, UL 2054.

24.3.5 A rechargeable lithium battery pack (multiple cells) shall be protected from abnormal charging currents during use and comply with the Standard for Household and Commercial Batteries, UL 2054.

25 Servicing Protection

25.1 General

25.1.1 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.

25.2 Trained service personnel

25.2.1 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 in), then protection by properly applied insulating tape, barriers, or equivalent, shall be provided.

25.2.2 Insulating barriers, or equivalent required by 25.2.1 shall be permanently and prominently marked with the cautionary marking “CAUTION – High Voltage” or equivalent.

25.2.3 In lieu of the minimum 152 mm (6 in) 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."

25.2.4 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.

25.3 Antenna terminal discharge assembly

25.3.1 Each terminal provided for the connection of an external antenna shall be conductively connected to the supply circuit grounded conductor. The conductive connection shall have a maximum resistance of 5.2 MΩ, a minimum wattage rating of 1/2 W, 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 MΩ.

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 W.

25.3.2 The maximum value of 5.2 MΩ specified in 25.3.1 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 MΩ with 20% tolerance or a resistor rated 4.7 MΩ with a 10% tolerance.

PROTECTION AGAINST INJURY TO PERSONS

26 General

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

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

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

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

26.5 A risk of injury to persons is 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 29);

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.

27 Telescoping Antenna

27.1 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-in) diameter button or ball on the end that complies with the Antenna End-Piece Secureness Test, Section 63.

28 Sharp Edges

28.1 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.

28.2 For edges where the degree of sharpness cannot be determined by inspection, compliance with 28.1 is determined by the test procedure in the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

29 Stability

29.1 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.

29.2 A product shall not tip over when tilted 10° 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.

29.3 The requirements in 29.4 – 29.8 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.

29.4 In conducting the tests described in 29.5 – 29.7, 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.

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

29.6 With regard to the requirement in 29.5, delicate parts such as keyboards, control panels, or spools are not determined as prone to being stepped on or sat upon.

29.7 A freestanding product more than 39-3/8 in (1.00 m) high and weighing more than 55.1 lbs (25.0 kg) shall not tip over when a force equal to 1/5 the weight of the unit but not more than 56.2 lbf (250 N) is applied in any direction, except upward, at a height not exceeding 78-3/4 in (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 29.8.

29.8 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 67.1.24.

PERFORMANCE

GENERAL

30 Details

30.1 Tests and voltages

30.1.1 Except as otherwise indicated, the performance of a product shall be investigated by subjecting a representative sample in commercial form to the tests described in Section 31 – 64.

30.1.2 Products that currently meet all the requirements of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, UL 60065 or the Standard for Audio/Video, Information and Communication Technology Equipment – Safety Requirements – Part 1, UL 62368 are not required to be evaluated to the following sections: 43, 48, 50, 51, 55.4, 55.6, 55.7, 56, 57, and 62.1.

30.1.3 Unless otherwise specified, the test voltage for each test of a product is to be as indicated in Table 30.1 at the rated frequency of the product.

Table 30.1
Test voltages

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

30.1.4 Radio frequency transmitters and equipment intended to be connected to the public telephone network shall comply with applicable Federal Communications Commission (FCC) rules and regulations.

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

30.1.6 All measurements are to be made with a true RMS meter or an oscilloscope.

30.2 Maximum rated load

30.2.1 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. This includes the maximum configuration including all remote communications stations in the active condition and all notification appliances used to signal the operator at the master control unit in the signaling/alerting condition.

30.2.2 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/wiring diagram, connected to the external circuit, with the input voltage to the product adjusted to the value determined by 30.1.3.

30.2.3 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.

OPERATION TESTS

31 Specifics

31.1 A product shall be capable of operating for all conditions of its intended performance when used in conjunction with initiating means, attendant 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 wiring diagram/instructions.

31.2 To determine compliance with 31.1, remote communications stations, attendant notification appliances, interconnected equipment, and power-supply circuits are to be connected to the master control unit as specified by the installation wiring diagram/instructions to form a typical system, and the system operated for each condition of its intended performance.

31.3 The items in (a) – (c) used for testing are to be those specified by the installation wiring diagram/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) Remote communications stations;

b) Attendant notification appliances (bells, strobes, speakers, and similar appliances or parts);

c) Interconnected equipment (accessories, other master control units, annunciators, supplementary devices, and the like).

31.4 During the tests in Sections 31 – 40, each power-supply circuit shall be supplied from a source of rated frequency and voltage as specified in 30.1.3.

31.5 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 condition. The fault condition is then to be separately introduced, the results noted, the fault removed, and the system restored to the normal condition before the next fault is introduced.

TWO-WAY EMERGENCY COMMUNICATIONS OPERATION

32 Operation

32.1 General

32.1.1 The operation of any remote communications station and supervisory condition shall cause the system to produce a clearly defined signal of the type for which the system is designed.

32.1.2 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) Attendant notification appliances, where utilized

2) Local emergency signal and/or supervisory signal annunciation,

3) Commencement of programmed delays,

shall not be greater than 10 s from the activation of the remote communications station and supervisory conditions.

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

Exception: The initial battery trouble signal annunciation from a battery-operated product that complies with 34.4.1.

32.1.3 Emergency, supervisory and trouble signals shall be annunciated at the Master Control Unit.

32.1.4 The rescue assistance system shall have the capability of signaling emergency and trouble conditions to a fire alarm system and/or other equipment.

32.1.5 Emergency, supervisory and trouble signals shall result in distinctly different annunciation from each other and other signals.

32.1.6 The master control unit shall have the capability of simultaneously broadcasting a one-way voice message to all activated remote communications stations.

32.2 Two-Way Emergency Communications Functional Sequence

32.2.1 The initiation means of the remote communications station shall meet all of the following:

a) operated without hand or finger dexterity, fine motor movement, or simultaneous actions and do not require tight pinching, twisting, or grasping;

b) push-activated control not requiring more than 5 pounds of force;

c) be mechanically self-restoring;

d) be readily distinguishable from the surrounding background;

e) be mechanically-actuated;

f) be a minimum one inch in the smallest dimension.

32.2.2 When a remote communications station(s) is activated by a building occupant(s), an emergency signal shall be transmitted to an in-building master control unit.

32.2.3 When provided, in addition to that described in 32.2.2, other emergency functional sequences are not prohibited.

32.2.4 The system shall provide a timed automatic means to connect with an off-site constantly attended location when the in-building master control unit operator is not responding to the emergency signal.

32.2.5 When the emergency signal must be transmitted to an off-site location, the emergency signal shall include the identity of the specific location of the building and have the capability to verbally communicate the building address prior to initiating live voice two-way communication with the off-site attendant.

32.3 Master Control Unit Display information

32.3.1 In response to an emergency signal, the master control unit shall minimally be capable of providing the following:

a) Provide a visual and audible indication distinct from other signals to indicate an emergency signal has occurred.

b) The audible signal distinct from other signals shall have the capability to produce a sound level not less than 70 db at 3 ft (1 m) from the master control unit. Additional sound levels are permitted to be field selected when the 70 db is the default level.

c) The audible indication shall sound until the two-way communication path has been established with an active remote communications station.

d) When multiple remote communications stations are simultaneously active in the system, the audible signal shall cease upon the operator establishing two-way communication with one of the active remote communications stations so that the audible signal does not interfere with the conversation.

e) After two-way communication has been established with any active remote communications station, and the communication circuit (s) is active, any subsequent call-in signals from other remote communications stations shall result in the reenergization of the audible call-in signal for a minimum of 2 seconds.

Exception No. 1: Only a visual indication for pending calls is permitted as long as a pending call queue is visible at all times to the attendant.

Exception No. 2: Manual deactivation of the audible call-in signal is permitted when the manual control complies with 33.1.1.

f) Display the location including floor and area of the remote communications station sending the signal.

32.3.2 Where all status changes are not displayed simultaneously, all the following conditions apply:

a) The display shall indicate the initial status change for the highest priority signal (signal for which two-way communications were not previously established), and in the order for which they were received.

b) Simultaneous display of a minimum of 8 active remote communications stations.

c) An indication for the quantity of each type (such as emergency signal, supervisory signal, and trouble signal) of active non-displayed status changes shall be continuously visible during any off-normal condition.

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

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

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

1) Signals associated with life safety,

2) Supervisory signals,

3) Trouble signals associated with life safety,

4) All other signals

32.3.3 After the call has been answered, the master control unit shall provide the manual means to assign a normal or heightened priority to calls from the remote communications station(s).

32.3.4 An emergency signal from the remote communications station shall be maintained continuously (locked in) by the master control unit until a resetting device in the master control unit is operated manually.

32.4 Supervisory signals

32.4.1 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. 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.

32.4.2 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.

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

a) Limited access as described in 33.1.1(a)(1) – (4).

b) A visible supervisory indicator shall remain activated or is simultaneously activated when the sounding device is de-energized.

c) The visible indicator shall be located and identified so that the user will recognize the signal as soon as it is activated.

d) Subsequent supervisory signals will reenergize the supervisory signal sounding device.

e) The sounding device shall sound when the means is in the "silence" position and no supervisory condition exists.

32.4.4 A supervisory signal that has been deactivated shall:

a) Automatically reactivate the audible and visible supervisory signal at the master control unit every 24 hr 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.

32.4.5 Non-electrical 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.

32.4.6 A visual “power-on” indication, visible after the product is installed, is to be present. A unique character presentation on a display device meets the intent of this requirement.

32.5 Remote Communications Station Display information

32.5.1 There shall be a visual and audible indication that the remote communications station was activated by the user.

32.5.2 The visual and audible indication of 32.5.1 shall persist until the master control unit answers the emergency signal by establishing the two-way live voice communication path.

32.5.3 There shall be a visual and audible indication, distinct from initial activation, that the master control unit has answered the emergency signal and the two-way communication path is active. The silencing of the audible at the remote communications station meets the requirements for distinct audible indication.

32.5.4 The visual indication in 32.5.3 shall only deactivate when the master control unit operator manually disconnects the two-way live voice communication to the respective remote communications station.

32.5.5 If the building occupant activates the remote communications station again, the remote communications station shall perform the same as described in 32.5.1 – 32.5.3

32.5.6 Upon resetting of the master control unit, when the emergency situation has been concluded, all visual and audible indications that are active on any remote communications stations shall be deactivated.

32.5.7 A continuous visual "power on" indication (visible after the product is installed) is to be present on all remote communications stations consisting of either a unique character presentation on a display device or a discrete LED.

32.5.8 While energized under secondary power, the visual discrete LED "power on" indication of 32.5.7 is permitted to be energized a minimum of one half second duration not less than once every 10 seconds.

32.6 Other signals

32.6.1 There shall be a visual distinction between signals associated with the two-way emergency communication system and signals of other types, such as supplementary signals.

32.6.2 When a common audible, distinct from emergency, is employed for trouble annunciation for all types of signals, distinction shall be achieved visually.

33 Two-Way Emergency Communications Control

33.1 General

33.1.1 All manual controls of the master control unit shall comply with 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;

3) Limited by a software security code providing a minimum of 1000 combinations and with a maximum 30-min time-out feature after the last activity; or

4) Arranged to provide equivalent protection against unauthorized use.

5) A switch that is left in the "off normal" position, when there is no active emergency signal, shall cause the trouble signal to sound until the switch is restored to normal.

33.1.2 Where there are multiple master control units networked together, only one shall be in control at any given time per group of remote communications stations and the location in control shall be identified by a visible indication at that location.

33.1.3 Where a combination of or multiple master control units are employed, the system shall be capable of transferring control from one unit to another.

33.1.4 When a master control unit is indicating that it is not in control, it shall not act as if it is in control.

33.1.5 Any switches utilized for the control of the two-way emergency communication system shall be either:

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

b) Located inside of a locked enclosure;

c) Access limited by a software security code providing a minimum of 1000 combinations and with a maximum 30-min time-out feature after the last activity; or

d) Arranged to provide equivalent protection against unauthorized use.

33.1.6 In the event that the emergency signal was transmitted off-site to a constantly attended location, the master control unit shall provide a manual means to regain control of the remote communications station's two-way communication and disconnect the off-site communications.

33.2 Monitoring integrity

33.2.1 Failure of any component in the audio chain (such as amplifiers, preamplifiers, tone generators, and interconnected wiring) resulting in the loss of emergency signaling capability shall cause an audible trouble signal. Compliance is to be verified with the two-way emergency communication system in the normal condition and repeated with the system in the emergency condition.

Exception: Wiring internal to a mechanically protected enclosure is not required to be supervised.

33.2.2 Microphones employed in both the remote communications stations and master control unit shall be monitored for integrity such that loss of the microphone results in a trouble signal.

Exception: Remote communications stations and master control unit hand-free microphones meeting the 5 ft-lb impact test.

33.2.3 Communication circuits shall be monitored for integrity such that the faults described in 35.3.1 result in both an audible and visual trouble indication.

33.2.4 Unacknowledged emergency signals at the master control shall not be interrupted if a fault on a communications circuit occurs while there is an emergency condition on that circuit.

33.2.5 Two-way emergency communication systems sharing components, circuitry and installation wiring with other systems shall comply with Combination Systems, Section 39.

COMMON REQUIREMENTS

34 Power Supplies

34.1 General

34.1.1 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: Products complying with 34.4.1 are not prohibited from using a primary battery as the sole source of power.

Exception No. 2: Products deriving power from separate equipment complying with this standard and which are supplied by at least two independent power sources.

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

34.1.3 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 off-normal signaling condition.

34.2 Primary power source

34.2.1 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 34.2.3, an audible and visual trouble signal shall be annunciated at a master control unit for all products located on premise.

34.2.2 The requirement of 34.2.1 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.

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

a) Total instantaneous loss of primary power; and

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

Transfer to the secondary power source shall occur between 85% and 90% of rated voltage. Restoration of the primary operating source to a value of not more than 90% of rated voltage shall result in the transfer of product operation to the primary operating source within 30 min.

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

34.2.4 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 34.2.1 shall occur as described in 34.3.4.

34.2.5 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.

34.3 Secondary power source(s)

34.3.1 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 the master control unit shall annunciate an audible and visual trouble signal for the two-way emergency communication systems located on premises.

34.3.2 The system shall produce the same emergency, and trouble 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.

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

34.3.4 With regard to 34.3.3, products employing voltage controlled charging methods shall initiate a trouble signal when the charging voltage decreases below the marked nominal rated battery voltage.

34.3.5 The secondary power sources shall comply with the standby times of Section 46.

34.4 Primary batteries

34.4.1 Primary batteries are not prohibited from being used when all of the following conditions are met:

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

1) Transmission of the transmitter with the product in the emergency communication mode of operation; or

2) A load equivalent to the load imposed by transmission in the emergency communication mode of operation.

b) A required battery trouble status signal shall be transmitted to the master control unit for a minimum of 7 days before the battery capacity of the transmitter/transceiver/product has depleted to a level insufficient to maintain four hours of proper emergency operation of the transmitter/transceiver/product.

c) The battery trouble signal annunciation at the master control unit is not prohibited from initially being delayed up to 4 hr.

d) The battery trouble signal shall be retransmitted at intervals not exceeding four hours or the product locks in the signal to the control unit until the battery is replaced.

Exception: Transmitter/transceiver/receiver combinations utilizing two-way communication where all of the following conditions are met:

a) The transceiver/receiver acknowledges receipt of the change of status signal to the corresponding transceiver/transmitter; and

b) The receiver/master control unit annunciates the current trouble status of the corresponding input or output RF device after manual reset of the receiver/master control unit.

e) Batteries (of the transmitter/product) shall be capable of operating the transmitter/product, including the remote communications stations (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.

f) Annunciation of the battery trouble status signal at the master control unit shall be distinctly different from emergency, tamper, and remote communications stations circuit trouble signals. It shall consist of an audible and visual signal that shall identify the affected transmitter/transceiver/product.

g) The audible trouble signal of the master control unit is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hr.

h) The battery trouble status signal shall persist at the master control unit until the depleted battery has been replaced.

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

j) Where a single battery failure affects the intended operation of the transmitter/transceiver/product, each transmitter/transceiver/product shall serve only one device and shall be individually identified at the master control unit.

k) A transmitter/transceiver/product shall be permitted to serve more than one device when all the following are met:

1) Multiple batteries are used;

2) A single battery failure does not affect the operation of transmitter/transceiver/product;

3) Each battery shall be individually monitored for battery depletion as described in (a);

4) Each battery upon reaching depletion shall cause the transmitter/transceiver/product to transmit a low battery trouble signal as described in (b);

5) Each transmitter/transceiver/product shall be individually identified at the master control unit.

35 Common Performance and Monitoring for Integrity – Two-Way Emergency Communication Systems

35.1 General

35.1.1 All means of interconnecting equipment, devices, and appliances 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.

Exception: Pathways required to operate with a specific Class designation in accordance with 35.1.8 – 35.1.11.

35.1.2 The requirement in 34.1.1 does not apply to the following circuits:

a) Trouble signal circuits;

b) Interconnection between equipment within a common enclosure;

c) A circuit for supplementary system components when 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) A non-interfering shunt circuit, when a fault condition of the circuit wiring results only in the loss of the non-interfering feature operation; and

f) The circuit connections extended to additional two-way emergency communication equipment when these wiring connections are intended to be made within 20 ft (6.1 m) of each other and are enclosed within conduit or equivalently protected against mechanical injury.

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

35.1.4 A single break or a single ground on any circuit shall not cause an emergency signal.

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

35.1.6 A multiple ground fault or short-circuit fault on an attendant notification appliance, and/or communication circuit (s) intended for connection to limited-energy cable, that would prevent required emergency operation, shall result in a trouble signal.

35.1.7 Where power to a device or appliance is supplied over a separate pathway from the attendant notification appliance, and/or communication circuit(s), the operation of the power pathway shall meet the performance requirements of the attendant notification appliance, and/or communication 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 35.1.8 – 35.1.11.

Exception: Operation of the power pathway as defined for other classes are permitted to be utilized and included in the product installation wiring diagram/instructions.

35.1.8 Pathways designated Class A shall operate as follows:

a) A redundant path/channel is included.

b) Operational capability continues past a single open, and the single open fault shall result in the annunciation of a trouble signal.

c) Operational capability in a radio frequency and/or wireless pathway/channel continues during a single fault consisting of each of the following applied separately:

1) Application of an adverse condition at a transceiver/repeater other than the device under test;

2) Blocking one transmission path/channel while in use at the device under test for sending and/or receiving signals; and

3) Blocking one path/channel at the control unit receiver/transceiver while that channel is in use for receiving signals from and/or sending signals to the device under test.

The fault shall result in the annunciation of a trouble signal when two paths/channels are no longer available.

d) Each transceiver and/or repeater in a radio frequency and/or wireless pathway/channel is powered by one of the following means:

1) Both a primary source meeting 34.2 and a secondary source meeting 34.3;

2) Multiple primary batteries meeting 34.4(k).

e) Conditions that affect the intended operation of the required paths are annunciated as a trouble signal.

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.

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

Exception No. 1: Requirements (f) and (g) shall not apply to non-conductive pathways (e.g. wireless or fiber).

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

35.1.9 Pathways designated as Class B shall operate as follows:

a) A redundant path is not included.

b) Operational capability stops at a single open.

c) Conditions that affect the intended operation of the path are annunciated as a trouble signal.

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.

f) Each transceiver and/or repeater in a radio frequency and/or wireless pathway/channel is powered by one of the following means:

1) Both a primary source meeting 34.2 and a secondary source meeting 34.3;

2) Multiple primary batteries meeting 34.4(k).

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

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

35.1.10 Pathways designated as Class X shall operate as follows:

a) A redundant path is included.

b) Operational capability continues past a single open, and the single open fault shall result in the annunciation of a trouble signal.

c) Operational capability in a radio frequency and/or wireless pathway/channel continues during a single fault consisting of each of the following applied separately:

1) Application of an adverse condition at a transceiver/repeater other than the device under test;

2) Blocking one transmission path/channel while in use at the device under test for sending and/or receiving signals; and

3) Blocking one path/channel at the control unit receiver/transceiver while that channel is in use for receiving signals from and/or sending signals to the device under test.

The fault shall result in the annunciation of a trouble signal

d) Each transceiver and/or repeater in a radio frequency and/or wireless pathway/channel utilizes frequency hopping spread spectrum technology or equivalent means to ensure the reliability of pathways.

e) Each transceiver and/or repeater in a radio frequency and/or wireless pathway/channel is powered by one of the following means:

1) Both a primary source meeting 34.2 and a secondary source meeting 34.3;

2) Multiple primary batteries meeting 34.4(k).

f) Operational capability continues past a single short circuit, and the single short-circuit fault shall result in the annunciation of a trouble signal.

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

h) Conditions that affect the intended operation of the path are annunciated as a trouble signal.

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

j) A single ground condition shall result in the annunciation of a trouble signal.

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

Exception No. 1: Requirements (h), (i), and (k) shall not apply to nonconductive pathways (e.g. wireless or fiber).

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

35.1.11 Pathways designated as Class N shall operate as follows:

a) It includes two or more pathways where operational capability of the primary pathway and a redundant pathway to each device shall be verified through end-to-end communication.

Exception: When only one device is served, only one pathway shall be required.

b) A loss of intended communications between endpoints shall be annunciated as a trouble signal.

c) A single open, ground, short, or combination of faults on one pathway shall not affect any other pathway.

d) Conditions that affect the operation of the primary pathway(s) and redundant pathway(s) shall be annunciated as a trouble signal when the system's minimal operational requirements cannot be met.

e) Primary and redundant pathways shall not be permitted to share traffic over the same physical segment.

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

35.1.12 Where two or more two-way emergency communication systems are interconnected, the interconnecting pathways shall be defined by class A, B, X and/or N in the product installation wiring diagram/instructions consistent with the operation of the particular pathway during the specified fault conditions specified in 35.1.8, 35.1.9, 35.1.10, and 35.1.11.

35.2 Attendant notification appliance circuits

35.2.1 Where provided, each attendant notification appliance circuit shall be defined by class A, B, X and/or N in the product installation wiring diagram/instructions consistent with the operation of the particular pathway during the specified fault conditions specified in 35.1.8, 35.1.9, 35.1.10, and 35.1.11.

Exception: The circuit of an attendant notification appliance intended to be installed in the same room within 10ft of the master control unit, is not required to be monitored for integrity regarding single open, single ground, wire-to-wire short faults when the attendant notification appliance circuit conductors are to be installed in conduit or have equivalent protection against mechanical injury.

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

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

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

35.3 Communications circuit between master control units and remote communications stations and networked master control units

35.3.1 Each communications circuit shall be defined by class A, B, X and/or N in the product installation wiring diagram/instructions consistent with the operation of the particular pathway during the specified fault conditions specified in 35.1.8, 35.1.9, 35.1.10, and 35.1.11.

35.3.2 Where digital communications are used, the inability of a product to send or receive digital signals over a communications circuit shall result in a trouble signal.

35.4 Auxiliary power supply supervisory circuit

35.4.1 Each system shall provide a means for monitoring auxiliary power supplies necessary for system function.

35.4.2 The off-normal condition of the auxiliary power supply shall be annunciated as a supervisory signal.

35.4.3 The auxiliary power supply supervisory circuit shall be defined by class A, B, X and/or N in the product installation wiring diagram/instructions consistent with the operation of the particular pathway during the specified fault conditions specified in 35.1.8, 35.1.9, 35.1.10, and 35.1.11.

35.5 Low-power radio-frequency signaling

35.5.1 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.

35.5.2 The requirements in 35.5.3 – 35.5.10 are based upon all required annunciation occurring at the master control unit.

35.5.3 A primary battery shall comply with 34.4.1 when a primary battery is used.

35.5.4 An emergency signal from a RF remote communications station shall latch at the master control unit until manually reset, and shall identify the particular RF remote communications station that is activated.

35.5.5 When a master control unit activates RF appliance (s) such as relays or attendant notification appliances, the activated appliance shall remain locked-in until manually reset at the master control unit.

35.5.6 To provide higher priority to emergency signals than to other signals, emergency signals shall be periodically repeated at intervals not exceeding 60 s until the remote communications station is returned to its normal condition. Master control units activating RF appliances shall automatically repeat emergency signal transmissions at intervals not exceeding 60 s or until confirmation that the output appliance received the signal. The duty cycle of the transmission shall be not more than 15% measured over a one-min interval.

Exception: Transmitter/transceiver/receiver combinations utilizing two-way communication where all the following conditions are met:

1) The transceiver/receiver acknowledges receipt of the change of status signal to the corresponding transceiver/transmitter; and

2) The receiver/master control unit annunciates the current trouble status of the corresponding input or output RF device after manual reset of the receiver/master control unit.

35.5.7 A master control unit shall annunciate a latching trouble signal and identify an inoperative transmitter/product in the system within 200 s.

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

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

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 dB;

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

d) By another equivalent means.

35.5.9 The audible tamper signal of the master control unit is not prohibited from being silenceable when provided with an automatic feature to resound the signal at intervals not exceeding 4 hr. Both of the following actions shall cause the annunciation of a tamper signal at the master control unit additionally identifying the affected device within 200 s.

a) Removal of a remote communications station 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.

35.5.10 Reception of any unwanted (interfering) transmission by a retransmission device (repeater), or by the master control unit that exceed the maximum specified ambient noise level or minimum signal-to-noise ratio (see 60.3.2) for a continuous period of 20 s or more shall result in an audible trouble signal indication at the master control unit. This indication shall identify the specific trouble condition (interfering signal) as well as the device(s) affected (repeater and/or master control unit).

36 Trouble Signals

36.1 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 emergency) is to be employed for trouble annunciation for both emergency and non-emergency related signals, distinction shall be achieved visually.

36.2 Cancellation of the off-normal signal is acceptable annunciation for a trouble restoration signal.

36.3 The activation of a self-restoring trouble signal and its restoration to normal shall be automatically indicated as described in 36.1 and 36.2.

36.4 The activation of a latching trouble signal shall be automatically indicated as described in 36.1. Restoration of a latching trouble signal shall be indicated as described in 36.1 and 36.2 after activation of a manual reset.

36.5 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;

3) Limited by a software security code providing a minimum of 1000 combinations and with a maximum 30-min time-out feature after the last activity; 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.

36.6 An audible trouble signal that has been silenced at the master control unit shall

a) Automatically reactivate the audible trouble signal at the master control unit every 24 hr or less until trouble signal conditions are restored to normal; and

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

37 Components – Monitoring for Integrity

37.1 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 master control unit.

37.2 Failure of components associated with controlling the environment within an enclosure, such as a cooling fan motor, which would result in product temperatures exceeding those in Table 45.1 and Table 45.2 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 master control unit.

37.3 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 master control unit.

37.4 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 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 master control unit.

37.5 To determine if a switching part of a product complies with 37.3 and 37.4, the investigation is to start with the representative system combination in the normal condition; the system is then to be operated for signals with the manual-switching part in each position.

37.6 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.

37.7 A system shall not be affected if the system fails to execute any supplementary program.

37.8 Where an audible trouble signal is used to annunciate the conditions indicated in 37.1 – 37.6 for the master control unit, the trouble signals shall comply with the requirements in Trouble Signals, Section 36.

38 Software

38.1 General

38.1.1 Any product that is dependent upon software program(s) to achieve proper operation shall meet all the requirements in this section.

38.1.2 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 as described in 68.17 shall be provided in the front of the programming manual 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 throughout the manual where the specific feature or option appears describing the requirements of this standard.

38.1.3 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.

38.1.4 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.

38.1.5 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.

38.1.6 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 for the master control unit, a total number of remote communications station circuits plus remote communications stations connected to all communication circuits up to a maximum of 10 or ten percent of the total, whichever is greater.

38.1.7 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 control unit to perform in a degraded mode with regard to the status changes which are stored in memory.

38.1.8 Software and firmware within a two-way emergency communication 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 systems. This does not apply to supplementary functions.

38.2 User access and programming

38.2.1 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.

38.2.2 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 setting of parameters and variables that relate only to topics influenced by use and installation of the product.

38.2.3 A security means shall be provided to restrict unauthorized access to site specific programming. The means shall provide a minimum of 1000 possible combinations. The security means shall not be the same as the access means provided to enable the products operational controls or features. The use of different passwords meets the intent of this requirement.

38.2.4 Initial site specific programming or any subsequent reprogramming of an in-building master control unit shall require manual actuation of the security means at the in-building master control unit. Once activated, programming may be completed on-site or downloaded from an off-site location.

38.2.5 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 at the master control unit.

38.3 Software integrity

38.3.1 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.

38.3.2 With regard to 38.3.1, evidence of software integrity shall be any of the following:

a) Software development using a documented process, which includes the test procedures, with anticipated test results, specified in 38.3.3 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 38.3.3.

Documentation for (a) and (b) shall include a description of the test methods used, test result(s), and identification of test equipment.

38.3.3 The test program specified in 38.3.2 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) Supervised output (attendant notification appliance, etc.) circuits:

i) Subjecting the 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.

2) Communications circuits:

i) Subjecting the 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.

3) Supervisory circuit:

i) Subjecting the 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 a supervisory condition, and that the system responds as required.

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 by verifying that the panel correctly controls the device as designed.

38.3.4 The testing information specified in 38.3.2 (a) and (b) shall be submitted for review for any new products and whenever functions are added to the software of an existing product.

39 Combination Systems

39.1 When a two-way emergency communication system is intended to share components, equipment, circuitry, or installation wiring with non-emergency equipment, and the non-emergency equipment complies with this standard, or complies with one of the standards shown in 39.2, the requirements of 39.3 – 39.5 shall apply.

39.2 With respect to 39.1, the following standards apply:

a) The Standard for Mass Notification Systems, UL 2572;

b) The Standard for General-Purpose Signaling Devices and Systems, UL 2017, Type SM or AM; and

c) The Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

39.3 It shall be permitted to attach the non-emergency equipment to the two-way emergency communication system circuits when the following requirements are met:

a) The two-way emergency communication system equipment and circuits shall continue to meet the circuit requirements of Common Performance and Monitoring for Integrity – Two-Way Emergency Communication Systems, Section 35 with the non-emergency equipment attached.

b) Failures of the non-emergency equipment that affect the operation of the two-way emergency communication system shall be detected and reported at the master control unit.

c) The installation document of the two-way emergency communication system shall specify that all wiring, including that to the non-emergency equipment, shall be installed in accordance with the requirements of the National Fire Alarm and Signaling Code, NFPA 72.

d) The non-emergency equipment shall be compatible with the two-way emergency communication system or it shall have a contact closure interface for the connected load.

39.4 When the non-emergency equipment is connected to the two-way emergency communication system through separate wiring, opens and short circuits shall not impair the operation of the two-way emergency communication system.

39.5 Single ground faults which impede or impair the monitoring for integrity of the two-way emergency communication system, or impede or impair any emergency or trouble signal transmissions or operation shall be reported at the master control unit as trouble signals when they occur on the wiring interconnecting the non-emergency equipment with the two-way emergency communication system.

39.6 When a two-way emergency communication system is intended to share components, equipment, circuitry, or installation wiring with non-emergency equipment, and that equipment does not comply with either this standard or any of the standards shown in 39.2, the requirements of 39.7 – 39.9 shall apply.

39.7 Short circuits or open circuits in the non-emergency equipment or in the wiring between the non-emergency equipment and the two-way emergency communication system shall not impede or impair the monitoring for integrity of the two-way emergency communication system as described in Common Performance and Monitoring for Integrity – Two-Way Emergency Communication Systems, Section 35, nor impede or impair any two-way emergency communication system signal transmissions or operations.

39.8 Single ground faults in the non-emergency equipment shall not impede or impair the monitoring for integrity of the two-way emergency communication system, or impede or impair any emergency or trouble signal transmissions or operation.

39.9 The required operation of the two-way emergency communication system equipment shall not be impaired by any failure of the 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-emergency equipment.

39.10 The monitoring for integrity as described in the Common Performance and Monitoring for Integrity – Two-Way Emergency Communication Systems, Section 35, shall continue to be met during the period the combination system is used for non-emergency purposes.

39.11 Emergency control or other non-emergency functions shall have the capability of not interfering with any required operation of the two-way emergency communication system.

39.12 In combination systems, two-way emergency communication system related signals shall be distinctive, clearly recognizable, and shall be indicated as follows in descending order of priority:

a) Signals associated with rescue assistance.

b) Trouble signals associated with two-way emergency communication system.

c) All other signals.

39.13 Where the two-way emergency communication system 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 – Two-Way Emergency Communication Systems, Section 35.

b) Non-emergency data transmitted to the two-way emergency communication system shall not impair the operation of the two-way emergency communication system.

39.14 All equipment which affect the operation of the two-way emergency communication system shall meet the requirements of this standard.

40 Interconnected Two-Way Emergency Communication Systems

40.1 The interconnections of multiple two-way emergency communication system intended to function as a single system shall be monitored for integrity in accordance with the Common Performance and Monitoring for Integrity – Two-Way Emergency Communication Systems, Section 35.

40.2 Each interconnected two-way emergency communication system shall have the capability of being monitored separately for emergency, and trouble conditions, as applicable.

40.3 Unless interconnected two-way emergency communication system located within the same building are intended to be installed such that the display annunciation at each unit can be simultaneously observed for, emergency and trouble conditions, as well as reset, or trouble silence actuation originating at any unit shall be annunciated at each master control unit.

40.4 The time periods for processing and activation of signals between interconnected two-way emergency communication system shall comply with 32.1.2 as applicable.

40.5 The programming of remote communications stations, and attendant notification appliances of the interconnected/networked two-way emergency communication systems shall comply with Software, Section 38.

40.6 The operation of relays or other modules providing emergency, or trouble output signaling shall operate as described for one of the following categories:

a) Common – Operates for all of the signals relative to its type (such as emergency, trouble).

b) Zone – Operates for specific zone/circuit input signals (non-programmable).

c) Programmable – Operates for any signals for which it is programmed.

The function of the relay or output module shall be clearly defined in the installation wiring diagram/instructions for the product.

OTHER TESTS

41 Electrical Ratings Test

41.1 General

41.1.1 A low-voltage circuit of a product shall comply with the limits specified in 3.12(b).

41.2 Power input circuits

41.2.1 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.

41.2.2 Where the operating voltage of a product is specified at two or more discrete values, the requirement in 41.2.1 shall be applied at each voltage rating.

41.2.3 Where the input to the product is specified as a 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.

41.3 Other external circuits

41.3.1 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.

41.3.2 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.

41.3.3 Where the circuit is not power limited as defined in the Power-Limited Circuits Test, Section43, 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 14.4.

41.3.4 Output current measurements of either half-wave and full-wave rectifier circuits are to be based on the average value of the waveform.

42 Variable Voltage Operation Test

42.1 The product, when connected to maximum rated load as described in 30.2.2 and subjected to the input voltage conditions described in 42.2 – 42.6, shall meet all of the following:

a) operate as intended,

b) operate without risk of fire or electric shock,

c) comply with the requirements of the Audio Performance Test, Section 52,

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.

42.2 The product is to be subjected to the following variable voltage conditions:

a) 110% of the rated primary input voltage specified in Table 30.1. The secondary power source is to be connected to rated voltage.

b) 110% of the marked rated nominal standby battery voltage or rated secondary power input voltage specified in Table 30.1. The primary input voltage is to be disconnected.

c) 85% of rated primary input voltage specified in Table 30.1 or at some lower level of transfer voltage as specified in 34.2.1 – 34.2.4. The standby battery or, when provided, a secondary power source shall be disconnected.

d) 85% of the marked rated nominal standby battery voltage or rated secondary power input voltage specified in Table 30.1. The primary input voltage is to be disconnected.

42.3 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.

42.4 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).

42.5 The increased voltage tests are to be made with zero line impedance in each external circuit.

42.6 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.

42.7 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 emergency 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% of rated voltage or at some lower level of transfer voltage as determined according to 34.2.1 – 34.2.4.

42.8 A charged battery is defined as a battery having the capacity to maintain the product in the normal and emergency conditions for the time period required in the Charging Current Test, Section 46.

43 Power-Limited Circuits Test

43.1 General

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

43.1.2 The power source (or sources) supplying a power-limited 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 power-limited circuit has electrical characteristics as described in Table 43.1 for AC circuits or Table 43.2 for DC circuits.

Table 43.1
Power limitations for AC circuits

Circuit voltage V_{max} [a]		Inherently limited power source (overcurrent protection not required)			Not inherently limited power source (overcurrent protection required)		
		0 – 20	over 20 – 30	over 30 – 100	0 – 20	over 20 – 100	over 100 – 150
Power limitations VA_{max} [b] (volt-amps)		–	–	–	250[d]	250	–
Current limitations I_{max} [c] (amps)		8.0	8.0	$150/V_{max}$	$100/V_{max}$	$100/V_{max}$	1.0
Maximum overcurrent protection (amps)		–	–	–	5.0	$100/V_{max}$	1.0
Power source maximum nameplate ratings	VA (volt-amps)	$5.0 \times V_{max}$	100	100	$5.0 \times V_{max}$	100	100
	Current (amps)	5.0	$100/V_{max}$	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$

[a] V_{max} is the maximum output voltage regardless of load with rated input applied.

[b] VA_{max} is the maximum volt-ampere output after 1 min of operation regardless of load and with overcurrent protection bypassed if used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] I_{max} is the maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed if used. If a transformer limits the output current, I_{max} limits apply after 1 min of operation. If a current-limiting impedance, determined to be suitable for the purpose, is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery to limit the output current, I_{max} limits apply after 5 s of operation.

[d] If the power source is a transformer, VA_{max} is 350 or less when V_{max} is 15 or less.

NOTE – Reproduced in part from the National Electrical Code, ANSI/NFPA 70, copyright National Fire Protection Association, Quincy, MA 02269.

Table 43.2
Power limitations for DC circuits

Circuit voltage V_{max} [a]	Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)		
	0 – 20	over 20 – 30	over 30 – 100	over 100 – 250	0 – 20	over 20 – 100	over 100 – 150
Power limitations VA_{max} [b] (volt-amps)	–	–	–	–	250[d]	250	–
Current limitations I_{max} [c] (amps)	8.0	8.0	$150/V_{max}$	0.030	$100/V_{max}$	$100/V_{max}$	1.0

Table 43.2 Continued on Next Page

Table 43.2 Continued

Circuit voltage V_{max} [a]		Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)		
		0 – 20	over 20 – 30	over 30 – 100	over 100 – 250	0 – 20	over 20 – 100	over 100 – 150
Maximum overcurrent protection (amps)		–	–	–	–	5.0	$100/V_{max}$	1.0
Power source maximum nameplate ratings	VA (volt-amps)	$5.0 \times V_{max}$	100	100	$0.030 \times V_{max}$	$5.0 \times V_{max}$	100	100
	Current (amps)	5.0	$100/V_{max}$	$100/V_{max}$	0.030	5.0	$100/V_{max}$	$100/V_{max}$

[a] V_{max} is the maximum output voltage regardless of load with rated input applied.

[b] VA_{max} is the maximum volt-ampere output after 1 min of operation regardless of load and with overcurrent protection bypassed if used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] I_{max} is the maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed if used. If a transformer limits the output current, I_{max} limits apply after 1 min of operation. If a current-limiting impedance, determined to be suitable for the purpose, is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery to limit the output current, the limits apply after 5 s of operation.

[d] If the power source is a transformer, VA_{max} is 350 or less when V_{max} is 15 or less.

NOTE – Reproduced in part from the National Electrical Code, ANSI/NFPA 70, copyright National Fire Protection Association, Quincy, MA 02269.

43.1.3 Relative to 43.1.2, 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).

43.1.4 Relative to 43.1.2, 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.

43.1.5 The overcurrent protection device specified in 43.1.2 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.

43.1.6 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.

43.1.7 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.

43.1.8 The loads referenced in 43.2.1 – 43.4.1 shall be resistive.

43.2 Maximum voltage

43.2.1 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 43.1 or Table 43.2.

43.3 Maximum current

43.3.1 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 Table 43.1 and Table 43.2. The load resistor is then to be connected to the circuit and the current through the load resistor measured after 1 min or after 5 s as determined from Table 43.1 or Table 43.2.

43.3.2 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 43.3.1, and continues until the current is continuously below the I_{max} value indicated in Table 43.1 or Table 43.2. The time period is to include any momentary period where the output current temporarily drops below the required I_{max} value limit.

43.3.3 Where a transformer limits the value of I_{max}, and when I_{max} cannot be maintained for 1 min due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 min. The results satisfy the requirement of the test when the extrapolated value of I_{max} at 1 min does not exceed the I_{max} limitations as indicated in Table 43.1 or Table 43.2.

43.3.4 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 s 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 43.1 or Table 43.2. The results are in compliance when the I_{max} value stated in Table 43.1 or Table 43.2 cannot be maintained for more than 5 s.

43.4 VA_{max} (not inherently limited circuits only)

43.4.1 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 min, 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 min does not exceed the value specified in Table 43.1 or Table 43.2, as appropriate.

44 Compatibility Tests

44.1 General

44.1.1 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.

44.1.2 The requirements in 44.1.1 apply to products connected to or providing circuits described in 44.2.1.1 – 44.3.6, and by which the operating parts of the product are actuated for signaling and/or action.

44.2 Attendant notification appliance circuits (NAC)

44.2.1 Rating

44.2.1.1 All attendant notification appliance circuits of a product and power supply output circuits intended to directly supply attendant notification appliance circuits shall be identified by at least one of the rating designations shown in Table 44.1

Table 44.1
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

Note: FWR = full-wave rectified

44.2.2 Voltage measurement test

44.2.2.1 While the product is energized at the voltage extremes described in the Variable Voltage Operation Test, Section 42, the voltage of the circuit shall be maintained within the voltage range limits shown in Table 44.1, under the maximum rated load conditions as indicated in the manufacturer's installation instructions.

44.3 Power output circuits

44.3.1 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 44.3.2 – 44.3.4 and shall have a single voltage rating. A special application output shall comply with 44.3.5 and 44.3.6.

44.3.2 The output voltage of a regulated circuit shall not exceed 110% 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% of rated value. Any secondary operating power to the product is to be connected during this test.

44.3.3 The output voltage of a regulated circuit shall not be less than 85% of rated voltage when the input operating voltage to the product is adjusted to 85% of rated value or to 1 V above the low-voltage level transfer voltage as determined in accordance with 34.2.3, 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.

44.3.4 For products using a standby battery, the same regulation (85 – 110% 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% of the nominal marked battery rating, under the circuit load conditions described in 44.3.2 and 44.3.3, respectively.

44.3.5 A power output circuit that has a voltage deviation greater than permitted in 44.3.2 – 44.3.4 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.

44.3.6 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% 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 31 – 64, and the Variable Voltage Operation Test, Section 42.

45 Component Temperature Test

45.1 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 Table 45.1 and Table 45.2.

Exception: A component with a temperature exceeding that indicated in Table 45.1 is not prohibited from being used when reliability data at the higher temperature is provided by the manufacturer to justify its use.

Table 45.1
Maximum temperature rises – electronic components

Component or device	Normal (i.e. any long term l condition of operation or non-emergency operating condition), °F	(°C)	Emergency condition (i.e. short term operating condition), °F	(°C)
A. COMPONENTS				
1. Capacitors[a]	45	(25)	72	(40)

Table 45.1 Continued on Next Page

Table 45.1 Continued

Component or device	Normal (i.e. any long term l condition of operation or non-emergency operating condition), °F	(°C)	Emergency condition (i.e. short term operating condition), °F	(°C)
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 reliability assessment specified in 45.1 shall be conducted.

[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% of its rated junction temperature, or storage temperature when not rated for junction temperature, during the normal condition and during any non-emergency signaling condition.

b) 75% of its rated junction temperature, or storage temperature when not rated for junction temperature, under the emergency 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%. For integrated circuits, the loading factor shall not exceed 50% of its rating under the normal condition and 75% under any condition of operation.

2) Not exceed 100% 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% 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 hr, 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 45.2
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)

Table 45.2 Continued on Next Page

Table 45.2 Continued

Materials and component parts	°F	(°C)
5. Any point on or within a terminal box on a permanently wired unit (see 67.1.9)	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, transformers, 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.

45.2 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 Table 45.1 and Table 45.2 are to be reduced by the amount of the difference between that higher ambient temperature and 77°F.

45.3 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 in (19.1 mm) wood such that the walls of the enclosure make a close fit with the product and extending

approximately 2 in (50.8 mm) on the top, sides and rear, and the front extended to be flush with the product cover.

45.4 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 Hz is to be tested at both direct current and 60-Hz alternating current. A product rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 50-Hz alternating current.

45.5 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.

45.6 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 67.1.22.

45.7 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 53.1 is questionable and, therefore, requiring the measurements indicated in 45.8.

45.8 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 in (0.8 mm) maximum in total thickness] of cotton, paper, rayon, or the like.

45.9 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 Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

45.10 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 °C;

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

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

t is the known temperature in °C.

45.11 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.

45.12 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.

45.13 Component temperature is to be determined while the product is operated under the following conditions:

a) Normal condition (i. e. any long term condition of operation or any 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 46.2.1 – 46.2.5).

b) Emergency condition (i. e. any short term operating condition or emergency signaling which produces the maximum component temperature dissipation) under maximum rated load conditions until constant temperatures occur.

45.14 A temperature is determined to be constant when three successive readings taken at intervals of 10% of the previously elapsed duration of the test, but not less than 5-min intervals, indicate no change.

45.15 In a product having provision for multiple remote communications stations, all remote communications stations s shall be actuated during the emergency condition.

46 Charging Current Test

46.1 General

46.1.1 This test is to be conducted in conjunction with the Component Temperature Test, Section 45, on products provided with standby batteries.

46.2 Discharged battery

46.2.1 The terminal voltage of a battery discharged as specified in 46.2.2 – 46.2.5 shall not be less than 85% of the marked nominal battery voltage.

46.2.2 The battery is first to be charged by applying AC input power to the product for 48 hr, during which the product is to be operated continuously with normal condition load connected. AC input is then to be disconnected, and terminal voltage of the battery is to be measured one min after disconnection.

46.2.3 The battery is then to be discharged by maintaining the normal condition load connected to the output for the applicable period specified in (a), (b), or (c):

a) 4 hr, where secondary (standby) power is intended to be used in conjunction with an automatic-starting engine-driven generator;

b) 24 hr; or

c) A longer than 24-hr period as described in the installation document of the product.

46.2.4 For products which normally have no status change signaling operations during the discharge period, the normal condition load shall be the quiescent current of the product plus any specified normal condition 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 (RF repeaters) and which draw more operating current when signaling then while in the quiescent mode, the

normal condition load shall be a steady state load equal to the signaling current of the product plus any specified normal condition power supply loads not automatically disconnected upon transfer to secondary power.

46.2.5 At the conclusion of the discharge period, the two-way emergency communication system operating notification appliances used to signal the operator at the master control unit shall have the maximum rated emergency condition load applied for 4 hours or any longer period as described in the installation document of the product. The emergency condition load shall be the maximum configuration including all remote communications stations in the active condition and all notification appliances used to signal the operator at the master control unit in the signaling/alerting condition.

46.3 Charged battery

46.3.1 The terminal voltage of a battery charged as specified in 46.3.2 shall be at least 95% of the voltage measured in 46.2.2.

46.3.2 At the conclusion of the test sequence described in 46.2.2 – 46.2.5, AC input power is to be reapplied to the product for 48 hr. During charging, the product is to be operated continuously with normal condition load connected. At the conclusion of the 48-hr recharge time, AC power is to be disconnected and battery terminal voltage measured after one min.

46.4 Discharged battery – second trial

46.4.1 The terminal voltage of a battery shall not be less than 85% of the marked nominal battery voltage after the battery has been discharged as specified in 46.2.3 and 46.2.5 following charging as specified in 46.3.2.

47 Variable Ambient Temperature and Humidity Tests

47.1 General

47.1.1 At the test ambient conditions specified in 47.2.1 – 47.4.1:

a) A product shall operate in the intended manner for all conditions of intended use; and

b) Shall meet the requirements of the Audio Performance Test, Section 52.

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 hr.

b) The equipment is marked with the ambient temperature limitations.

47.1.2 The unit is to be energized from a source of rated voltage and frequency, and connected to maximum rated load as described in 30.2.2.

47.1.3 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.

47.2 Low temperature test

47.2.1 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.

47.2.2 The unit is to be maintained in the normal condition at the test ambient until thermal equilibrium has been reached (4 hr minimum).

47.3 High temperature test

47.3.1 A product 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.

47.3.2 The unit is to be maintained in the normal condition at the test ambient until thermal equilibrium has been reached (4 hr minimum).

47.4 Humidity test

47.4.1 A product shall operate in the intended manner after having been exposed for 24 hr to moist air having a relative humidity of 93 ±2% 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 the conditions specified in 47.1.1.

48 Endurance Test

48.1 Except as indicated in 48.2, the current-interrupting contacts and the operating mechanism of a remote communications station shall perform as intended when subjected to the endurance conditions specified in 48.3. There shall not be electrical or mechanical malfunction of the remote communications station, nor burning, pitting, or welding of contacts.

48.2 The endurance test may be waived if the remote communications station uses a single-pole switching device having an ampere rating of not less than twice the ampere rating of the remote communications station.

48.3 A remote communications station is to be operated manually for 500 cycles of operation at the rate of 6 cycles per minute. Each cycle is to consist of making and breaking 150 percent of the rated current and at rated voltage.

48.4 The remote communications station is to be tested for which the contacts are intended to control. Also:

a) A remote communications station intended and marked for use on alternating current only is to be tested with alternating current.

b) A remote communications station intended for use on direct current and a box not specifically marked for alternating current only shall be tested with direct current.

c) A remote communications station with a single voltage rating and a single current rating is to be tested at that voltage and current.

d) A remote communications station with multiple voltage ratings and a single current rating is to be tested at the highest voltage indicated and at the current indicated.

e) A remote communications station with multiple current ratings is to be tested under conditions of maximum voltage, power, and current interrupted. If the box has different current ratings for alternating current and direct current, the box is to be tested for each rating. Separate samples are to be used for testing at each different rating.

49 Leakage Current Test

49.1 Where a cord-connected product is powered by a source greater than 42.4 V peak, the leakage current at any exposed surface, or between any accessible part and earth ground, or any other accessible part with an open potential of greater than 42.4 V peak shall not be more than the following values when tested in accordance with 49.2 – 49.8:

a) 0.5 mA for an ungrounded (2-wire) portable or stationary;

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

c) 0.75 mA 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 mA 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 23;

b) With the filter removed from the product, the leakage current does not exceed the limits specified in 49.1 (b) and (c), as applicable; and

c) The product is marked in accordance with 67.1.15.

49.2 With regard to the requirements in 49.1, 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.

49.3 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 in (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 ft (1.8 m) apart.

49.4 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 in (10 by 20 cm) in contact with the surface. Where the surface is less than 3.94 by 7.88 in, 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.

49.5 The measurement circuit for the leakage current test is to be as illustrated in Figure 49.1. 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.

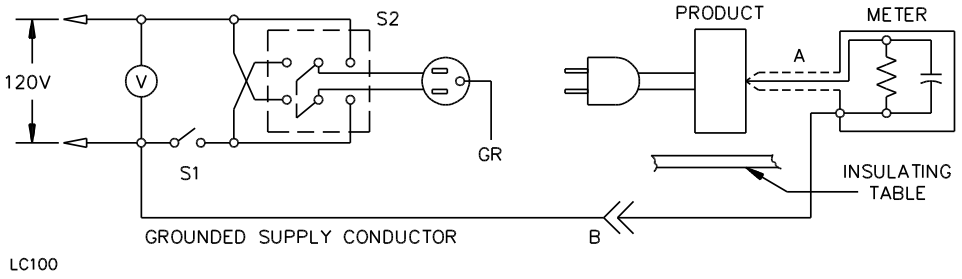
a) The meter is to have an input impedance of 1500 ohm resistive shunted by a capacitance of 0.15 μF;

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 kHz, 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 μF capacitor to 1500 ohm. At an indication of 0.5 or 0.75 mA, the measurement is to have an error of not more than 5% at 60 Hz.

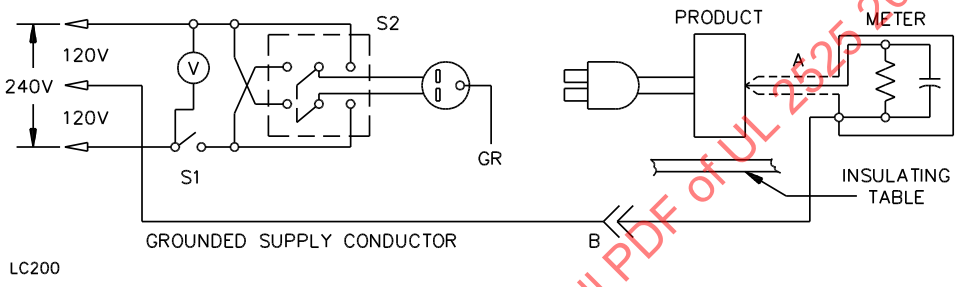
Figure 49.1

Leakage current measurement circuits



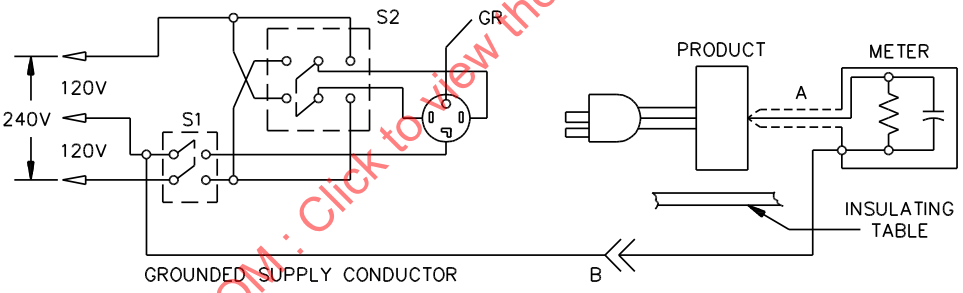
LC100

Product intended for connection to a 120-V power supply.



LC200

Product intended for connection to a 3-wire, grounded neutral 120/240-V power supply, as illustrated above.



LC300

Product intended for connection to a 3-wire, grounded neutral 120/240-V 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/120 V supply.

49.6 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.

49.7 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.

49.8 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 hr 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 30.1.3 or shall be as described in 45.6, but not less than 120 or 240 V. The test sequence (with regard to Figure 49.1) 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 s 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 45.

50 Jarring Test

50.1 A remote communications station shall withstand jarring resulting from impact and vibration as described in 50.2 without:

a) Resulting in a risk of shock or fire hazard;

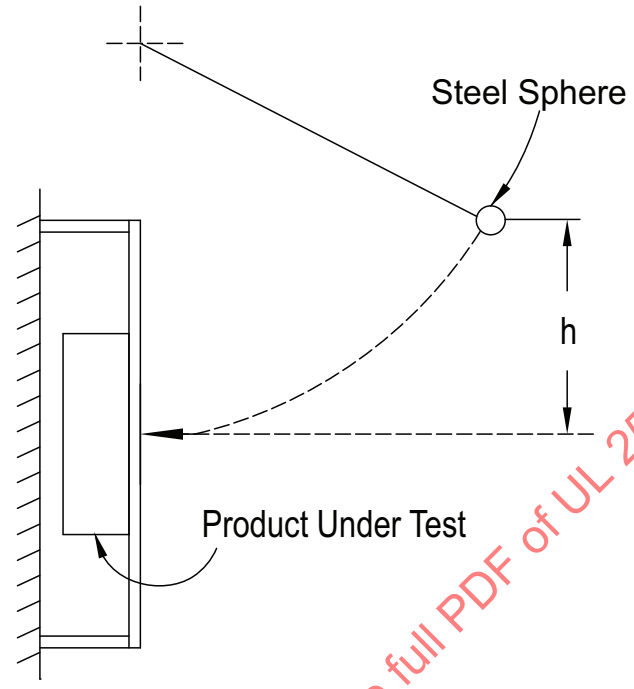
b) Causing false signaling operation of any part; and

c) Impairing the subsequent intended operation.

50.2 The product is to be mounted as intended to the center of a 1.8- by 1.2-m (6- by 4-ft) nominal 19.1-mm (3/4-in) thick plywood board secured in place at four corners. A 4.08 J (3 ft·lb) direct 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 swung through a pendulum arc from a height (h) of 775 mm (2.54 ft). See Figure 50.1

Figure 50.1

Jarring test



ip110d

51 Transient Tests

51.1 General

51.1.1 While energized from a source of supply in accordance with Table 30.1, a product shall:

a) Not generate an emergency condition;

b) Not generate troubles

c) Not reset during an emergency condition;

d) Experience no electrical or mechanical failure of any components of the product;

e) Operate as intended following the test;

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

g) Shall meet the requirements of the Audio Performance Test, Section 52, following the test when subjected to the tests described in 51.2.1 – 51.4.3.

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.

51.2 Externally-induced supply-line transients

51.2.1 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.

51.2.2 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.

51.2.3 The product is to be subjected to 500 transient pulses induced at an average rate of 3 pulses every min. A total of 250 pulses are to be applied so that the transient is induced 90° into the positive phase with reference to earth ground of the 60 Hz cycle, and the remaining 250 pulses are to be induced 90° into the negative phase with reference to earth ground of the 60 Hz cycle. Of the total 250 pulses at each polarity, 225 are to be applied with the product in the normal condition and 25 are to be applied with the product in the emergency condition.

51.3 Internally-induced transients

51.3.1 The product is to be energized in the intended supervisory 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 s at a rate of not more than six interruptions per min. 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.

51.4 Input/output (low-voltage) field-wiring transients

51.4.1 The product is to be energized in the normal condition while connected to a source of supply in accordance with Table 30.1. All field-wiring circuits are to be tested as specified in 51.4.2 and 51.4.3.

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

51.4.2 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	Figure 51.1
1000[a]	0.31	150	Figure 51.2
500[a]	0.10	250	Figure 51.3
100	0.011	1120	Figure 51.4

[a] Other applied transients having peak voltages representative of the entire range of 100 – 2400 V 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 51.5) and minimum energy level (Figure 51.6) parameters, and shall have an equal or faster minimum transient pulse rise time than that specified in Figure 51.7.

Figure 51.1

Signal line transients – 2400V curve

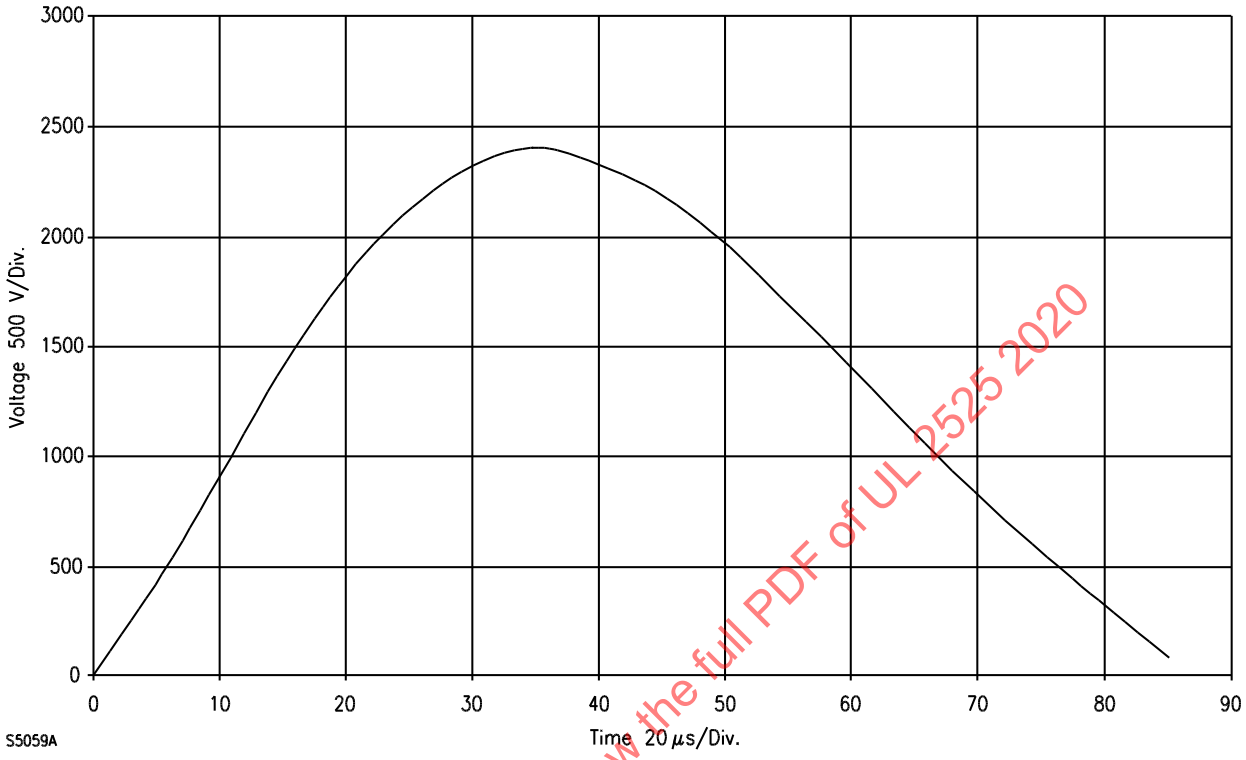


Figure 51.2

Signal line transients – 1000V curve

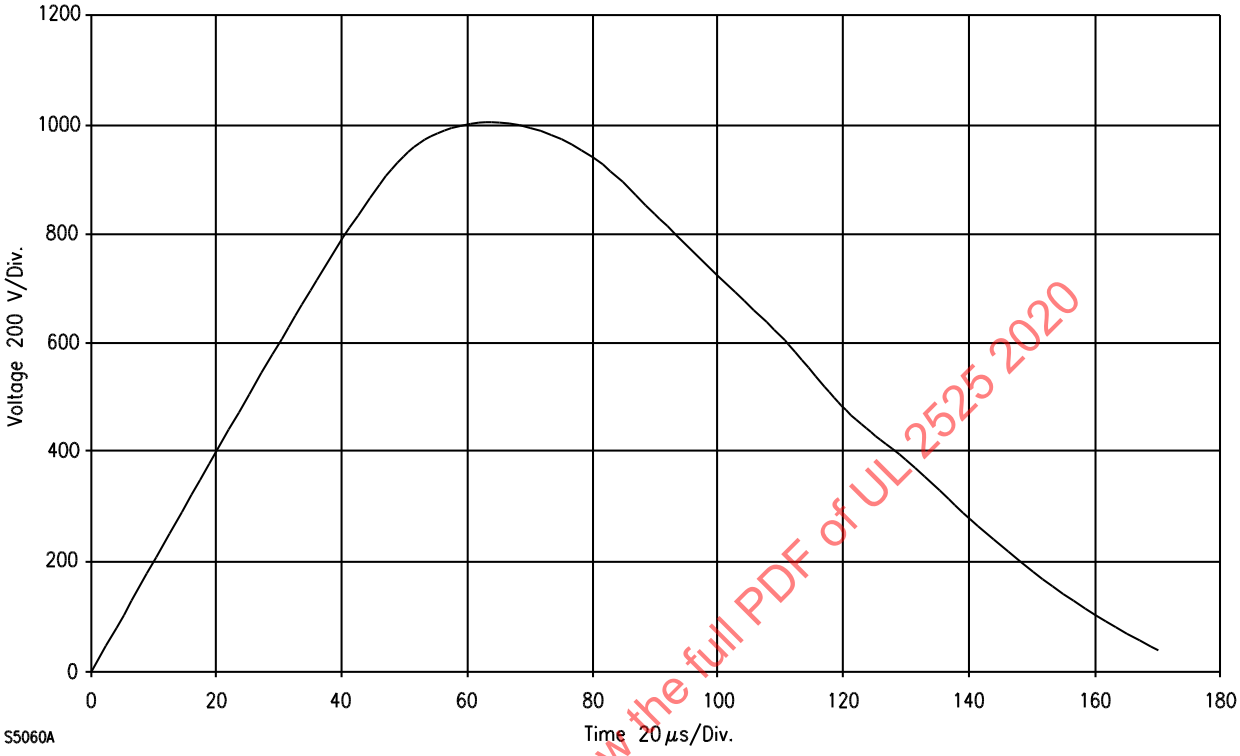


Figure 51.3

Signal line transients – 500V curve

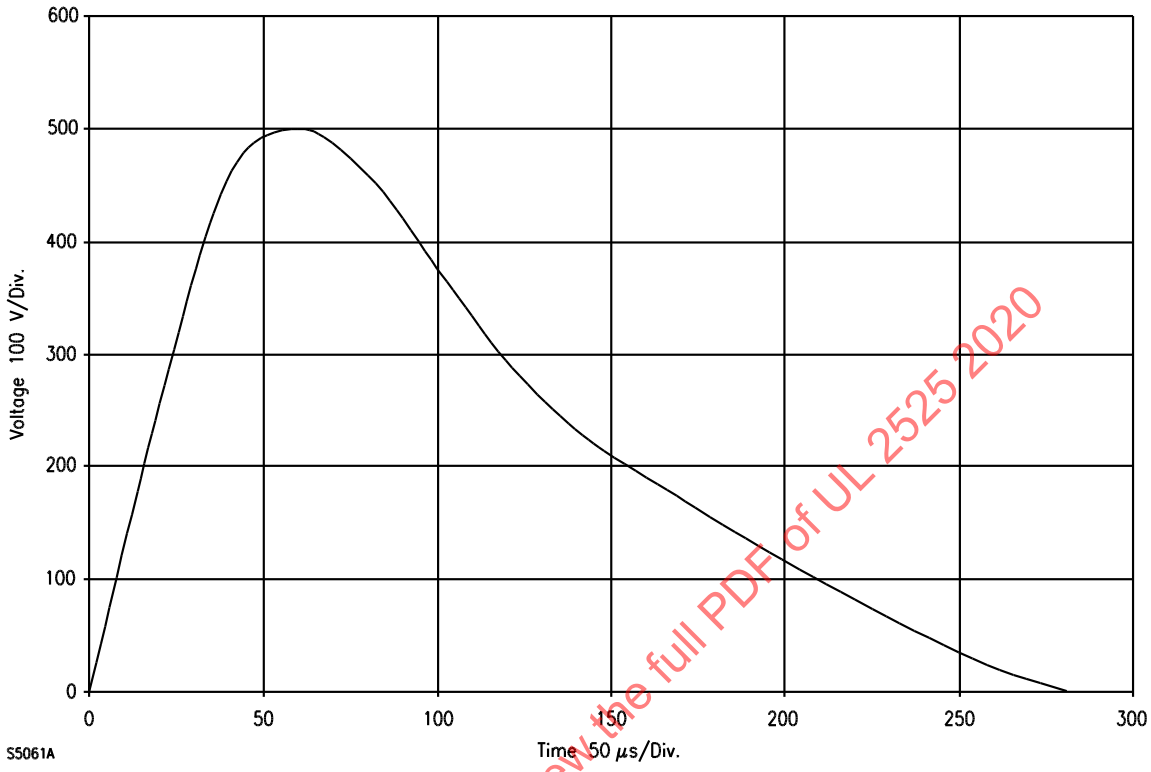


Figure 51.4

Signal line transients – 100V curve

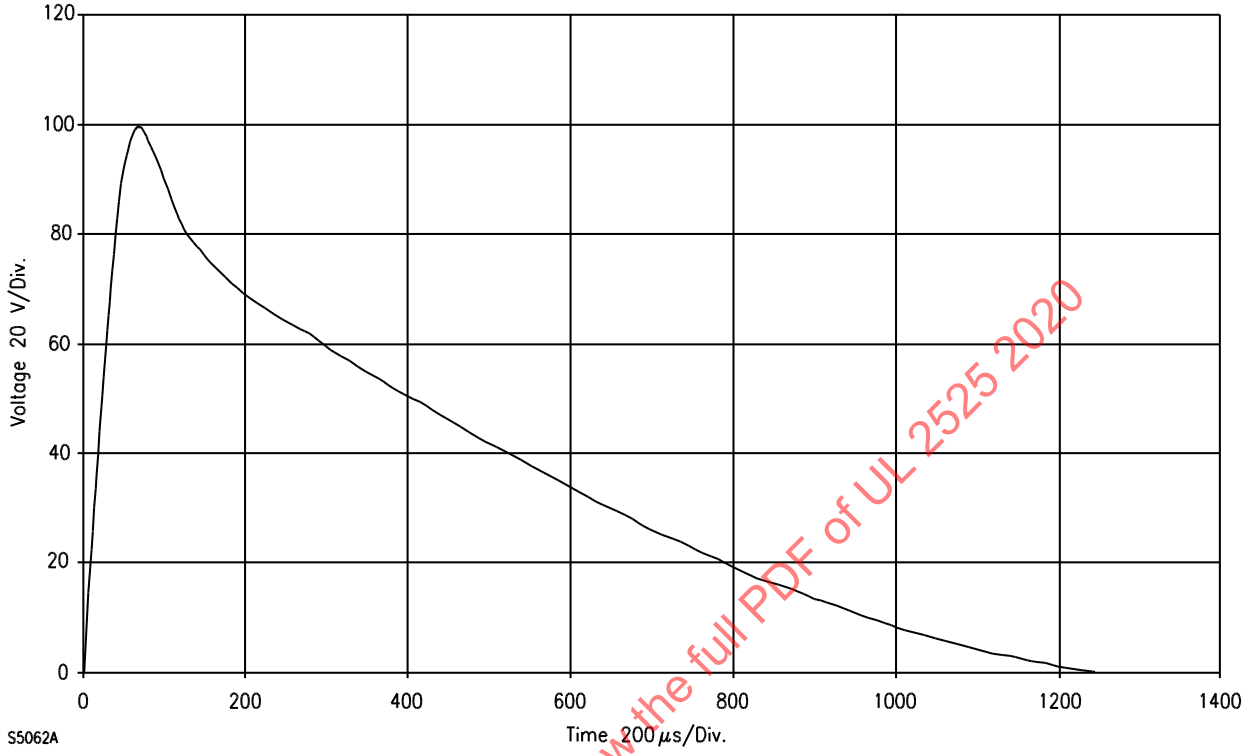


Figure 51.5

Minimum transient pulse duration vs. transient peak voltage

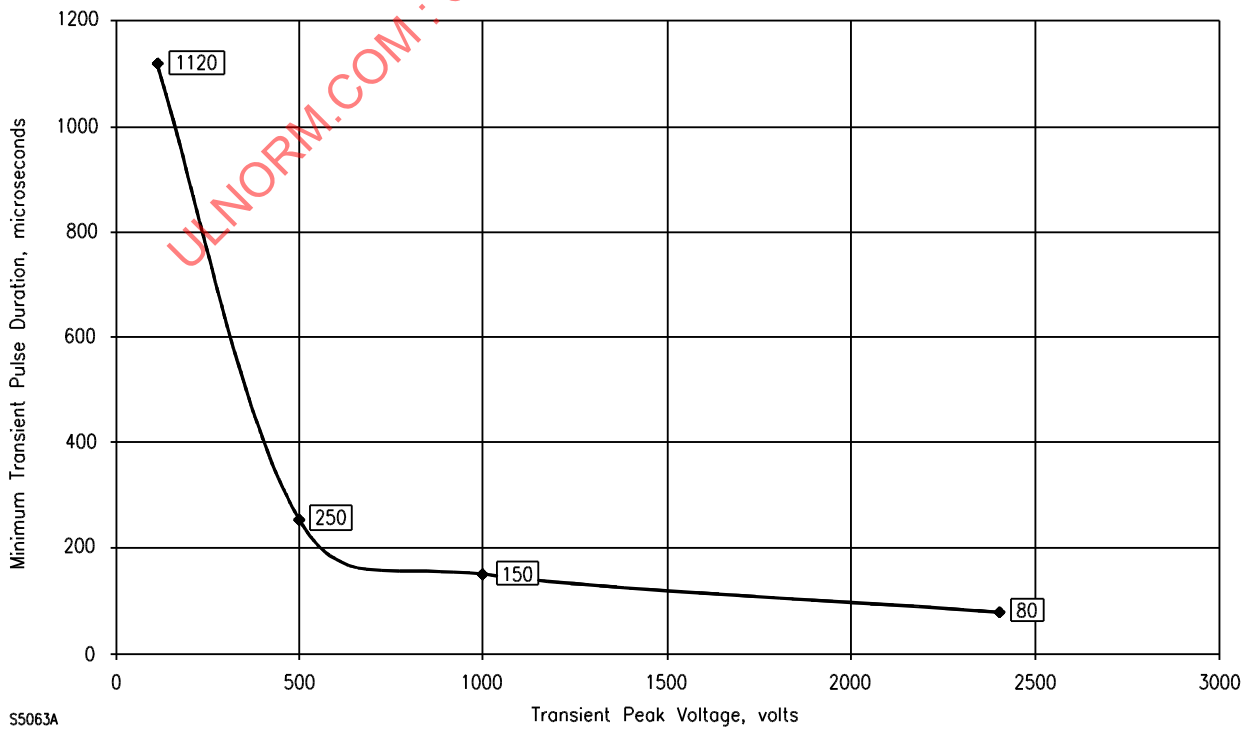


Figure 51.6

Minimum transient energy level vs. transient peak voltage

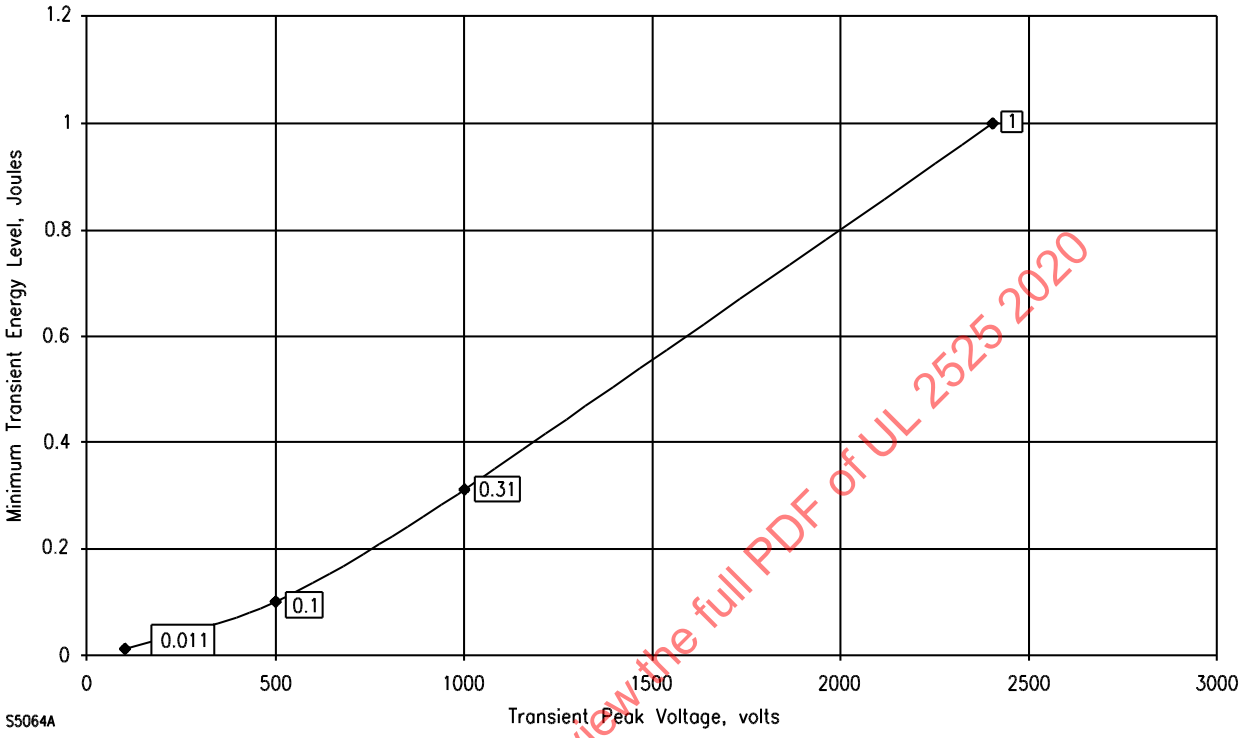
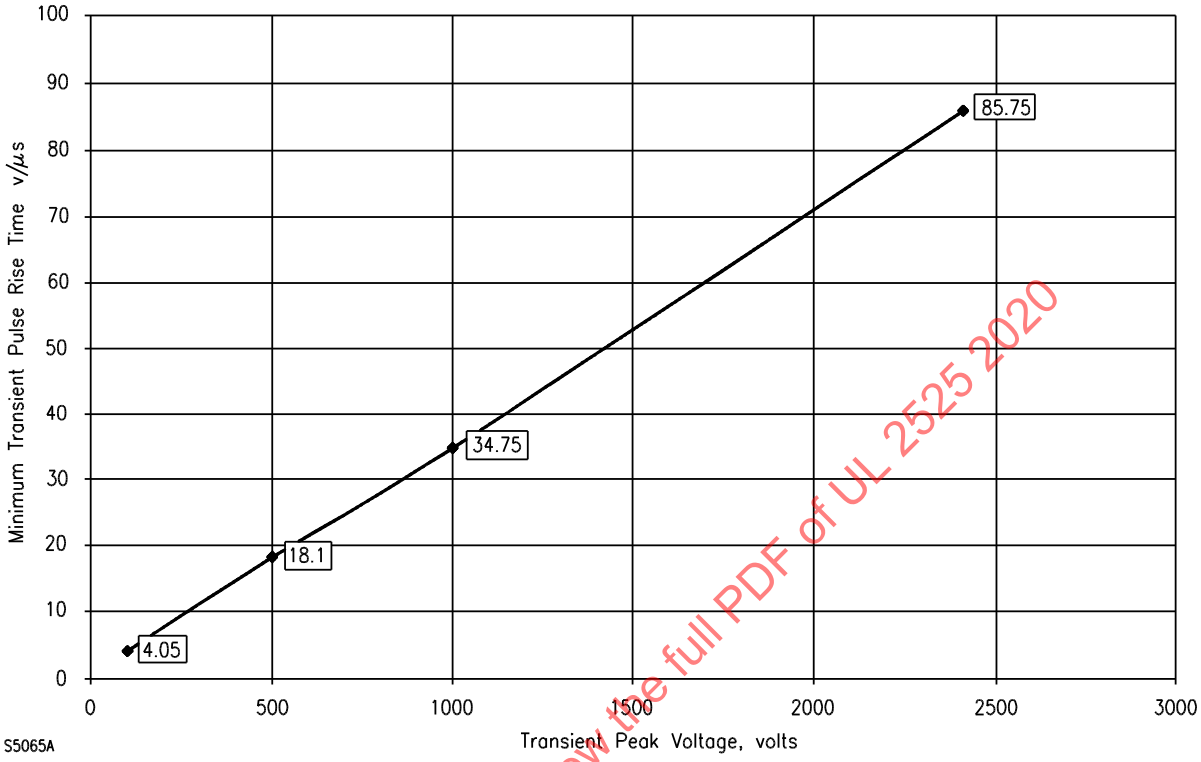


Figure 51.7

Minimum transient pulse rise time vs. transient peak voltage



51.4.3 Each conductor of a circuit is to be subjected to 40 transient pulses induced at the rate of six pulses per min as follows:

a) Twenty pulses (four at the 2400 peak voltage level and two at each of the other transient voltage levels specified in 51.4.2) 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 51.4.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten pulses of the opposite polarity.

52 Audio Performance

52.1 General

52.1.1 Each system shall be tested to verify audio performance for audio paths between:

a) Remote Communications Stations to Master Control Unit.

b) Master Control Unit to Remote Communications Station.

52.1.2 The system shall be configured and loaded to provide rated output conditions, as specified by the manufacture, such that the minimum required output sound pressure, as required by 52.2 is achieved.

52.1.3 The equipment under test shall be configured with worst case impedance and equipment loading of the system.

52.1.4 The audio performance tests requirements utilize acoustic testing which include speakers and microphones (as provided) in the audio paths, and include:

a) Sound Output;

b) Frequency Response;

c) Total Harmonic Distortion (THD+N).

52.1.5 Acoustic test signal shall utilize pink noise, or discrete or sweeping sine waves as required by specific tests in 52.2 – 52.4.

52.1.6 Acoustic test signals shall be applied to the equipment under test as stipulated by 52.1.7 – 52.1.11.

52.1.7 Test conditions shall meet the following requirements:

a) Ambient noise in the environment used to induce acoustic test signals shall not exceed 40 dB (A) SPL in an anechoic chamber or semi-anechoic location.

b) The environment used to measure acoustic test signals shall utilize an anechoic chamber.

c) Where devices under test have adjustable volume, the volume shall be set to the optimal level as provided by the manufacture (rated volume levels) such that the minimum required sound output levels are obtained.

d) During acoustic tests, Master Control Units and Remote Communication Stations shall be acoustically isolated from each other.

e) The device under test (DUT) is to be mounted or placed (as appropriate) in its intended position on a rigid plywood surface, no less then 20cm larger than the DUT, and placed in an anechoic or semi-anechoic room.

f) Handsets shall be in a fixed position and tightly coupled to an artificial ear or artificial mouth as appropriate.

g) A minimum of 3 sound pressure levels shall be integrated (averaged) over a minimum 30-second period.

52.1.8 For Master Control Units that employ a handset an ear simulator shall be used to acoustically couple signals the earpiece of the handset under test to the test equipment

NOTE: An example of a suitable ear simulator is Bruel and Kjaer model 4185.

52.1.9 For speakers used for hands free listening at the Master Control Units and Remote Communications Stations a microphone shall be used to monitor the audio from the unit under test. The microphone shall be mounted on axis to the speaker.

52.1.10 A mouth simulator shall be used to acoustically couple test signals to the microphone of the following devices to the test equipment:

a) Coupled directly to a Master Control Unit handset.

b) 10 cm from hands-free microphone the Master Control Unit.

c) 10 cm hands-free microphone of Remote Communications Station.

NOTE: An example of a suitable mouth simulator is Bruel and Kjaer model 4227.

52.1.11 Acoustic test signals shall utilize a sound pressure level from the mouth simulator calibrated as follows:

a) Using pink noise, on the axis of the mouth simulator 25 mm away from the protection grid of the mouth simulator.

b) The axis of the microphone for calibration shall be oriented 90 degrees to the mouth simulator axis.

c) The sound pressure level from the mouth simulator shall be adjusted to an output of 96.3 dB SPL A Weighting.

52.2 Rated Sound Output

52.2.1 Both Master Control Units and Remote Communications Stations shall be capable of producing a minimum of 70db (A) SPL, at rated volume levels, utilizing an acoustic pink noise test signal under the following conditions:

a) At the simulated Ear for Master Control Units with a handset.

b) At a distance of 1 meter on axis from the speaker for all hands-free units.

52.3 Frequency Response

52.3.1 Both Master Control Units and Remote Communications Stations shall be capable of maintaining frequency response, within the limits provided by Figure 52.1 utilizing an acoustic sine wave test signal, under the following conditions:

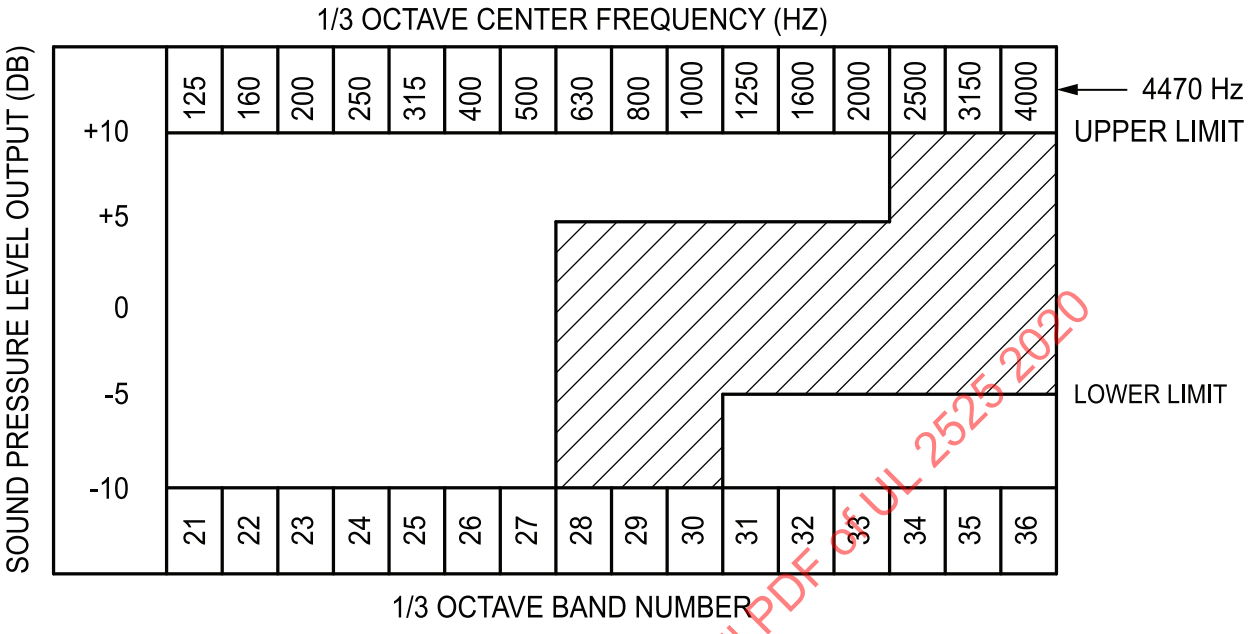
a) Delivering the rated sound output of the system, with volume controls established in 52.2.

b) At the simulated Ear for Master Control Units with a handset.

c) At a distance of 1 meter on axis from the speaker for all hands-free units.

Figure 52.1

Frequency Response and Output Sound Pressure Level



su0998

52.3.2 In determining acceptability, the zero-decibel reference line may be shifted vertically to determine whether the one-third octave response of the system will fit between the upper and lower limits shown in Figure 52.1.

52.4 Total Harmonic Distortion

52.4.1 Both Master Control Units and Remote Communications Stations shall not shall not exceed 20 percent total harmonic distortion in the frequency range of 400 – 4000 Hz under the following conditions:

a) Utilizing acoustic sine wave test signals at 400, 800, 1000, 1250, 1600, 2000, 2500, 3150, and 4000 Hz.

Note: when testing digital devices, or devices which have any internal digital processing, some of these frequencies should be adjusted up to ±1% so they do not coincide with the sampling frequency, typically 8000 Hz, or submultiples thereof. An example would be to use a frequency between 990 and 1010 Hz instead of 1000 Hz to avoid measuring specific distortion peak values.

b) Delivering the rated sound output of the system, with volume controls established in 52.2.

c) At the simulated Ear for Master Control Units with a handset.

d) At a distance of 1 meter on axis from the speaker for all hands-free units.

53 Ignition Test Through Bottom-Panel Openings

53.1 The bottom-panel constructions described in 6.9.1 – 6.9.3 are permitted without testing. Other constructions can be used when they comply with the test described in 53.2 – 53.5.

53.2 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.

53.3 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 in on a side has 32 threads in one direction and 28 in the other or square 1 cm 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 in (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.

53.4 A small metal ladle not more than 2-1/2 in (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°, 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 min and then is to be poured at the approximate rate of, but not less than 0.034 ounces (1 cm3/s or 1 mL/s) in a steady stream onto the center of the pattern of openings from a position 4 in (100 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

53.5 Five min 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 min later, a third identical pouring is to be made. The openings do not comply with the requirement in 53.1 if the cheesecloth is ignited during any of the three pourings.

54 Dielectric Voltage-Withstand Test

54.1 A product shall withstand for 1 min without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 Hz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead-metal parts (see 54.2), and between live parts of circuits operating at different potentials or frequencies (see 54.3). The test potential is to be:

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

b) For circuits rated greater than 30 and equal to or less than 150 V AC rms (42.4 and 212 V DC) – 1000 V AC (1414 V, when a DC potential is used);

c) For circuits rated more than 150 V AC rms (212 V DC) – 1000 V AC plus twice the rated voltage (1414 V plus 2.828 times the rated AC rms voltage, when a DC potential is used).

See 54.4 – 54.6.

54.2 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.

54.3 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 54.1 (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.

54.4 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 54.1.

54.5 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% 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 s; and then

b) Maintained at the test potential for 1 min without an indication of a breakdown.

Manual or automatic control of the rate of rise is not prohibited.

54.6 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.

55 Abnormal Operation Tests

55.1 General

55.1.1 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.

55.1.2 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.

55.1.3 During the tests, a single layer of bleached cheesecloth, fabricated at 14 – 15 yd^2 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 30.1.3 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 amp, whichever is less. Only one abnormal condition is to be simulated at a time.

55.1.4 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 fuseholder(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 67.1.25 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".

55.1.5 All abnormal conditions are to be continued until ultimate results are obtained, such as burnout or stabilization of temperatures.

55.1.6 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 54, within 1 min of the conclusion of the test, or

2) The Leakage Current Test, Section 49, when it is not practical to conduct the dielectric voltage-withstand test due to numerous components electrically connected to the product chassis or ground.

55.2 Operation

55.2.1 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.

55.3 Field-wiring circuits

55.3.1 Each output circuit of the product to which field wiring is intended to be connected is to be individually opened or shorted.

55.3.2 The test condition in 55.3.1 shall be applied one at a time. The abnormal condition shall be introduced while the equipment is operating in any condition of normal use.

55.4 Electronic components

55.4.1 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 ohm 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 ohm 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 43.1 or Table 43.2; 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.

55.4.2 The faults referenced in 55.4.1 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.

55.4.3 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.

55.4.4 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.

55.4.5 The test of 55.4.2 is to be continued for 1 hr 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 hr, 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 hr).

55.4.6 Immediately following each fault described in 55.4.3, within one min of the conclusion of the test, the product shall be subjected to the Dielectric Voltage-Withstand Test, Section 54.

55.5 Cooling fans and blowers

55.5.1 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.

55.5.2 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) Nonresettable thermal elements that are integral with fan or motor windings;

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