UL 1480A

STANDARD FOR SAFETY

Speakers for Commercial and Professional Use

UL Standard for Safety for Speakers for Commercial and Professional Use, UL 1480A

First Edition, Dated February 3, 2016

Summary of Topics

This revision of ANSI/UL 1480A dated March 24, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated January 8, 2021.

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UL 1480A

Standard for Speakers for Commercial and Professional Use

Prior to this first edition, the requirements for the products covered by this standard were included in the Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use, UL 1480.

First Edition

February 3, 2016

This ANSI/UL Standard for Safety consists of the First Edition including revisions through March 24, 2021.

The most recent designation of ANSI/UL 1480A as a Reaffirmed American National Standard (ANS) occurred on March 24, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover speakers for indoor and/or outdoor use in dry, damp, wet, or underwater locations and are intended for one or more of the following:

a) Commercial and professional audio systems providing non-emergency sound reinforcement and reproduction in accordance with the National Electrical Code, NFPA 70 (this includes equipment for institutional, industrial use);

b) Non-fire emergency voice-warning systems in accordance with NFPA 70; examples of non-fire emergency-warning systems include, but are not limited to:

1) Critical process monitoring (nuclear plant, oil refinery, hazardous chemical processing);

2) Distress alert systems (help for handicapped, for life safety, for rape, for robbery);

3) Crowd control in public places (sporting arena, theater, shopping mall, transportation center); and

4) Non-fire emergency voice-systems covered by the Life Safety Code, NFPA 101.

c) Underwater speakers in accordance with Article 680 of NFPA 70. An underwater speaker is not to be used in a fire alarm system or as an emergency (non-fire) voice-warning system.

1.2 These requirements do not cover the following:

a) Speakers intended for use in hazardous locations as defined in the National Electrical Code, NFPA 70; this includes speakers tested with the requirements in the Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment For Use In Hazardous (Classified) Locations, UL 1203;

b) Speakers intended for personal or private consumer use; this includes speakers for household/domestic use covered by the requirements in the Standard for Audio-Video Products and Accessories, UL 1492 and the Standard for Audio/Video and Musical Instrument Apparatus for Household, Commercial, and Similar General Use, UL 6500;

c) Speakers which are intended for commercial or professional audio applications and which employ integral active electronics; these products are covered in the Standard for Commercial Audio Equipment, UL 813; the Standard for Professional Video and Audio Equipment, UL 1419; and the commercial audio amplifier applications covered in UL 6500; and

d) Speakers intended for security applications; these products are covered in the Standard for Local Burglar Alarm Units and Systems, UL 609; and the Standard for Household Burglar-Alarm System Units, UL 1023.

1.3 Speakers intended for use with fire alarm systems are covered by Standard for Speakers for Fire Alarm and Signaling Systems, Including Accessories, UL 1480. Speakers with integral amplifiers must comply with the requirements in UL 1480 and the Standard for Amplifiers for Fire Protective Signaling Systems, UL 1711.

1.4 Speakers intended for use with emergency and non-emergency systems and having integral amplifiers must comply with this standard in addition to the requirements in the Standard for General-Purpose Signaling Devices and Systems, UL 2017.

1.5 Speakers intended for use in air-handling spaces in accordance with Installation of Air Conditioning and Ventilating Systems, NFPA 90A, shall comply with the requirements in this standard and 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.

2 General

2.1 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

2.2.1 Unless otherwise indicated, all voltage and current values mentioned in this standard are rms.

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

3.2 AUDIO CIRCUITS (HIGH-VOLTAGE) – Commercial or professional speakers for connection in accordance with Article 640 of the National Electrical Code, ANSI/NFPA 70, that are used for music or voice communication and are rated more than 120 volts.

3.3 AUDIO CIRCUITS (LOW-VOLTAGE) – Commercial or professional speakers for connection in accordance with Article 640 of the National Electrical Code, ANSI/NFPA 70, that are used for music or voice communication and are rated 120 volts or less.

3.4 BI-AMPLIFIED SYSTEMS – Systems that employ two or more speakers that are cross-overed before the amplifier with separate amplifiers powering the low and high frequency transducers.

3.5 CHEESECLOTH INDICATORS – Cheesecloth used for tests shall be untreated cotton cloth running 14 – 15 square yards per pound (26 – 28 square meters per kilogram) and having what is known in the trade as a "count of 32 by 28".

3.6 CRITICAL COMPONENT – With regard to the risk of fire and electric shock, a critical component is a part that:

a) Encloses a high-voltage part(s);

b) Is capable of coming into contact with a source of ignition;

c) Supports a live part; or

d) Is capable of coming into contact with a live part.

3.7 DISTRIBUTED AUDIO SYSTEMS – Distributed audio systems, also referred to as constant voltage systems, provide a constant voltage from the amplifier to the speaker and usually have long wire runs between the amplifier and the speakers. Typical distributed audio voltages are 25, 70, or 100 volts.

3.8 ELECTRICAL CIRCUIT (HIGH-VOLTAGE) – A circuit other than audio involving a potential of not more than 300 volts and having circuit characteristics in excess of those of a low-voltage circuit.

3.9 ELECTRICAL CIRCUIT (LIVE PART) – A conductive part of a circuit carrying (or having the potential to carry) voltage, power, or current of sufficient magnitude to present a risk of fire or electric shock.

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

3.11 FIELD-WIRING LEADS – Leads to which electrical connections are made in the field.

3.12 FIELD-WIRING TERMINALS – Terminals to which electrical connections are made in the field.

3.13 INSTALLATION LOCATIONS:

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

b) Damp – A location protected from sun, rain, and water, but subject to moisture (such as basements, barns, cold-storage warehouses, greenhouses, indoor swimming facilities, and similar locations); may also include partially protected locations under canopies, marquees, roofed open porches, and similar spaces.

c) Wet – A location subject to rain and the spray of non-corrosive and non-flammable liquids that may become saturated with water or that is unprotected from the weather.

d) Underwater – A location such as a swimming pool or diving tank.

3.14 NON-DISTRIBUTED AUDIO (LOW IMPEDANCE) SYSTEMS – Non-distributed audio systems are low impedance systems with short wire runs between the amplifier and the speaker. Typical impedance for these systems are 4, 8, or 16 ohms.

3.15 PINK NOISE – Broadband noise whose energy content is inversely proportional to frequency.

3.16 PRODUCT – Any type of speaker covered by the Scope of these requirements.

3.17 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist within a circuit unless that circuit meets one of the following criteria:

a) The circuit is supplied by an isolating source, such that the maximum open-circuit voltage potential available to the circuit is 30 V AC rms, 42.4 V DC, or 42.4 V peak or less;

b) The circuit is supplied by an isolating source such that the current available through a 1500-ohm resistor connected across any potential in the circuit (including to ground) is 5 milliamperes or less; or

c) The circuit is supplied by a low-voltage source such as the audio circuit described in 3.3.

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

a) The circuit is supplied by a power source such that the maximum open-circuit voltage potential available to the circuit is 30V AC or 42.4 V peak or more and

b) The power available to the circuit is 15 watts or greater.

3.19 SPEAKER ASSEMBLY – Includes one or more speaker transducers, a mounting frame or enclosure, a means for field connection, and any electrical components.

3.20 SPEAKER TRANSDUCER – The component within in a speaker assembly which converts the electrical signal into an acoustical signal.

3.21 TISSUE PAPER – Used as a flame indicator. Undyed, lightweight tissue paper weighing between 12 and 30 g/m^2.

3.22 UNDERWATER SPEAKERS:

a) Dry-niche – A dry-niche underwater speaker as covered by these requirements is one intended to be permanently mounted and sealed in the wall of the swimming pool or diving tank. It is equipped with provisions for conduit connection, and is designed to be serviced from the rear in a passageway or tunnel behind the wall of the pool or tank.

b) No-niche – A no-niche underwater speaker as covered by these requirements is intended to be securely held or suspended within the pool or diving tank. It is to be provided with a flexible cord of a sufficient length to permit the underwater speaker to be removed and lifted to the deck of the pool or tank for servicing.

c) Wet-niche – A wet-niche underwater speaker as covered by these requirements is one intended for installation in or on the wall of a swimming pool or diving tank where the underwater speaker will be surrounded by water. The underwater speaker is supplied by a flexible cord of sufficient length to permit the underwater speaker to be removed from the niche and lifted to the deck of the pool or tank for servicing.

3.23 VANDAL-RESISTANT – A speaker enclosure constructed so that the sounder cannot be compromised. See 6.2.6.

4 Instructions and Drawings

4.1 Each product shall be provided with installation instructions and drawings that shall include the following information:

a) Typical representative installation wiring diagram for the product indicating recommended wiring methods. The recommended methods shall be in accordance with the applicable section of the National Electrical Code, ANSI/NFPA 70, as applicable. The wiring method and compartment shall be such as not to interfere with the operation of the speaker.

b) Identification of replacement parts (such as fuses) by a part number, manufacturer's model number, ratings, or the equivalent if intended to be replaced.

4.2 The instructions are not prohibited from being incorporated on a visible interior or exterior surface of the product, on a separate sheet, or as part of a manual. When not included directly on the product, the instructions or manual shall be referenced in the marking information on the product, which shall include an issue date, number, or the equivalent.

CONSTRUCTION

ASSEMBLY

5 General

5.1 The construction of a speaker shall comply with the construction requirements contained in Sections 5 – 20 unless, where permitted by test, the construction is determined to be equivalent. A means of determining construction equivalence shall comply with the requirements in Recommended Loudspeaker Safety Practices, CEA-CEB19.

5.2 Unless specifically indicated otherwise, the construction requirements specified for a product also apply to any remote accessories with which it is to be employed.

5.3 If provision is made for testing the operability of a product, the means provided shall not involve a risk of electric shock or injury to persons.

5.4 A test means shall be constructed and located so as to reduce the risk of tampering by unauthorized personnel.

6 Enclosures

6.1 General

6.1.1 The frame and enclosure of a product shall have the strength and rigidity to resist total or partial collapse with attendant reduction of spacings, loosening or displacement of parts, and development of other conditions that could impair operation of the product and result in a risk of fire, electric shock, or injury to persons.

6.1.2 Uninsulated high-voltage electrical parts or hazardous moving parts of a product shall be located or enclosed to provide protection from unintentional contact by persons.

6.1.3 The mounting means of an enclosure shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

6.1.4 An attachment point provided for mounting of the speaker system shall be of sufficient strength for mounting as outlined in the installation instructions. See the mounting/handle securement test in Mechanical Strength Tests, Section 24.

6.1.5 An enclosure intended for outdoor use, or for use in wet locations, shall be provided with external means for mounting.

Exception: Internal means for mounting are not prohibited from being used when constructed to prevent water from entering the enclosure.

6.1.6 When knockouts or unthreaded holes are provided for use with conduit, there shall be provision for drainage of the enclosure when the hole is located above the lowest terminal lug or live part within the enclosure, unless:

a) The installation instructions specify the use of watertight cable, conduit, or EMT fittings for installation in outdoor or wet locations and

b) The unused knockouts and/or unthreaded holes are sealed to resist the entrance of water.

6.1.7 A gasket used as an environmental seal shall consist of material that is suitable for its application (see Gasket Testing, Section 32). A gasket that will be disturbed during routine servicing as described in the installation instructions shall be cemented, pinned, or otherwise secured to one of the contacting surfaces.

6.1.8 An underwater speaker shall be mounted in a metal forming shell. The shell shall have a metal screen or grill that is electrically bonded to the forming shell by a positive locking device that requires a tool for removal.

6.2 Openings

6.2.1 Openings in enclosures intended for outdoor use, or for use in damp or wet environments, are only permitted when the internal components are protected from the accumulation of moisture that may degrade the integrity or protection of the enclosure.

6.2.2 An opening in the top of the enclosure shall be constructed and sized to reduce the risk of entry of a foreign object and contact by persons with uninsulated high-voltage live or moving parts. An opening directly over an uninsulated live part shall be less than 0.187 inches (4.75 mm) in any dimension unless the configuration of the opening prevents direct entry to uninsulated high-voltage live parts. To determine accessibility of parts, the probe illustrated in Figure 6.1 shall be used. See Figure 6.2 for examples of acceptable top cover openings.

Figure 6.1

Articulate probe with web stop

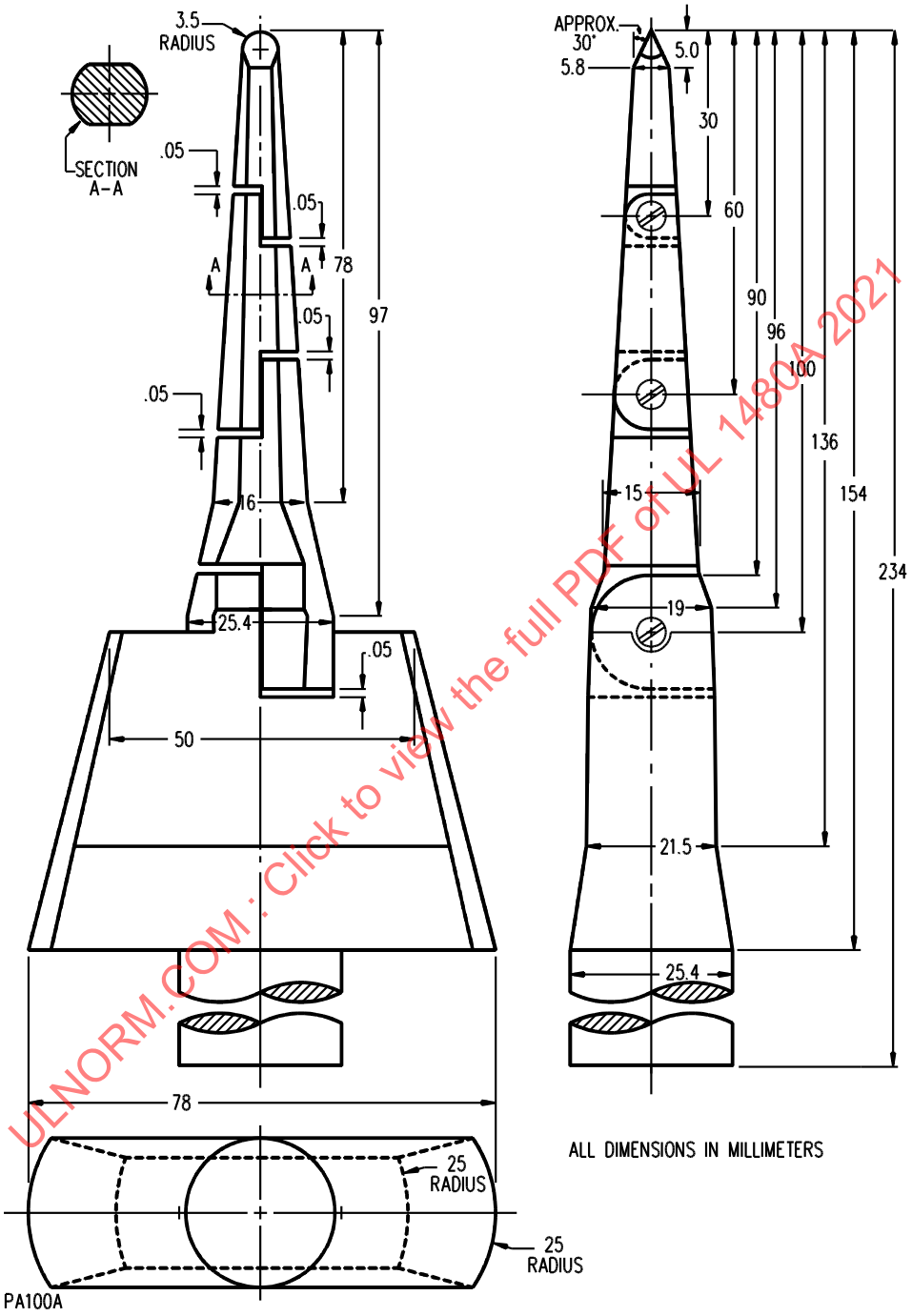
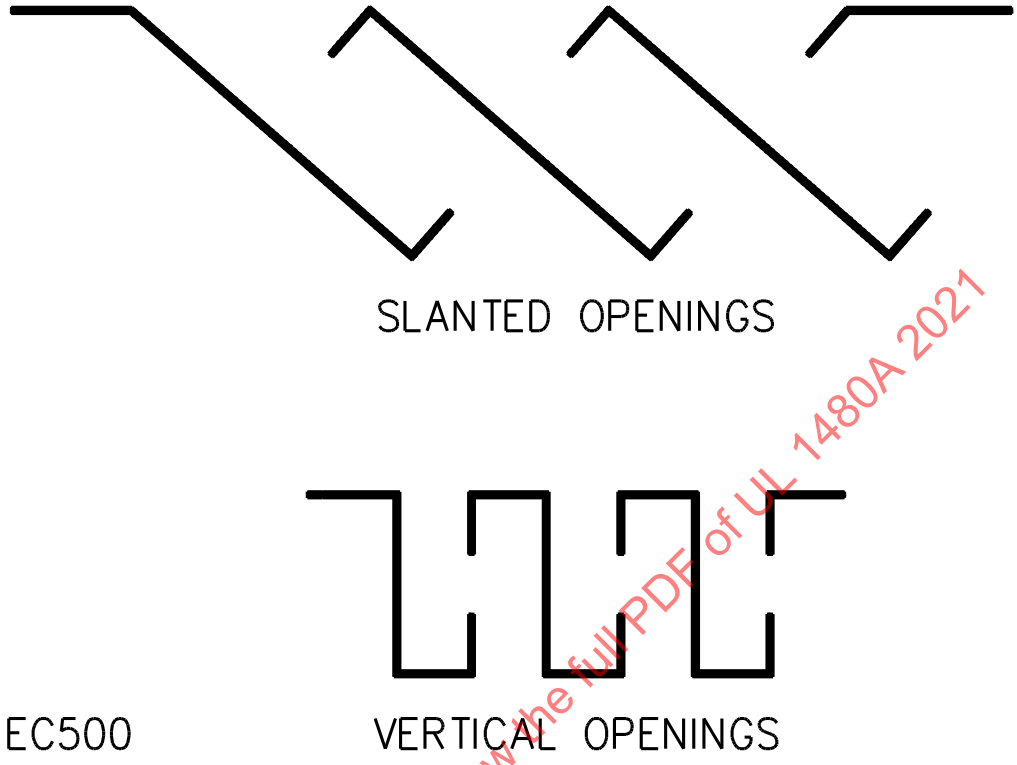


Figure 6.2

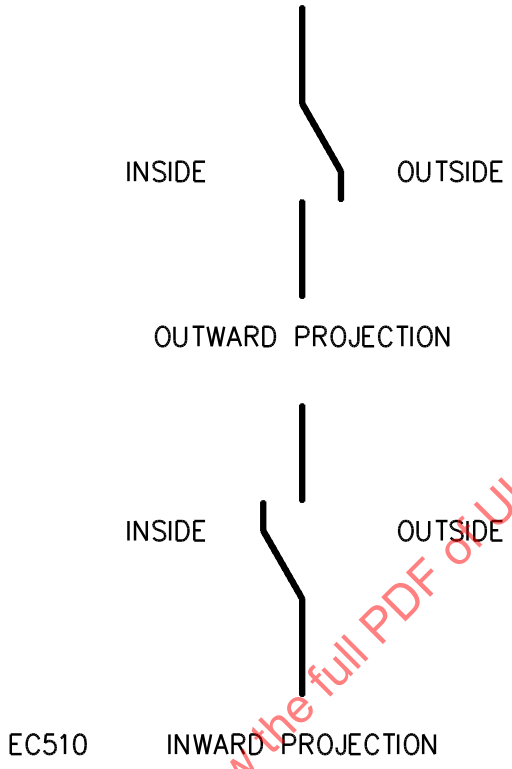
Cross-sections of top cover openings



6.2.3 An opening in the side of the enclosure shall be located and sized to reduce the risk of entry of a foreign object and contact by persons with internal parts. A louver is not prohibited from being used when shaped to deflect external falling objects outward. See Figure 6.3 for examples of acceptable louver constructions.

Figure 6.3

Cross-sections of side louvers



6.2.4 An opening in the enclosure of a fire or emergency warning speaker shall prevent access to a relay, terminal, control, or related component that is capable of affecting the performance or safety of the product.

6.2.5 A speaker assembly intended for mounting through a wall surface into a concealed space of a building structure such as a hollow space in the wall shall have no openings that vent into the concealed space when the product is mounted as intended. The speaker assembly is permitted to be mounted in an enclosure to prevent venting into the concealed space. The front panel mounting surface is required to be gasketed to insure that venting has been prevented only when the front panel mounting surface is irregular.

Exception: This requirement does not apply to the following:

a) Openings which must be used for product mounting or for manufacturing operations (such as paint drainage or bend relief);

b) Openings which are effectively sealed unless used (such as knock-outs and flashed-over molded holes in plastic assemblies); and

c) Openings which may be used for product mounting or other purposes (such as cable entry) which do not exceed the area limitations of Table 6.1.

Table 6.1
Speaker assembly or enclosure openings

Maximum linear dimension of enclosure,		Area of largest surface of enclosure,		Maximum number of openings	Maximum total area of openings,	
inches	(cm)	square inches	(cm^2)		square inches	(cm^2)
7	17.8	32	206	4	1.2	7.7
18	45.7	135	870	6	1.2	7.7
40	102.0	1000	2540	6	1.5	9.7
Over 40	102.0+	Over 1000	2540+	8	2.0	12.9

6.2.6 A vandal resistant speaker shall restrict direct access to the sound producing element by a rigid rod 0.8 mm (0.031 inch) in diameter. The grill covering the acoustical opening shall withstand the force indicated in the speaker grill test, 24.4. All exterior exposed covers and grills shall be secured with tamper resistant hardware that prevents removal by common tools such as a screwdriver, pliers, or an Allen wrench.

6.3 Cast metal

6.3.1 The thickness of cast metal for an enclosure shall be at least the applicable value specified in Table 6.2.

Table 6.2
Cast-metal electrical enclosures

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

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

6.3.2 When threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall be not less than 3-1/2 nor more than five threads in the metal, and the construction shall permit a standard conduit bushing to be attached as intended.

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

6.3.4 A product intended to be supported by rigid conduit shall be provided with conduit hubs, or the equivalent, having not less than five full threads.

6.4 Sheet metal

6.4.1 The thickness of sheet metal employed for the enclosure of a product shall be at least the minimum applicable value specified in Table 6.3 or Table 6.4.

Exception: Sheet metal of lesser thickness is not prohibited from being employed when, considering the shape, size, and function of the enclosure, it provides equivalent mechanical strength to an enclosure of the applicable thickness specified in the tables.

Table 6.3
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

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

[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 that may be applied via the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frames include:

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

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

3) An enclosure surface loosely attached to a frame, such as by spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece that 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 that 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 continuous flange at least 1/2 inch (12.7 mm) wide.

Table 6.4
Minimum thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches	(mm)
3.0	7.6	Not limited		7.0	17.8	Not limited			
3.5	8.9	4.0	10.2	8.5	21.6	9.5	24.1	0.023	0.58
4.0	10.2	Not limited		10.0	25.4	Not limited			
5.0	12.7	6.0	15.2	10.5	26.7	13.5	34.3	0.029	0.74
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] See note a in Table 6.3.
[b] See note b in Table 6.3.
[c] See note c in Table 6.3.

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

6.4.3 A knockout in a sheet metal enclosure shall be reliably secured, but the removal of the knockout shall not result in undue deformation of the enclosure.

6.4.4 A knockout shall be provided with a surrounding surface area of sufficient size to permit seating of a conduit bushing, and shall be located so that a bushing employed at any knockout likely to be used during installation will not reduce spacings between uninsulated live parts and the bushing to values less than those specified in Spacings, Section 18.

6.4.5 A sheet metal member to which a metal-enclosed wiring system is to be connected in the field shall not be less than:

a) 0.032 inch (0.81 mm) thick when of steel and

b) 0.045 inch (1.14 mm) thick when of nonferrous metal.

6.5 Nonmetallic

6.5.1 An enclosure or part of an enclosure of nonmetallic material shall have sufficient mechanical strength and durability and shall be formed so that operating parts will be protected against damage. The

mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 6.2.

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

a) Flammability;

b) Mechanical strength;

c) Resistance to impact;

d) Dielectric strength and insulation resistance; and

e) Resistance to distortion at temperatures to which the material will be subjected under conditions of anticipated use.

All these factors are considered with regard to aging. See Polymeric Materials, Section 17.

6.5.3 A wooden enclosure shall be solid or laminated wood at least 3/8 inch (9.5 mm) thick and be spaced at least 1/2 inch (12.7 mm) from live or arcing parts and potential sources of ignition.

FIELD WIRING CONNECTIONS

7 General

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

8 Field-Wiring Compartments

8.1 A field-wiring compartment to which connections are to be made shall be of sufficient size for completing all wiring connections specified by the installation wiring diagram.

8.2 The wiring of a product intended for mounting in or on 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 that can damage the conductor insulation.

8.3 An outlet box or compartment of a fire or emergency warning speaker in which field-wiring connections are to be made shall be located such that the connections may be inspected after the product is installed as intended. The removal of mounting screws, or equivalent arrangement, to view the field-wiring connections is acceptable.

8.4 A forming shell for an underwater speaker shall be provided with the means of connection to rigid metal conduit, intermediate metal conduit or rigid nonmetallic conduit. Where rigid nonmetallic conduit is used, the installation instructions shall instruct that an 8 AWG insulated copper conductor shall be installed in the conduit with provisions for termination in the forming shell and the outlet box.

9 Field-Wiring Terminals and Connectors

9.1 A field-wiring terminal shall be constructed to prevent the turning or shifting of connections. Friction between surfaces is not to be used to prevent movement of the terminal.

9.2 A field-wiring terminal shall be of sufficient size for completing all field-wiring connections as specified in the installation instructions. The terminal construction shall bind the field wiring to prevent reduction of spacings.

9.3 A wire-binding screw intended for field-wiring connections shall be a No. 8 (ASTM) or M4 (metric) or larger. The screw is not prohibited from being of plated steel.

Exception: A No. 6 or M3.5 screw is not prohibited from being used for the connection of one 14 AWG (2.1 mm^2) or smaller conductor, and a No. 4 or M3 screw is not prohibited from being used for the connection of an 18 AWG (0.65 mm^2) or smaller conductor.

9.4 A terminal plate tapped for wire-binding screws shall:

a) Have at least 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 are not prohibited from being used when they provide equivalent security of the wire-binding screw threads.

b) Be of a nonferrous metal not less than 0.050 inch (1.3 mm) thick for a No. 8 or M4 or larger screw, and not less than 0.030 inch (0.76 mm) thick for a No. 6 or M3.5 screw.

9.5 The following terminal configurations that comply with 9.4 are not prohibited from being employed on all circuits to which field-wiring connections are to be made:

a) Quick-Connect Terminals – Nonferrous (push-type) quick-connect terminals consisting of male posts permanently secured to the product and provided with compatible female connectors for connection to field wiring. Such terminals require a specific tool for crimping of field wires. Mating terminals shall be shipped with the product with instructions for their installation. Electrical supervision of the field wiring shall include the mating of the connector on a speaker intended for fire- or emergency-warning systems.

b) Push-In Terminals – Nonferrous push-in terminals (screwless) of the type employed on some switches and receptacles, wherein solid conductors are pushed into slots containing spring-type contacts. The leads can be removed by means of a tool inserted to relieve the spring tension on the conductor.

c) Other Terminals – Other terminal connections and materials are not prohibited from being used when determined to be equivalent to those specified in (a) or (b) and limited to the same restrictions.

9.6 A product employing a terminal of any of the configurations described in 9.5 shall comply with all of the following:

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

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size shall be as indicated in the applicable section of the National Electrical Code, NFPA 70.

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

10 Leads

10.1 A lead provided for field connection of a high-voltage speaker shall be at least 6 inches (152 mm) long, provided with strain relief, and 18 AWG (0.82 mm^2) or larger with insulation not less than 1/32 inches (0.8 mm) thick. A lead provided for field connection of a low-voltage speaker shall be at least 6 inches (152 mm) long, provided with strain relief, and no smaller than 22 AWG (0.32 mm^2) with insulation not less than 1/64 inches (0.4 mm) thick.

Exception: A lead is not prohibited from being less than 6 inches (152 mm) long when it is evident that the use of a longer lead is capable of resulting in damage to the insulation.

11 Grounding

11.1 For a product intended to be connected to a grounded circuit, one terminal or lead shall be identified for the connection of the grounded conductor.

11.2 A terminal intended for the connection of a grounding conductor shall be identified on the product and in the installation wiring diagram. A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly marked "G", "GR", "GROUND", "GROUNDING", or equivalent marking, or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be secured to the frame of the product and located so that it is unlikely to be removed during servicing of the product.

11.3 Acceptable means for equipment-grounding include the following:

a) For a product intended to be permanently connected by a metal-enclosed wiring system, a knockout (or equivalent opening) in the metal enclosure.

b) For a product intended to be connected by a nonmetal-enclosed wiring system (such as nonmetallic-sheathed cable or multiple-conductor cord), an equipment-grounding terminal or lead.

11.4 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. No other lead shall be so identified.

INTERNAL WIRING AND ASSEMBLY

12 General

12.1 Internal wiring shall have insulation rated for the potential temperature and environmental conditions to which it may be subjected during intended use of the product.

12.2 A lead or a cable assembly connected to a part mounted on a hinged cover shall be of sufficient length to permit the full opening of the cover without the lead or cable being pulled taught and applying stress to the lead or the connections. The lead shall be secured or equivalently arranged to reduce the risk of abrasion of the insulation and jamming of the leads between parts of the enclosure.

12.3 A wireway shall be smooth and free from sharp edges, burrs, fins, moving parts, and similar defects that may cause abrasion of conductor insulation.

12.4 A splice or connection shall have mechanical and electrical integrity.

12.5 A stranded conductor clamped under a wire-binding screw (or similar part) shall have the individual strands soldered together or equivalently arranged.

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

13 Separation of Circuits

13.1 Internal wiring of circuits that operate at different potentials shall be separated by barriers, clamps, or routing (or other equivalent means), unless all conductors are provided with insulation rated for the highest potential involved.

14 Bonding for Grounding

14.1 An exposed dead-metal part that could become energized by an internal high-voltage potential to earth ground shall be bonded to the point of connection of the product equipment-grounding terminal or lead, or to the metal surrounding the knockout, hole, or bushing provided for field-wiring connections.

14.2 A bonding means shall be an acceptable electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The bonding conductor shall be installed so that it is protected from mechanical damage.

14.3 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall penetrate nonconductive coatings such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material. The electrical continuity of the bonding system of a product shall not rely on the dimensional integrity of nonmetallic material.

14.4 A bolted or screwed connection that incorporates a star washer or serrations under the screwhead is not prohibited from being used to penetrate nonconductive coatings (as required by 14.3).

14.5 When the bonding means depends upon screw threads, either two or more screws or two full threads of a single screw engaging metal are acceptable.

14.6 A metal-to-metal hinge-bearing member for a door or cover is not prohibited from being used as a means for bonding the door or cover for grounding, when a multiple bearing-pin type (piano-type) hinge is employed.

Exception: A metal-to-metal hinge-bearing or slip joint is not prohibited from being used when the resistance between the two parts is not more than 0.1 ohm.

14.7 A bonding wire shall be a continuous wire without splices.

COMPONENTS

15 General

15.1 Mounting of components

15.1.1 A stationary part that supports a moving component shall be securely mounted in position and prevented from loosening or turning by means other than friction between surfaces.

15.1.2 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position, when such motion is capable of reducing spacings below the required minimum values. See Spacings, Section 18.

15.1.3 Friction between surfaces is not to be used as a means to prevent turning, loosening, or shifting of a part (as required by 15.1.1 and 15.1.2) however, a toothed lock washer that provides both spring take-up and an interference lock or equivalent means is not prohibited from being used.

15.2 Insulating materials

15.2.1 A base for the support of live parts shall be a combustion- and moisture-resistant insulating material. Among the factors to be considered in evaluating electrical insulation are:

a) Mechanical and electrical strength;

b) Resistance to burning, moisture, arcing, and creep (flow due to stress); and

c) Thermal endurance at temperatures encountered in intended use. See Polymeric Materials, Section 17.

15.2.2 An insulating material is not prohibited from being used for insulating bushings, washers, separators, and barriers, but not for the sole support of live parts when shrinkage, current leakage, or warping of the insulating material is capable of resulting in a risk of fire or electric shock.

15.2.3 A small conforming-shaped insulating cover, such as might be secured over an exposed electrical component, the omission of which may result in a risk of electric shock to the user or service personnel, shall be secured to the component so that it is not likely to be discarded during intended use; its removal shall be required only during servicing or replacement of the component it covers.

15.3 Bushings

15.3.1 A hole in a wall or partition through which insulated wires or flexible cords pass and on which they may bear shall have smooth, rounded surfaces to prevent abrasion of the insulation. When a bushing or grommet is employed in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and similar defects, if it is capable of cutting into the bushing or grommet.

15.3.2 An insulating grommet is not prohibited from being used in lieu of an insulating bushing, when the insulating material used is at least 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the material in which it is mounted.

15.4 Flammability

15.4.1 Critical components (other than electrical, see Figure 15.1) shall comply with the applicable flammability requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or the Standard for Tests for Flammability of Small Polymeric Component Materials, UL 1694 for the flame class specified in Table 15.1; or shall comply with the requirements in 15.4.3 – 15.4.9. Electrical components shall comply with the flammability requirements specified in Electrical Components, Section 16.

Figure 15.1
Flammability requirements

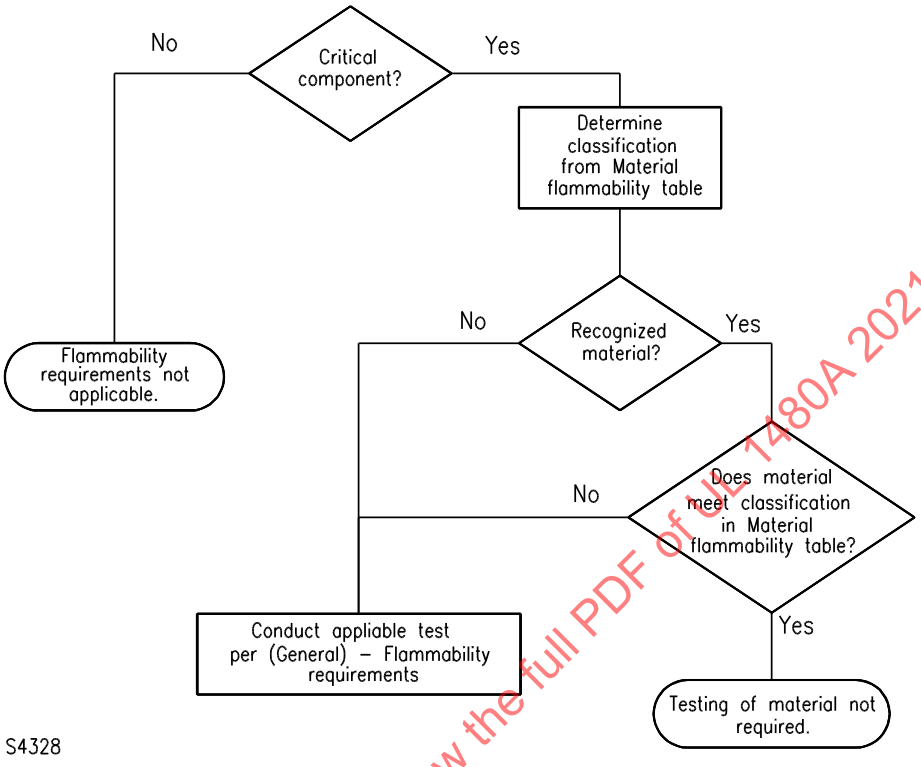


Table 15.1
Material flammability

Component	Flammability classification
Wood, metal, or non-critical component	None
Polymeric enclosure (high-voltage non-audio)	5VA
Polymeric enclosure (high-voltage audio)	V-0, 5VA
Polymeric enclosure (low-voltage non-audio and low-voltage audio greater than 15 W audio power)	V-0
Polymeric enclosure (low-voltage audio less than 15 W)	HB, V-1, V-0
Polymeric or fiber part in contact with a component located in a potential ignition source circuit	V-2, V-1, V-0, HF-2, HF-1, HF-0
Components with an overall volume less than 2500 mm^3 (0.15 in^3) and located in a potential ignition source circuit	SC-1, SC-0, SC-TC1, SC-TC0 (per the Standard for Tests for Flammability of Small Polymeric Component Materials, UL 1694)
Sound-deadening material used in speakers operating at or greater than 15 W audio power.	V-2, V-1, V-0, HF-2, HF-1, HF-0
Grille-covering material, cloth, and reticulated foam	Tablet test[a]

[a] A methenamine tablet (Lilly tablets No. 1588 are capable of being used for this purpose) comprised of hexamethylene-tetramine ($C_6H_{12}N_4$) having a weight of 0.15 ±0.02 grams, and having a controlled burning time of 105 ±5 seconds, is to be placed on the thinnest section of the component to be tested. The tablet is then to be ignited with a match. The tablet is to be permitted to burn until it is completely consumed and the part ceases to flame or glow. When the tablet burns through the part and falls to the surface below, the test is completed when the part ceases to flame or glow. Burning of the part shall be 5 cm or less from the center of the tablet.

15.4.2 The tablet test specified in note (a) to Table 15.1 is to be conducted on a speaker system oriented so that the material is tested in the horizontal position. A methenamine (Lilly) tablet is to be placed on top of the material to be tested, and the top of the tablet is then ignited with a match.

15.4.3 Materials used in critical components can be determined to be equivalent to the materials shown in Table 15.1 by testing the complete assembly with the requirements in 15.4.4 – 15.4.9.

15.4.4 A complete speaker assembly is to be placed on a single layer of tissue paper and a single layer of cheesecloth is to be draped over the assembly. Starting with the voice coil and working to each additional critical component, a flame is to be applied as follows:

a) A needle flame per the Standard for Tests for Flammability of Small Polymeric Component Materials, UL 1694, is to be applied to the outer perimeter of the lowest point of the voice coil or dust cap.

b) A UL 94 (Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances) or UL 1694 flame size per the flame classification of the component in Table 15.1, shall be applied to the area most likely to become ignited.

15.4.5 Prior to the application of the flames specified in 15.4.6 or 15.4.7, the sample is to be conditioned for 7 hours in a full-draft air-circulating oven at 158°F (70°C), followed by four hours at 73°F (23°C) both at 50 percent relative humidity.

15.4.6 Flammability classifications of 5VA shall be subjected to five applications of the test flame, with each application consisting of 5 seconds of the test flame in contact with the material and 5 seconds between each application. The test is considered to be completed after the fifth flame is removed and the material ceases to flame or glow. At the completion of the test, there shall be no ignition of the cheesecloth or tissue paper or visible flame extension outside of the enclosure.

15.4.7 Flammability classifications of V0 – HB shall be subjected to five applications of the test flame, with each application consisting of 30 seconds of the test flame in contact with the material and 60 seconds between each application. The test is considered to be completed after the fifth flame is removed and the material ceases to flame or glow. At the completion of the test, there shall be no ignition of the cheesecloth or tissue paper or visible flame extension outside of the enclosure, and there shall be no exposure of live components.

15.4.8 Flammability classifications of SC-1, SC-0, SC-TC1, and SC-TC0 shall be subjected to two applications of the test flame, with each application consisting of 5 seconds of the test flame in contact with the material and 60 seconds between each application. The test is considered to be completed after the second flame is removed and the material ceases to flame or glow. At the completion of the test, there shall be no ignition of the cheesecloth or tissue paper or visible evidence of flame impingement on the outside surface of the enclosure, and there shall be no exposure of live components.

15.4.9 Polymeric material that is not used as an enclosure but that is attached to or exposed on the outside of a product, shall have flammability characteristics as specified in Table 15.2.

Table 15.2
Flammability characteristics of flammable material

Polymeric material area/dimensions	Flammability required
0.24 inches^3 (4 cm^3) maximum and 2.4 inches (61 mm) maximum length	None
Greater than 0.24 inches^3 (4 cm^3) but not more than 2 square feet (0.19 m^2), 6 feet (1.83 m) maximum length	HB, V-2, V-1, V-0, or 5V
Greater than 2 square feet (0.19 m^2) but not more than 10 square feet (0.93 m^2), 6 feet (1.83 m) maximum length	V-1, V-0, or 5V
Greater than 10 square feet (0.93 m^2), or longer than 6 feet (1.83 m)	Maximum flame spread rating of 200 in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, or the radiant panel flame spread test in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94

16 Electrical Components

16.1 General

16.1.1 Material used within an enclosure shall be classified V-2 or HF-2, or less flammable, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A coil, relay, capacitor, semiconductor, transformer, switch, insulating tubing or tape, or other electrical element is not required to comply with this requirement when it complies with the flame test applicable to the component.

Exception No. 2: The cone, dust cap, spider, pad ring, mounting gasket and surround are excluded from the requirements in 16.1.1. The flammability of these components is covered in Speaker Burnout Test, Section 27.

Exception No. 3: The material used to form strain-relief bushing applied over a PVC-jacketed cord (or other small part that contributes negligible fuel to a fire) is not required to be investigated when the part is isolated from uninsulated electrical parts that involve a risk of electric shock/high current levels by:

a) At least 0.5 inch (12.5 mm) of air or

b) A solid barrier of material classified V-2 or less flammable.

16.2 Switches

16.2.1 A switch provided as part of the product shall have a current and voltage or power rating not less than the RMS value of the circuit it controls when the product is operated under any condition of intended service.

16.3 Transformers and coils

16.3.1 A coil or transformer shall be treated to exclude moisture.

16.3.2 Film-coated or equivalently coated wire is not required to be given additional treatment to prevent moisture absorption.

16.4 Printed-wiring boards

16.4.1 A printed-wiring board shall comply with the applicable requirements in the Standard for Printed-Wiring Boards, UL 796. The securing of components to the board shall be made in the intended manner and the spacings between circuits shall comply with the requirements in Spacings, Section 18. The board shall be securely mounted so that deflection of the board during servicing will not result in damage to the board or in development of a risk of fire or electric shock. A printed-wiring board shall have a minimum flammability rating of V-2, be rated for direct support of current-carrying parts, and be suitable for the soldering process used.

17 Polymeric Materials

17.1 An enclosure of polymeric material (where the enclosure has been determined to be a critical component), or a polymeric material used to provide support of current-carrying electrical parts shall have:

a) Structural integrity in accordance with the requirements in Sections 6, 24, 25, and 26;

b) A minimum flammability classification as specified in 15.4.

17.2 A polymeric material used to enclose high-voltage parts (or used to provide support of a live part) shall comply with the Mold Stress-Relief Distortion Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

17.3 A polymeric material used to enclose high-voltage parts (or used to provide support of a live part) and is used in outdoor, damp, wet, or underwater locations shall comply with the (Permanence) Water Exposure and Immersion requirements and the Ultraviolet Light Exposure Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. For the Water Exposure and Immersion requirements and the Ultraviolet Light Exposure Test, small-scale physical tests as described in the permanence requirements in UL 746C are to be conducted when the samples are too large to fit into the test chambers.

17.4 A polymeric enclosure intended for the connection to rigid metallic conduit (such as products provided with circular openings or knockouts), shall comply with the Polymeric Enclosure Rigid Metallic Conduit Connection Tests in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50. A polymeric enclosure for the connection to non-rigid wiring systems (such as flexible conduit or wiring) and provided with instructions as specified in 34.7 is not required to comply with the conduit connection tests.

17.5 A polymeric enclosure intended for use with rigid non-metallic conduit shall comply with the applicable requirements in the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

18 Spacings

18.1 The spacing between an uninsulated live part and a wall or cover of a metal enclosure, a fitting for conduit or metal-clad cable, or a metal piece attached to a metal enclosure, where deformation of the enclosure is likely to reduce spacings, shall be at least the minimum applicable value specified in Table 18.1.

Table 18.1
Minimum spacings

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

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

[b] Rigidly-clamped assemblies include contact springs on relays or cam switches, printed-wiring boards, and similar parts.

[c] Spacings less than those indicated are not prohibited from being used for the connection of integrated circuits and similar components where the spacings between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

18.2 The spacing between an uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded part other than the enclosure, or an exposed dead-metal part that is isolated (insulated) shall be at least the applicable value specified in Table 18.1. See also 18.6.

Exception: The spacing between the voice coil and dead-metal parts is not required to comply with the spacing requirements in Table 18.1. The acceptability of the spacing between the voice coil and dead-metal parts is to be evaluated (and shall comply) with the requirements in the Dielectric Voltage-Withstand Test, Section 29.

18.3 When a short-circuit between uninsulated live parts of the same polarity would prevent the intended signaling operation of the product without simultaneously producing a trouble or abnormal signal, the spacings between such parts shall be at least the minimum applicable value specified for "Other parts" in Table 18.1.

18.4 Film-coated wire is considered an uninsulated live part in determining compliance with spacing requirements, but a film coating is not prohibited from being used as turn-to-turn insulation in coils.

18.5 Minimum values of spacings are not specified for a socket or similar related component part, such as a relay, used in an electronic circuit. However, when the spacings in such a component do not comply with the requirements in 18.2 – 18.4, the circuit shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 29.

18.6 An insulating liner or barrier shall be at least 0.028 inch (0.7 mm) thick.

Exception: A liner or barrier not less than 0.013 inch (0.3 mm) thick is not prohibited from being used in conjunction with an air spacing of not less than one-half of the through-air spacing required, when the liner is located so that it will not be subjected to the direct effects of arcing.

19 Operating Components

19.1 A moving part shall have sufficient play at bearing surfaces to prevent binding.

19.2 An adjusting screw, cam, knob (or similar adjustable part) shall be prevented from loosening under the conditions of intended use.

19.3 Inter-related operating parts shall be formed and assembled so that their alignment will be maintained under all conditions of intended use.

PERFORMANCE

20 Test Samples

20.1 Samples that are fully representative of production are to be used for each of the following tests unless otherwise specified.

20.2 When a product is intended to be mounted in a specified position in order to function as intended, it is to be tested in that position.

20.3 Installation and operating instructions (see 4.1 and 4.2) are to be provided for use as a guide in testing. In addition, the following number of samples are to be provided for testing:

a) Eight speakers intended for indoor use only and of a single voltage rating, and two additional samples of each additional voltage rating, or

b) Ten speakers, when intended for outdoor use and of a single voltage rating, and two additional samples of each additional voltage rating, and

c) One or more of each encapsulated or sealed assembly used in a product, prior to encapsulation or sealing.

d) Additional samples may be required for the Flammability tests (15.4.1 – 15.4.9) or the Speaker Burnout Test, Section 27.

To reduce the number of samples required, samples may be used for multiple tests when agreed upon between the test engineer and the manufacturer before testing starts. Reducing the number of samples may increase the length of time for an investigation.

20.4 Samples are to be subjected to analysis and tests as specified in Table 20.1.

Table 20.1
Tests and analyses

Performance section	Commercial/professional audio systems	Underwater systems
Power Input Test	X	X
Component Temperature Test	X	X
Abnormal Operation Test	X	X
Mechanical Strength Test	X	X
Tip Stability Test	X	
Vibration Test	X	X
Speaker Burnout Test	X	X
Strain-Relief Test	X	X
Dielectric Voltage-Withstand	X	X
Variable Ambient Test	X	
Water Spray Test	X	
Gasket Testing	X	X
Immersion Test		X

21 Power Input Test

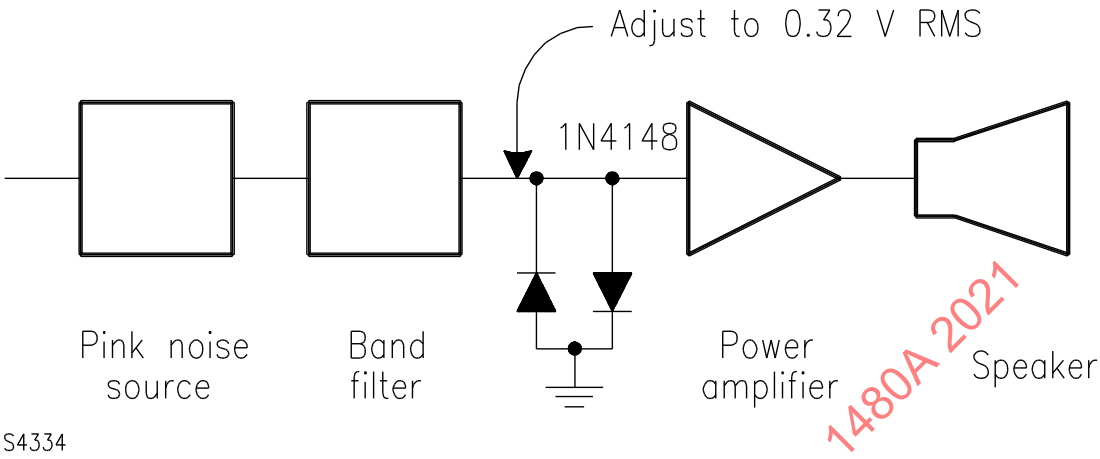
21.1 The measured electrical input power to a speaker shall equal or be less than the manufacturer's rated power of the speaker when powered by pink noise band limited over the manufacturer's specified frequency range.

21.2 Sub-woofers not intended for use in bi-amplified systems shall be tested for power input over the 20 Hz – 20000 Hz frequency range. Sub-woofers for use in a bi-amplified system shall be tested for power input over the manufacturers recommended frequency range.

21.3 Each sample is to be mounted in its intended position and placed in an anechoic or reverberation room. The speaker then is to be connected as shown in Figure 21.1 to an amplifier whose input is connected to a band pass filter to frequency limit the pink noise. The noise shall be bandpass filtered at 24 decibels per octave, with Butterworth filter response characteristics, and have a peak to RMS voltage ratio between 1.8 – 2.2.

Figure 21.1

Power input test



21.4 When a matching transformer or capacitor (or both) is used with a speaker, the input terminals of the transformer or capacitor are to be considered as the input terminals of the speaker.

21.5 The input power (watts) for a speaker used in a distributed audio system is to be determined by adjusting the input voltage to the speaker to its rated value. Input power is to be the product of the applied voltage and the true RMS current input.

21.6 On non-distributed (low impedance) audio systems where only the coil resistance or impedance and maximum power is specified, the minimum resistance or impedance over the manufacturer's specified frequency range (whichever is greater) shall have an average resistance or impedance of no less than the marked rating with no one-third octave band having a resistance or impedance of less than 80 percent of the marked rating.

22 Component Temperature Test

22.1 The materials employed in the construction of a product shall attain a temperature rise that is less than that required to:

a) Cause a risk of fire,

b) Damage any materials in the product, or

c) Exceed the temperature rises specified in Table 22.1

while the product is being driven under the conditions specified in the Power Input Test, Section 21. The product shall be energized continuously for one hour or until constant temperatures have been obtained.

Table 22.1
Maximum temperature rises – emergency and non-emergency products

Parts of the apparatus	Maximum temperature rises under normal operating conditions, (°C)
1. Accessible parts on surfaces of an enclosure[a,b]	65
2. Handles or knobs that are grasped for lifting, carrying, or holding[a,c]:	
a) Metallic	25
b) Nonmetallic	35
3. Accessible front panels, all accessible control panels, and handles or knobs that are contacted and do not involve lifting, carrying, or holding[a,d,e]:	
a) Metallic	35
b) Nonmetallic	60
4. Enclosure interior surfaces:	
a) Wood	65
b) Insulating material	see note (d)
5. Insulating materials:	
a) Polymeric	see note (d)
b) Varnished cloth	60
c) Fiber	65
d) Wood and similar material	65
e) Laminated phenolic composition[f]	100
f) Phenolic composition	125
6. Softening point of any sealing compound	see note (g)
7. Coil winding surfaces using impregnated organic insulation or enameled wire[h]:	
Thermocouple method	65
Resistance method	75
8. Capacitors[i]	
a) Electrolytic	40
b) Other types	65
9. Conductors with rubber, thermoset or thermoplastic insulation[f]	35
10. Solderless wrapped connections	75
11. Any point within a terminal box or wiring compartment of permanently-connected apparatus in which power supply conductors are to be connected (including such conductors themselves), unless the apparatus is marked in accordance with 34.1(j)	35
12. Transformers with Class 105 (A) insulation systems:	
Thermocouple method	65
Resistance method	75
13. Transformers with Class 130 (B) insulation systems:	
Thermocouple method	85
Resistance method	95
14. Transformers with Class 155 (F) insulation systems:	
Thermocouple method	110
Resistance method	120

Table 22.1 Continued on Next Page

Table 22.1 Continued

Parts of the apparatus	Maximum temperature rises under normal operating conditions, (°C)
15. Transformers with Class 180 (H) insulation systems:	
Thermocouple method	125
Resistance method	135
16. Fuses:	
Class G, J, L, T, or CC	
Tube	100
Terminals	65
Other[f]	65
17. Printed-wiring boards	Based on maximum-use temperature rating of printed-wiring board material

[a] Item 1 is concerned with ignition of materials that are capable of contacting the enclosure. Items 2 and 3 are concerned with skin-burn when contacted by the user. The lowest temperature limit on a given surface is the maximum rated temperature for that surface or part.

[b] This limitation does not apply to that portion of semiconductors (including their heat sinks) on the rear surface of the product and similar locations that are not capable of touching a vertical wall surface placed immediately behind the apparatus nor to semiconductors (including their heat sinks) of products that are intended for protected installations.

[c] A handle, knob, or similar object made of a material other than metal, that is plated or clad with metal having a thickness of 0.006 inch (0.15 mm) or less is determined to be (and is evaluated as) a nonmetallic part.

[d] Polymeric material shall be rated for the application when evaluated with regard to temperature.

[e] Heat sinks of commercial apparatus are not prohibited from exceeding the specified temperature when a marking (which is permanently affixed or adjacent to the heat sink) specifies the following or equivalent: "CAUTION – HOT SURFACE, AVOID CONTACT".

[f] Does not apply when investigated and determined to be capable of use at a higher temperature.

[g] The maximum sealing compound temperature (when corrected to 25°C ambient temperature) is 15°C less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring and Ball Apparatus, ASTM E28.

[h] A hot-spot temperature rise higher than 80°C on the surface of a coil winding is permitted when the temperature rise of the winding does not exceed 75°C. The temperature rise limits of 65°C by thermocouple method and 75°C by resistance method are based on the standardized allowance for a maximum hot-spot temperature rise of 80°C.

[i] A capacitor having a temperature rise higher than 40°C is to be evaluated on the basis of its marked temperature rating or, when not marked with a temperature rating, is capable of being investigated to determine its use at the higher temperature.

22.2 All values for temperature rises apply to equipment intended for use in ambient temperatures normally prevailing in occupiable spaces which usually are not higher than 77° F (25° C). When the equipment's installation instructions or its marking indicate the intended use in prevailing ambient temperatures higher than 77° F, testing of the equipment is to be made with such higher ambient temperature, and the allowable temperature rises specified in Table 22.1 are to be reduced by the amount of the difference between that higher ambient temperature and 77° F. A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test – but not less than 5 minutes – indicate no change.

22.3 The temperature of a component exceeding that indicated in Table 22.1 is not prohibited from being used when reliability data is provided by the manufacturer to justify its use, and when the higher temperature does not cause risk of fire nor damage to any materials in the product.

22.4 Temperatures are to be measured by the use of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2), except that:

a) The temperature of a coil may be measured by either the thermocouple or change-in-resistance method;

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

c) A thermocouple is not to be used for a temperature measurement at any point where supplementary thermal insulation is employed.

22.5 In measuring the temperature rise of a coil winding by the change-in-resistance method, the resistance of the winding at the temperature to be determined is to be compared with the resistance at a known temperature by means of the equation:

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

in which:

Δ t is the temperature rise in degrees C;

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

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

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

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

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum; values of the constant (k) for other grades must be determined.

22.6 For the purpose of determining R, a method shall be employed which allows the measurement to be taken simultaneous to the operation of the product under the conditions specified in 22.1.

22.7 Speaker voice coils are not required to be subjected to these temperature test requirements. Compliance of the voice coil assembly is determined with the Speaker Burnout Test, Section 27.

23 Abnormal Operation Test

23.1 Components within a speaker assembly shall withstand shorting of the voice coil without evidence of flame or molten metal. During and following this test, there shall be no ignition or charring of the cheesecloth. Following this test, and within one minute after the abnormal fault has been removed, the speaker shall comply with requirements in the Dielectric Voltage-Withstand Test, Section 29.

23.2 During this test, the input to the speaker assembly is connected as shown in Figure 21.1. The pink noise source is to be bandpass filtered between the manufacturers recommended frequency range at 24 decibels per octave, with Butterworth filter response characteristics, and having a peak to RMS voltage ratio between 1.8 – 2.2. The RMS voltage to the speaker assembly is to be increased to 130 percent of the rated voltage value. The speaker is to be covered with a single layer of cheesecloth and then operated continuously with the voice coil shorted until constant temperatures are attained or until burnout occurs. Circuit-protection devices are permitted to operate during this test.

23.3 During this test, all fuses which are field-renewable and are of an interchangeable type, shall be replaced by a fuse of the same size but having the highest available current rating for that size. Opening of the fuse before any condition of risk of fire or electric shock results satisfies the requirement of this test.

23.4 When during this test any component exceeds its temperature rating (see Table 22.1), the short across the speaker voice coil is to be removed and the AC Abnormal Operation Test contained in Recommended Loudspeaker Practices, CEA-CEB19, is to be conducted. During (and following) the AC Abnormal Operation Test, there shall be no ignition or charring of the cheesecloth.

24 Mechanical Strength Tests

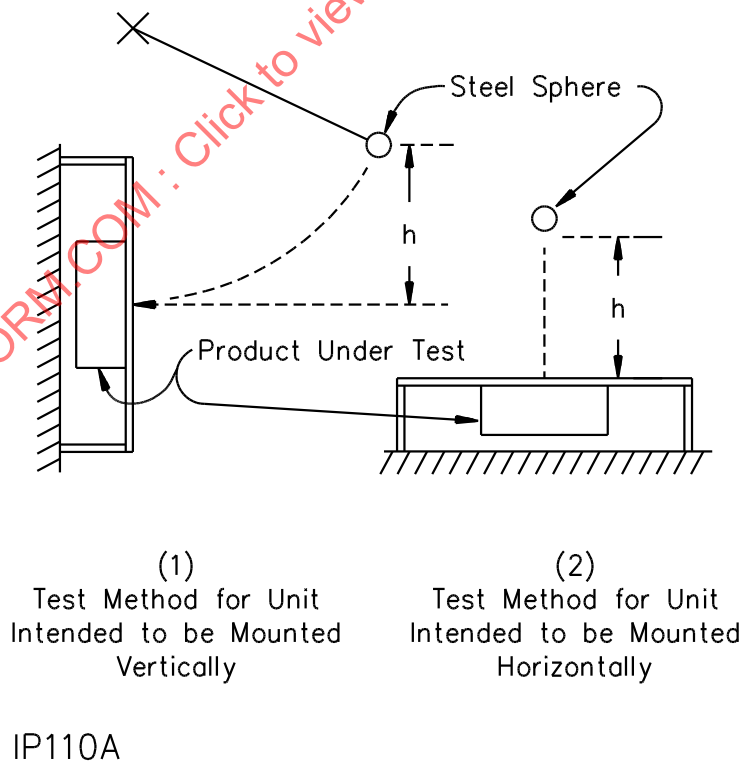
24.1 Jarring test

24.1.1 A speaker weighing less than 22 lbs (10 kg) shall withstand jarring resulting from impact anticipated in the intended application, without impairment of its intended operation.

24.1.2 The product and associated equipment are to be mounted as intended to the center of a 6- by 4-foot (1.8- by 1.2-m), 3/4-inch (19.1-mm) thick plywood board secured in place at four corners. An impact is to be applied to the center of the reverse side of this board by means of a 1.18-pound (0.54-kg), 2-inch (50.8-mm) diameter steel sphere either swung through a pendulum arc from a height of 30.5 inches (775 mm), or dropped from a height of 30.5 inches, depending upon the intended mounting of the product. See Figure 24.1.

Figure 24.1

Jarring test



24.1.3 Following completion of this test, the speaker shall comply with the Dielectric Voltage-Withstand Test, Section 29.

24.2 Impact test

24.2.1 Products with surfaces that are exposed after installation shall show no signs of excessive damage that results in:

a) A reduction of spacing less than that shown in Table 18.1 or

b) Live parts becoming dislodged or accessible when subjected to a 3-foot-pound (4.08-J) impact.

24.2.2 The impact required in 24.2.1 is to be delivered by a 1.18-pound (0.54-kg), 2-inch (50.8-mm) steel sphere either swung through a pendulum arc or dropped from a height of 30.5 inches (775 mm). Following the impact, the sample shall comply with the Dielectric Voltage-Withstand Test, Section 29.

24.3 Mounting/handle securement test

24.3.1 An attachment point for mounting shall withstand a force five times the weight of the speaker system or five times the maximum load rating of the attachment point (whichever is greater) for a period of one minute. The load shall be applied at an angle least favorable to the support of the speaker system that does not exceed the manufacturer specifications.

24.3.2 A handle used to carry a speaker assembly shall withstand the force of five times the weight of the speaker assembly. When more than one handle is provided, each handle shall be capable of withstanding five times the weight of the speaker. The weight is to be evenly distributed over a 3-inch (76.2-mm) width at the center of the handle.

24.4 Speaker grill test

24.4.1 A grill covering the acoustical openings of a speaker intended for fire or emergency warning use shall protect the sound producing element of the speaker from damage from a hard material (i.e. steel or lead) 12.7 mm (0.5 inch) diameter hemisphere forced into the acoustic opening with a 110 N (25 pound-force). The force is to be applied three times for an opening 200 mm (8 inches) or less, and five times for an opening greater than 200 mm (8 inches). Damage is determined by exposure of live high voltage parts or a reduction in spacing less than that shown in Table 18.1.

25 Tip Stability Test

25.1 A speaker assembly weighing 10 pounds (4.54 kg) or more, and not intended to be secured during operation, shall remain stable when placed on an incline of 10 degrees from the horizontal. All casters, wheels, adjustable feet (levelers), or other means of support of the speaker assembly are to be positioned in any combination of ways that results in the least stability. Legs and other means of support shall be blocked to keep the speaker assembly from sliding. The entire assembly is to be rotated slowly through an angle of 360 degrees about its normal axis.

25.2 In addition to the instability condition in 25.1, a speaker assembly shall withstand the following applicable horizontal force:

a) A speaker assembly weighing more than 10 pounds (4.54 kg) but less than 60 pounds (27 kg), or having an overall height greater than 3 feet (0.9 m), shall withstand a horizontal force of 20 percent of the weight of the speaker assembly or 24 pounds (110 N), whichever is less, applied to a point on the speaker assembly most likely to overturn it, but not more than 5 feet (1.5 m) above the floor level.

b) A speaker assembly weighing more than 60 pounds (27 kg) shall withstand a horizontal force of 13 percent of the weight of the speaker assembly or 20 pounds (89 N), whichever is less, applied to

a point on the assembly most likely to overturn it, but not more than 5 feet (1.5 m) above the floor level.

26 Vibration Test

26.1 A speaker shall withstand vibration without breakage or damage to parts and without development of any condition that impairs its intended operation. Following completion of this test, the speaker shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 29.

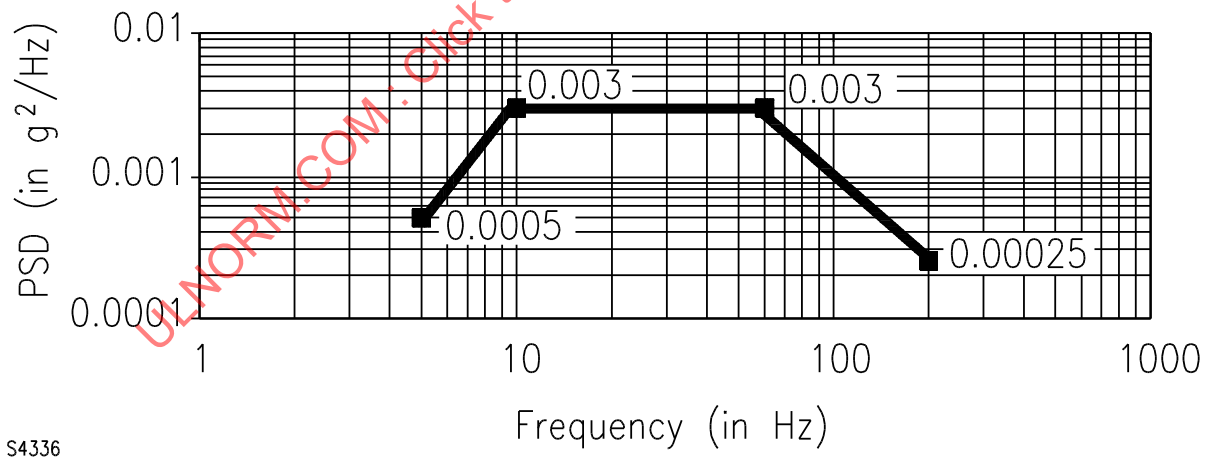
26.2 A sample is to be mounted, in turn, on each axis on a mounting board that is secured to a random noise vibration table. The sample is then to be subjected to random noise vibration in the frequency band of 5 – 200 Hz and having power spectral density (PSD) levels as indicated in Table 26.1 and Figure 26.1, and a total energy under the curve of 0.52 g RMS. The test shall be conducted for a period of 30 minutes in each axis of the speaker assembly, for a total of 90 minutes.

Table 26.1
Random noise vibration test table

Frequency (Hz)	PSD (g^2/Hz)
5	0.0005
10	0.003
60	0.003
200	0.00025

Figure 26.1

Random noise vibration test graphic



27 Speaker Burnout Test

27.1 A speaker assembly shall be free from a risk of fire as a result of an overload condition.

27.2 Compliance (of the speaker transducer) with 27.1 shall be determined with the DC Overload Abnormal Test requirements in Recommended Loudspeaker Safety Practices, CEA-CEB19. During and following this test, there shall be no ignition or charring of the cheesecloth.

27.3 Compliance of electrical components within a speaker assembly shall be determined with the Abnormal Operation Test, Section 23.

28 Strain-Relief Test

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

28.2 A cord provided for field wiring shall withstand for 1 minute, a 35 pounds-force (156 N) without any evidence of damage, or transmittal of the stress, to internal connections. The cord shall also be provided with means to prevent the cord from being pushed inside the enclosure when, pushed inside, the following is capable of occurring:

a) The insulation of the cord being subjected to temperatures or voltages above the assigned ratings;

b) The cord coming into contact with a sharp or moving parts capable of damaging the insulation of the cord or affecting the performance of a fire or emergency warning speaker; or

c) The cord displacing a part, resulting in a reduction of spacing.

29 Dielectric Voltage-Withstand Test

29.1 A speaker shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential as specified in Table 29.1, between:

a) Field-wiring connections and the enclosure;

b) Field-wiring connections and exposed dead-metal parts which are capable of becoming electrically alive;

c) Field-wiring connections of circuits operating at different potentials or at different frequencies; or

d) Live parts of circuits operating at different potentials or at different frequencies with spacings less than that required in Spacings, Section 18. The dielectric potential is to be applied after the device has been conditioned for 24 hours in a relative humidity of 95 ±5 percent.

Table 29.1
Dielectric voltage-withstand test potentials

Non-audio circuits voltage potential	AC test potential	DC test potential
30 volts AC rms (42.4 volts DC or AC peak) or less	500 volts	707 volts
Between 31 and 150 volts AC rms	1000 volts	1414 volts
More than 150 volts AC rms	1000 volts plus twice the rated voltage	1414 volts plus 2.828 times the rated AC rms voltage
Audio circuits voltage potential	**AC test potential**	**DC test potential**
Low-voltage[a]	500 volts	707 volts
High-voltage[a]	1000 volts plus twice the rated voltage	1414 volts plus 2.828 times the rated voltage
[a] As defined in the Glossary.		

29.2 A reference or component ground is to be disconnected prior to the test applications.

29.3 Exposed dead-metal parts referred to in 29.1 (b) are noncurrent-carrying metal parts that may become energized and accessible from outside of the enclosure of a product during normal or abnormal operation with the door of the enclosure closed.

29.4 For the application of a potential in accordance with 29.1 (c), the voltage is to be the applicable value specified in Table 29.1, based on the highest voltage of the circuits under test instead of the rated voltage of the product. Electrical connections between the circuits are to be disconnected before the test potential is applied.

29.5 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter is to be tested using the DC potential specified in Table 29.1.

29.6 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. The method of applying the test voltage is to be such that there are no transient voltages that result in the instantaneous voltage being applied to the circuit exceeding 105 percent of the peak value of the specified test voltage. The applied potential is to be:

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

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

Manual or automatic control of the rate of rise is acceptable.

29.7 A printed-wiring assembly or other electric circuit component that would be damaged by the application of, or would short-circuit, the test potential is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire unit. Rectifier diodes in the power supply may be individually shunted before the test to reduce the risk of destroying them in the case of a malfunction elsewhere in the secondary circuits.

30 Variable Ambient Tests

30.1 General

30.1.1 Speakers shall not present a risk of shock after being exposed to the applicable ambients in 30.2 – 30.4. At the completion of the variable ambient, the speaker shall comply with the requirements of the dielectric voltage-withstand test in Section 29.

30.2 Low-temperature test

30.2.1 A speaker intended for indoor use in dry locations, is to be placed in a position of intended use in an air circulating environmental chamber maintained at the lower of the following temperatures:

a) 0 ±5°C (32 ±9°F) or

b) The lowest ambient operating temperature specified in the products installation instructions or on its marking.

During the exposure the speaker is not to be energized. The exposure time is to be 3 hours or longer if required to achieve thermal equilibrium.

30.2.2 A speaker intended for indoor use in damp locations is to be placed in a position of intended use in an air circulating environmental chamber and subjected to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. to the lower temperature indicated in 30.2.1 for a period of 30 minutes, and back to a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. The rate of change is to be 2 ±1°C (36 ±1.8°F) per minute. During the exposure the speaker is not to be energized.

30.2.3 A speaker intended for outdoor use in damp or wet locations is to be placed in a position of intended use in an air circulating environmental chamber and subjected to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. to the lower the temperature indicated below for a period of 30 minutes, and back to a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. The rate of change is to be 2 ±1°C (36 ±1.8°F) per minute. During the exposure the speaker is not to be energized:

a) Minus 40 ±5°C (minus 40 ±9°F) or

b) The lowest ambient operating temperature specified in the products marking installation instructions or on its marking.

30.3 High-temperature test

30.3.1 A speaker intended for indoor use in dry locations is to be placed in a position of intended use in an air circulating environmental chamber maintained at the higher of the following temperatures:

a) 50 ±5°C (122 ±9°F) or

b) The highest ambient operating temperature specified in the products installation instructions or on its marking.

During the exposure the speaker is not to be energized. The exposure time is to be 3 hours or longer if required to achieve thermal equilibrium.

30.3.2 A speaker intended for indoor use in damp or wet locations is to be placed in a position of intended use in an air circulating environmental chamber and subjected to 20 cycles of temperature and humidity cycling. A cycle consists of a change from a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 degrees R.H. to the higher temperature indicated in 30.3.1 for a period of 30 minutes, and back to a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 degrees R.H. The rate of change is to be 2 ±1°C (36 ±1.8°F) per minute. During exposure the speaker is not to be energized.

30.3.3 A speaker intended for outdoor use in damp or wet locations is to be placed in a position of intended use in an air circulating environmental chamber and subjected to 20 cycles of temperature and humidity cycling. A temperature cycle consists of a change from a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. to the higher temperature indicated below for a period of 30 minutes, and back to a temperature of 25 ±5°C (77 ±9°F) at a humidity of 95 ±5 percent R.H. The rate of change is to be 2 ±1°C (36 ±1.8°F) per minute. During the exposure the speaker is not to be energized.

a) 66 ±5°C (151 ±9°F), 95 ±5 percent R.H. or

b) The highest ambient operating temperature specified in the products marking installation instructions or on its marking.

30.4 Humidity test

30.4.1 A speaker intended for indoor use in dry locations only is to be placed in a position of intended use in an air circulating environmental chamber having a relative humidity of 85 ±5 percent and a

temperature of 30 ±5°C (86 ±9°F) for a period of 24 hours. During the exposure the speaker is not to be energized.

30.4.2 A speaker intended for indoor or outdoor use in damp or wet locations is to be placed in a position of intended use in an air circulating environment chamber having a relative humidity of 95 ±5 percent and a temperature of 60 ±5°C (140 ±9°F) and maintained for 240 hours. During the exposure the speaker is not to be energized.

30.4.3 Immediately following exposure to the humid environment, a speaker shall comply with the Dielectric Voltage-Withstand Test, Section 29.

31 Water Spray Test

31.1 A speaker intended for outdoor use or use in a wet environment, shall operate as intended and shall be free from risk of electric shock following a 1-hour water spray exposure. An enclosure constructed from a polymeric material shall be subjected to a 7-hour aging test at 70°C prior to being subjected to this test. After exposure to the water spray, the product shall comply with the requirements in Dielectric Voltage-Withstand Test, Section 29, and shall show no signs of water in the enclosure capable of wetting uninsulated electrical components.

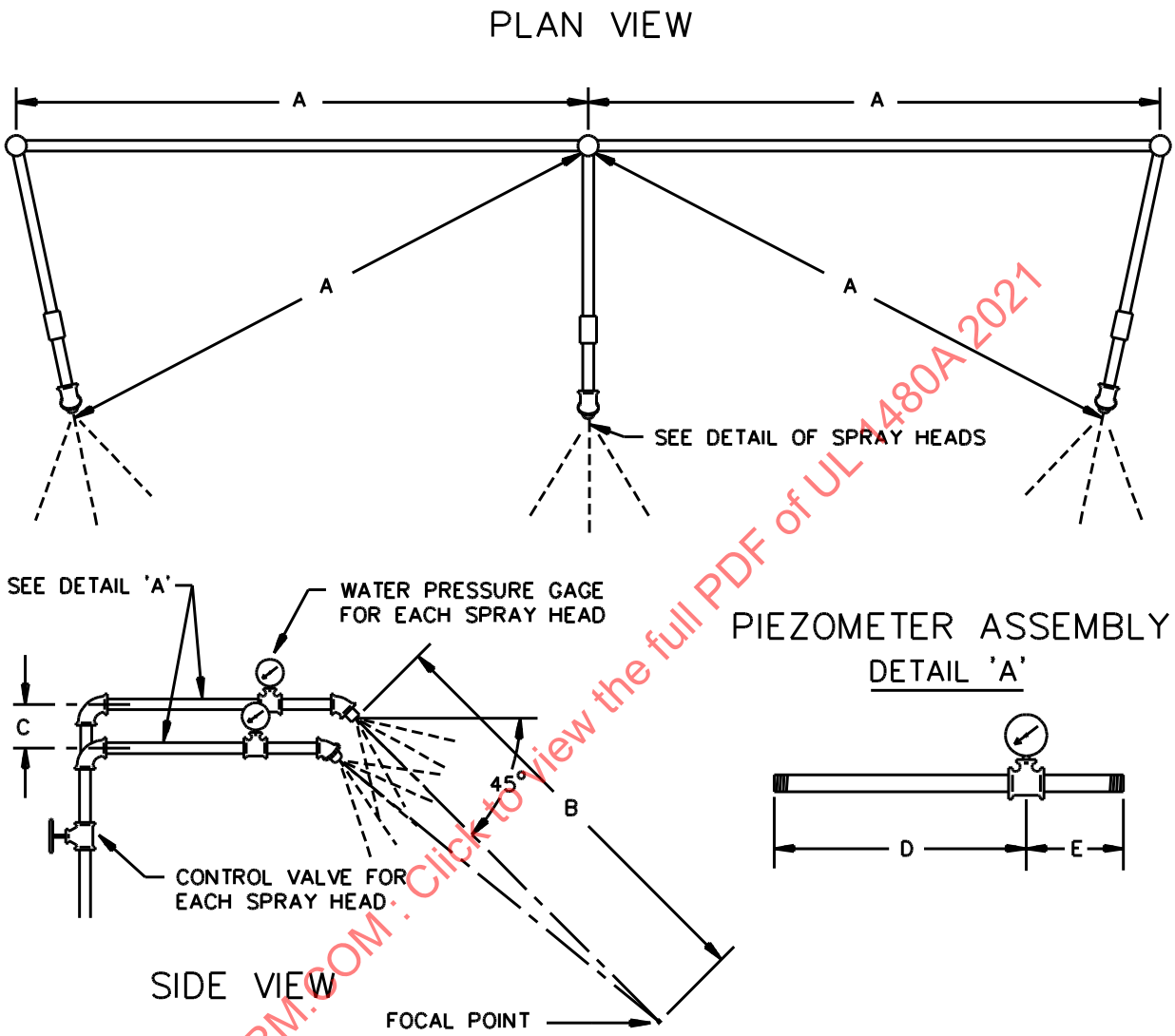
31.2 The speaker is to be tested while mounted in the position described in the installation instructions as most capable of allowing water to enter into the enclosure.

31.3 External wiring connections are to be made in accordance with the wiring diagram and installation instructions. Openings intended to terminate conduit are to be sealed. Openings intended for the entry of a conductor or conductors for wiring in a low-voltage circuit are not to be sealed.

31.4 The water-spray test apparatus is to consist of three spray heads mounted in a water supply rack as illustrated in Figure 31.1. Spray heads are to be constructed in accordance with Figure 31.2. The water pressure for all tests is to be maintained at 5 psi (34.5 kPa) at each spray head. The distance between the center nozzle and the speaker is to be approximately 3 feet (0.91 m). The speaker is to be brought into the focal area of the three spray heads in such position and under such conditions that the greatest quantity of water will enter the speaker enclosure. The spray is to be directed at an angle of 45 degrees to the vertical toward openings closest to live parts.

Figure 31.1

Spray head piping



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

RT101D