NATIONAL STANDARD
OF CANADA

# CAN/ULC-S525:2016-REV1
# (Including Revision 1)

# AUDIBLE SIGNALING DEVICES FOR FIRE ALARM AND SIGNALING SYSTEMS, INCLUDING ACCESSORIES

**Prepared and Published by:**

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Normes ULC

**Approved by:**

Standards Council of Canada
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ANSI

ANSI/UL 464:2017

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Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, CAN/ULC-S525:2016-REV1

Fourth Edition, Dated January 2016

***Summary of Topics***

***The September 2017 revision of CAN/ULC-S525:2016 contains the following changes in requirements:***

***1. Revision of outdoor use enclosure requirements includes item ″c″ in Clause 5.2.8.1, which was accidentally omitted, to be consistent with CAN/ULC S526 and CAN/ULC-S541***

***2. Revisions to Clause 7.10, Abnormal Operation and Burnout Test, to resolve the binational differences between Canada and the United States and to insert any missing requirements that were accidentally omitted during the creation of the original binational document***

***3. Revisions to clarify the temperature conditioning requirements for indoor and outdoor use appliances in Mechanical Strength Tests for Enclosures (clauses 7.21.2.1 and 7.21.4)***

***4. Additional reference document changes and corrections to existing requirements in CAN/ULC-S525***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 18, 2016.

A "**(REV1)**" marker in Bold will be inserted at the start of the applicable Clause(s) and in the applicable Subsection title(s). The Subsection title markers will appear in the TOC as a result. The markers may be found by searching for the characters "(REVx)". Including the parenthesis in the search term will find the markers, without also finding every page header.

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**ULC Standards**
**CAN/ULC-S525**
**Fourth Edition**

**Underwriters Laboratories Inc**
**UL 464**
**Tenth Edition**

# Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories

January 28, 2016

(Title Page Reprinted: September 5, 2017)

**ANSI/UL 464-2017**

*Approved by*

Standards Council of Canada
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International Classification for Standards (ICS): 13.220.20; 13.320.

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The revision to the Fourth Edition of this ULC Standard was based on, and supersedes, the Fourth Edition.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patent rights. ULC Standards shall not be held responsible for identifying any or all such patent rights.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The review and action to revise or reaffirm this Standard will not exceed 5 years from the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

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## Preface

This is the common UL and ULC Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories. It is the fourth edition of CAN/ULC-S525 and tenth edition of ANSI/UL 464.

This Joint Standard was prepared by Underwriters Laboratories Inc., ULC Standards, and the NEMA Technical Harmonization Committee on Notification Appliances. The standard was formally approved by the UL Standards Technical Panel on Signal Appliances; and the ULC Technical Committee on Fire Alarm and Life Safety Equipment and Systems. The efforts and support of the NEMA Technical Harmonization Committee, the UL Standards Technical Panel, and the ULC Technical Committee are gratefully acknowledged.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This standard has been approved as a National Standard of Canada by the Standards Council of Canada.

This standard has been approved by the American National Standards Institute as an American National Standard.

Annexes A, C, and E are identified as informative and are for informational purposes only. Annexes B and D are identified as normative and form a mandatory part of this Standard.

> **Note:** *Although the intended primary application of this Standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.*

### Level of Harmonization

This Standard is published as an equivalent standard for UL and ULC Standards. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical deviations are allowed for codes and governmental regulations and those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental, climatic, geographical, technological or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is to be word for word except for editorial changes.

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The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

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## 1 Scope

1.1 This standard applies to electrically operated bells, sirens, horns, and similar audible signaling devices, rated at 300 V or less, for fire alarm and signaling systems and intended for indoor and/or outdoor installation:

a) In Canada, in accordance with CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations; and with CAN/ULC-S524, Standard for Installation of Fire Alarm Systems. Refer to CAN/ULC-S541, Speakers for Fire Alarm and Signaling Systems, Including Accessories, for requirements pertaining to speakers.

b) In the United States in accordance with the National Electrical Code, NFPA 70, and the National Fire Alarm and Signaling Code, NFPA 72.

1.2 This standard applies to audible signaling devices for use in ordinary (non-hazardous or non-corrosive) locations.

1.3 This standard also applies to protective covers and accessories used with audible signals.

1.4 This standard does not apply to door bells, buzzers and chimes used in household and similar applications and intended for operation on Class 2 signal circuits as defined in:

a) In Canada, CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations,

b) In the United States, the National Electrical Code, NFPA 70.

NOTE: In the United States, general signaling appliances are covered by the Standard for Audible Signal Appliances for General Signaling Use, UL 464A.

1.5 Audible signaling devices for use in hazardous or corrosive locations shall comply with the requirements of this Standard and the applicable requirements of:

a) In Canada, CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, with respect to the location hazard;

b) In the United States, the National Electrical Code, NFPA 70.

1.6 A supplementary visual signal, incorporated as part of an audible signaling device which is intended for fire alarm application shall comply with the requirements of this Standard and the applicable requirements of:

a) In Canada, CAN/ULC-S526, Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories;

b) In the United States, the Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 1638.

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## 2 General

### 2.1 Components

2.1.1 Except as indicated in 2.1.2a 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 generally used in the products covered by this Standard.

2.1.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed 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 rating(s) established by its manufacturer for the intended conditions of use.

### 2.2 Units of Measurement

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

2.2.2 The metric unit shall be designated as the official unit for purposes of this standard. Where values of measurement are specified in both SI and English units, either unit is used. In cases of dispute, the metric unit shall be used. Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2.3 Wherever the abbreviation ″AWG″ appears in these requirements, it refers to American Wire Gauge.

### 2.3 Control Unit Interface

2.3.1 An audible signaling device incorporating circuitry for functional interfacing with a control unit for purposes such as supervision, point addressing, multiplexing, synchronization etc., shall also comply with the applicable functional requirements of standards such as:

a) In Canada, CAN/ULC-S527, Standard for Control Units for Fire Alarm Systems;

b) In the United States, the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

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## 2.4 Reference Publications

2.4.1 **(REV1)** The documents shown below are referenced in the text of this Standard. Unless otherwise stated elsewhere in this Standard such reference shall be considered to indicate the edition and/or revisions of the document available at the date on which this standard was approved. All undated references shall be interpreted as referring to the latest edition of that document.

**UL Standards**

UL 224,
*Extruded Insulating Tubing*

UL 746C,
*Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 796,
*Printed Wiring Boards*

UL 864,
*Control Units and Accessories for Fire Alarm Systems*

UL 969,
*Marking and Labeling Systems*

UL 1004-1,
*Rotating Electrical Machines – General Requirements*

UL 1004-2,
*Machines – General Requirements*

UL 1004-3,
*Thermally Protected Motors*

UL 60065,
*Audio, Video, and Similar Electronic Apparatus – Safety requirements*

UL 60384-14,
*Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains*

**ULC Standards**

CAN/ULC-S524,
*Standard for Installation of Fire Alarm Systems*

CAN/ULC-S526,
*Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories*

CAN/ULC-S527,
*Standard for Control Units for Fire Alarm and Signaling Systems*

CAN/ULC-S541,
*Speakers for Fire Alarm and Signaling Systems, Including Accessories*

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**Acoustical Society of America Standards**

ANSI S1.40-2006 (R2011),
*American National Standard Specifications and Verification Procedures for Sound Calibrators*

ANSI/ASA S12.51-2012/ISO 3741-2010,
*American National Standard Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms*

ANSI/ASA S1.4-2014/Part 1 / IEC 61672-1:2013,
*Electroacoustics – Sound Level Meters – Part 1: Specifications*

ANSI/ASA S1.4-2014/Part 2 / IEC 61672-2:2013,
*Electroacoustics – Sound Level Meters – Part 2: Pattern Evaluation Tests*

ANSI/ASA S1.4-2014/Part 3 / IEC 61672-3:2013,
*Electroacoustics - Sound Level Meters - Part 3: Periodic Tests*

**ASTM Standards**

ANSI/ASTM B86,
*Specifications for Zinc-Alloy Die Castings*

ASTM B117,
*Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM E27-81,
*Standard Method of Spectrochemical Analysis of Zinc-Base Alloys and High-Grade Zinc by the Solution Residue-DC Arc Technique*

ASTM E28,
*Standard Test Methods for Softening Point by Ring-and-Ball Apparatus*

**CSA Group Standards**

C22.1-15,
*Canadian Electrical Code, Part I, Safety Standard for Electrical Installations*

C22.2 No. 0.15-01 (R2012),
*Adhesive Labels*

CAN/CSA-C22.2 No. 0.4-04 (R2009),
*Bonding of Electrical Equipment*

CAN/CSA-C22.2 No. 0.17-00 (R2009),
*Evaluation of Properties of Polymeric Materials*

C22.2 No. 77-95 (R2009),
*Motors with Inherent Overheating Protection*

CAN/CSA-C22.2 No. 198.1-06 (R2010),
*Extruded Insulating Tubing*

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CAN/CSA-C22.2 No. 60065-03 (R2012),
*Audio, Video, and Similar Electronic Apparatus – Safety Requirements.*

**IEC Standards**

IEC 60651
*Sound Level Meters*

**ISO Standards**

ISO 8201,
*Acoustics – Audible emergency evacuation signal*

**National Research Council of Canada (NRC) Standards**

NBC 2010,
*National Building Code of Canada*

**2.5 Audible Signal Pattern**

2.5.1 Format for Evacuation Signals

2.5.1.1 **(REV1)** Devices used for evacuation signals whose signal format is not controlled by a control unit shall be capable of reproducing a 3 pulse signal temporal pattern conforming with Figure B1, Temporal Pattern for Fire Alarm Signal in Annex B, either internally or when pulsed from an external source.

2.5.2 Format for Carbon Monoxide Signals

2.5.2.1 **(REV1)** Audible signaling Devices used for carbon monoxide alarm and whose signal format is not controlled by a control unit, shall be capable of reproducing a 4 pulse signal temporal pattern either internally or when pulsed from an external source. Refer to Figure B2, Temporal Pattern for Carbon Monoxide Signal in Annex B.

**3 Glossary**

For the purpose of this Standard, the following definitions apply:

3.1 CONSTANT TEMPERATURE – Temperature is considered to be constant when three successive readings indicate no change when taken at intervals of 10% of the previously elapsed duration of the test, but not less than at 5 min intervals.

3.2 DECIBEL (dB) – One-tenth of a bel, the number of decibels denoting the ratio of the two amounts of power being ten times the logarithm to the base 10 of this ratio.

Note: The abbreviation dB is commonly used for the term decibel, and is determined as follows:

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$$n = 10 \log_{10} \frac{P_1}{P_2} \text{ dB}$$

Where:

$P_1$ and $P_2$ = The two values of power, expressed in the same unit (e.g. sound pressure level); and

n = Value in decibels

3.3 DUTY CYCLE – The ratio of the sum of all pulse durations to the total period, during a specified period of operation.

3.4 DWELLING UNIT[1] – A suite operated as a housekeeping unit, used or intended to be used as a domicile by one or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.

[1]Definition of this term is consistent with that used in the National Building Code of Canada

3.5 EMERGENCY WARNING – A system used to provide information and instructions to people in a building, area, site, or other space using intelligible voice communications methods. A Emergency warning System is used to notify occupants that an emergency exists.

3.6 FREE FIELD – An environment in which a sound wave may propagate in all directions without obstructions or reflections within the frequency range of interest.

3.7 PUBLIC MODE – Mode of operation intended to notify occupants or inhabitants in the area protected by the fire-alarm and signaling system.

3.8 PRIVATE MODE – Mode of operation intended to notify only those persons directly concerned with the implementation and direction of emergency action initiation and procedure in the area protected by the fire-alarm and signaling system.

3.9 REFERENCE AXIS – The ″reference axis″ of a signaling device is a line passing through the reference point coincident with the geometrical axis of the sound propagation pattern. For symmetrical structures, the reference axis is usually perpendicular to a plane passing through the edge of the sound source or opening of a horn

3.10 REFERENCE POINT – The ″reference point″ of a signaling device is a point on the outside of the signaling device in line with the geometrical centre of the sound source projected perpendicular to a plane passing through the edge of the sound source. For horn type audible signaling devices, the ″reference point″ is the geometrical centre of the opening of the horn.

3.11 RESONANCE – Condition of peak vibratory response where a small change in excitation frequency causes a decrease in system response.

3.12 SOUND – Energy that is transmitted by pressure waves in air or other materials and is the objective cause of the sensation of hearing. Commonly called noise if it is unwanted.

3.13 SOUND LEVEL METER – An electronic instrument for measuring the RMS level of sound in accordance with an accepted national or international standard.

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3.14 SOUND PRESSURE – A fluctuating pressure superimposed on the static pressure by the presence of sound. The unqualified term means the root-mean-square sound pressure. In air, the static pressure is barometric pressure.

3.15 SOUND PRESSURE LEVEL (SPL) – Ten times the common logarithm of the ratio of the square of the sound pressure under consideration to the square of the standard reference pressure of 20 μPa. The quantity obtained is expressed in decibels.

3.16 SPECIAL TOOL – A device not normally carried by the public (e.g. a key), normally provided by the manufacturer, to deter unauthorized access to the equipment.

Note: This is intended to deter unauthorized access to the equipment, while being available on site either at a defined location or from a "responsible person" familiar with and having knowledge of the equipment.

## 4 Instructions and Drawings

*Note: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require instructions to be in both official languages.*

4.1 Audible signaling devices packaged individually shall include installation instructions and drawings as specified in 4.2 through 4.5 with each unit. Where devices are packaged in bulk (multiple devices in one single package) and not intended for individual resale, a minimum of one set of installation instructions and drawings shall be provided.

4.2 Installation drawings shall include the following items:

a) Typical location, mounting, and orientation of units;

b) Directional characteristics and rated sound pressure level at power input(s) voltage as measured in Clauses 7.3, Output Sound Pressure Level, and 7.5, Directional Characteristic, and;

c) The effects of each specific accessory on the sound pressure level and the directional characteristics of the device.

4.3 Installation wiring drawings shall include the following items:

a) Wire gauge related to circuit voltage and power rating;

b) Wiring method which shall be in accordance with:

1) In Canada, CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, Section 32;

2) In the United States, the National Electrical Code, NFPA 70, and the National Fire Alarm and Signaling Code, NFPA 72;

c) Wire connections to the audible signaling device, including equipment grounding by wire color code and identified terminals, as applicable.

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4.4 Instructions shall include a statement to caution against changing factory applied finishes.

4.5 The information required by 4.2 through 4.4 may be incorporated on the audible signal device if it is visible after installation. Alternatively it may be incorporated inside of the audible signal device if it is visible by opening the enclosure cover or by the removal of only field installed fasteners.

## 5 Construction

### 5.1 General

5.1.1 The construction of an audible signaling device for fire alarm or emergency use shall comply with the construction requirements contained in this section, unless, where permitted by test, the construction is determined to be equivalent to these requirements.

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

### 5.2 Enclosures

5.2.1 General

5.2.1.1 The frame and enclosure of an audible signaling device shall be sufficiently strong and rigid to resist the abuses to which it is likely to be subjected without adversely affecting its performance due to total or partial collapse with attendant reduction of spacings, loosening or displacement of parts and development of other conditions which could impair operation of the audible signaling device and increase the risk of fire or electrical shock. See Mechanical Strength Tests for Enclosures, 7.21.

5.2.1.2 Electrical parts or hazardous moving parts of an audible signaling device shall be located or enclosed to provide protection from unintentional contact with uninsulated live parts.

5.2.1.3 An audible signaling device intended to be installed on an outlet box or similar mounting enclosure, is to be judged with respect to compliance of the combination with the requirements of 5.2.1.1 and 5.2.1.2.

5.2.1.4 An operating part, such as a gear mechanism, light-duty relay, or similar device, shall be protected against mechanical damage and fouling by dust or other material which impairs its intended operation.

5.2.1.5 The enclosure of a device shall be provided with means for mounting in the intended manner. Any fittings, such as brackets, hangers, or similar hardware required for mounting shall be furnished with the device.

5.2.1.6 An enclosure shall have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable. Space shall be provided within a terminal or wiring compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required for installation. An enclosure without such provision is permitted when:

a) It is furnished with definite instructions indicating the sections of the enclosure which are intended to be drilled in the field for the connection of raceways, or

b) The device is intended for mounting on a standard outlet box that is listed or approved for the intended use.

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5.2.1.7 An audible signaling device intended for either flush or surface mounting in a back box shall use a standard listed enclosure that is listed or approved for the intended use or an enclosure which complies with the requirements of this standard.

5.2.1.8 An audible signaling device need not be furnished with a back box where means for attachment to a standard outlet box are provided and the spacings comply with Spacings, 5.8.

5.2.1.9 The mounting means of an audible signaling device to an enclosure shall be accessible without disassembly of any components not identified in the installation instructions of the audible signaling device. The mounting means shall be independent of those means used for securing components or parts of the assembly. Removal of a complete assembly is not considered to be disassembly of a component.

5.2.1.10 **(REV1)** An enclosure shall be constructed to minimize the possibility of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See Abnormal Operation and Burnout Test, 7.11A.

5.2.1.11 An audible signaling device of less than 23 kg (50.7 lb) mass may be arranged for mounting to an outlet box provided that, if the audible signaling device mass is more than 11 kg (24-1/4 lb), it is plainly marked as specified in Marking, Section 6.

5.2.1.12 An audible signaling device of more than 23 kg (50.7 lb) mass shall incorporate space or a compartment for field wiring and shall be provided with means for physical mounting and support by other than an outlet box.

5.2.2 Openings

5.2.2.1 Openings in the top of the enclosure shall be so constructed and shall be of such size that the entry of foreign objects is prevented.

5.2.2.2 To ensure compliance with 5.2.2.1, openings directly over uninsulated live parts or operating parts shall not exceed 5 mm (0.20 in) in any dimension unless the configuration of the opening prevents entry of foreign objects. See Figure 1, Cross Sections of Top Cover Designs, for examples of acceptable top cover designs.

5.2.2.3 Openings in the sides of the enclosure shall be so constructed and shall be of such size that entry of foreign objects, or contact by service personnel, is prevented. Louvers are acceptable if shaped to deflect external falling objects outward. See Figure 2, Cross Sections of Louver Designs, for examples of acceptable louver designs.

5.2.2.4 **(REV1)** Openings in the bottom of enclosures under materials that do not have a flammability rating of V-1 or better, may be permitted if constructed so that dropping through of material from the enclosure would be prevented.

The flammability rating shall be determined by the Flammability Classification Test:

a) In Canada, CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials;

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b) In the United States, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Figure 3, Cross Sections of Baffle Design, illustrates a type of baffle that meets this requirement. A second acceptable construction is a nominal 1 mm (0.039 in) thick sheet steel bottom panel in which 2 mm (0.078 in) diameter round holes are spaced no closer than 1.5 times the hole diameter, center to center. Other constructions are acceptable if the audible signaling device complies with 7.11A, Abnormal Operation and Burnout Test.

5.2.2.5 The bottom of an enclosure under materials that have a flammability rating of V-1 or better, may have openings providing they are not larger in area than 40 $mm^2$ (0.062 $in^2$).

5.2.2.6 An enclosure intended for recessed or semi-recessed mounting and having a front panel intended 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.

5.2.2.7 The requirement in 5.2.2.6 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) if:

a) No non-mounting purpose opening has dimension greater than 7 mm (0.275 in) or an area greater than 36 $mm^2$ (0.056 $in^2$);

b) There is no more than one unused mounting screw hole for each 300 mm (11.8 in) of length of mounting surface, or fraction thereof, and

c) An opening for mounting does not have a dimension of greater than 19 mm (3/4 in or an area greater than 430 $mm^2$ (0.667 $in^2$) or there are no more holes than needed for mounting of the product.

5.2.2.8 Enclosure openings which are exposed after installation shall not permit entrance of a 19 mm (3/4 in) diameter rod and shall be of such size and so arranged that a probe, as illustrated in Figure 4, Accessibility Probe, cannot be made to contact any uninsulated live electrical part, when inserted through the opening in a straight or articulated position.

5.2.2.9 In addition to the requirement of 5.2.2.8, enclosure openings which are exposed after installation shall be sized and so arranged that a straight rod of circular cross section 6.4 mm (0.25 inch) diameter with a hemispherical end cannot be made to contact any uninsulated live part and cannot damage any part of the audible signaling device by a push force of 4.5 N (1 lb-f) so as to impair operation, reduce electrical spacings or otherwise reduce the reliability of the audible signaling device.

5.2.2.10 Acoustical openings for a vandal-resistant audible signaling device (see also Marking, 6) shall not provide 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.

5.2.2.11 Openings in an enclosure, that are required for the proper acoustic performance of an appliance (including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers) and provide access to the sound-producing element, shall be of such size or shape that no opening will permit passage of a rod having a diameter of 6.7 mm (17/64 in).

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5.2.2.12 With reference to 5.2.2.11, the wires of a screen shall be not less than 16 AWG (1.3 $mm^2$). Except as noted in 5.2.2.13 perforated sheet steel and sheet steel employed for expanded-metal mesh shall be not less than 1.07 mm (0.042 in) in average thickness, 1.17 mm (0.046 in) if zinc coated.

5.2.2.13 Expanded-metal mesh, 0.53 mm (0.021 in) thick or 0.61 mm (0.024 in) thick if zinc-coated, may be used when all of the following conditions are met:

a) The mesh openings are not more than 1.6 $cm^2$ (1/4 $in^2$) in area,

b) The maximum dimension of the overall opening so protected is not greater than 76.2 mm (3 in), and

c) Indentation of the guard or enclosure does not impair performance or reduce spacings below the required values as given in 5.8, Spacings, between uninsulated live parts, or between uninsulated movable parts.

5.2.2.14 An opening for a gong-shell striker or similar part shall be not larger than is required for the operation of the appliance.

5.2.3 Cast Metal Enclosures

5.2.3.1 The thickness of cast metal for an enclosure shall be as indicated in Table 1, Cast Metal Enclosures.

*Exception: Cast metal of lesser thickness may be employed if, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See Mechanical Strength Tests for Enclosures, 7.21.*

5.2.3.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall be not less than 3.5 or more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

5.2.3.3 If 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 3.5 full threads in the metal and there shall be a smooth, rounded inlet hole which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

5.2.3.4 An audible signaling device assembly designed to be supported by rigid conduit shall be of sufficient strength to be able to support 5 times the weight of the audible signaling device assembly and comply with Mechanical Strength Test for Enclosures, 7.21. When provided with a conduit hub, or the equivalent, the hub shall have not less than 5 full threads.

5.2.3.5 Die-cast metal for other than flush boxes is permitted when it complies with one of the alloy specifications given in Specifications for Zinc-Alloy Die Castings, ANSI/ASTM B86-98.

5.2.3.6 Compliance of a zinc-base alloy die casting with the requirement of 5.2.3.5 is to be determined by the Standard Method of Spectrochemical Analysis of Zinc-Base Alloys and High-Grade Zinc by the Solution Residue-DC Arc Technique, ASTM E27-81.

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5.2.4 Sheet Metal Enclosures

5.2.4.1 The thickness of sheet metal employed for the enclosure of an audible signaling device shall be not less than that indicated in Table 2, Minimum Thickness of Sheet Metal.

*Exception: Sheet metal of lesser thickness may be employed if, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See Mechanical Strength Tests for Enclosures, 7.21.*

5.2.4.2 A plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

a) 0.36 mm (0.014 in) for steel or 0.43 mm (0.017 in) for nonferrous metal for a hole having a 6.4 mm (1/4 in) maximum dimension; and

b) 0.69 mm (0.027 in) for steel or 0.81 mm (0.032 in) for nonferrous metal for a hole having a 35 mm (1-3/8 in) maximum dimension.

5.2.4.3 A hole larger than 35 mm (1-3/8 in) diameter shall have a closure whose thickness is not less than that required for the enclosure of the audible signaling device or shall have a standard knockout seal. Such plates or plugs shall be securely mounted.

5.2.4.4 A knockout in a sheet metal enclosure shall be secured but shall be capable of being removed without undue deformation of the enclosure. See Mechanical Strength Tests for Enclosures, 7.21.

5.2.4.5 A knockout shall be provided with a surrounding surface area of sufficient size to permit seating of a conduit bushing, and shall be so located that a bushing employed at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated under Spacings, 5.8.

5.2.4.6 A sheet metal member to which a wiring system is to be connected in the field shall have a thickness not less than 0.81 mm (0.032 in) for uncoated steel, of not less than 0.86 mm (0.040 inch) for galvanized steel, and not less than 1.14 mm (0.045 in) for nonferrous metal.

5.2.4.7 At any point where conduit or metal-clad cable is to be attached, sheet metal shall be of such thickness or shall be so formed or reinforced that it has a stiffness at least equivalent to that of an uncoated flat steel sheet having a minimum thickness of 1.35 mm (0.053 in).

5.2.4.8 An enclosure intended for recessed mounting shall have no nonfunctional openings on any of the enclosed sides.

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5.2.5 Nonmetallic Enclosures

5.2.5.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be so formed 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 2, Minimum Thickness of Sheet Metal. Refer to Mechanical Strength Tests for Enclosures, 7.21.

5.2.5.2 The continuity of any grounding system to which an appliance is capable of being connected shall not rely on the dimensional integrity of the nonmetallic material.

5.2.5.3 Among the factors taken into consideration when judging the acceptability of a nonmetallic enclosure are the following:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability and resistance to ignition from electrical sources;

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

f) Resistance to distortion and creeping at temperatures to which the material may be subjected.

Note: All these factors are considered with respect to aging in accordance with the Tests on Polymeric (Plastic) Materials, 7.20.

5.2.6 Enclosure Cover

5.2.6.1 An enclosure cover shall be secured against opening or removal by means requiring the use of a common or special tool. A decorative cover or trim that, if removed, does not expose live electrical or mechanical parts is exempt from this requirement.

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5.2.7 Transparent Covers

5.2.7.1 Glass covering an observation opening shall:

a) Be tempered or similarly treated material to minimize potential injuries;

b) Be secured in place so that it cannot be displaced in service; and

c) Provide mechanical protection for the enclosed parts.

5.2.7.2 The thickness of a glass cover shall not be less than that indicated in Table 3 Thickness of Glass Covers.

5.2.7.3 A glass panel for an opening having an area of more than 929 $cm^2$ (144 $in^2$), or having any dimension greater than 305 mm (1 ft), shall be supported by a continuous groove not less than 4.8 mm (0.19 inch) deep along all four edges of the panel, or by an arrangement that has been determined to be equivalent.

5.2.7.4 A transparent material other than glass shall not be used for the cover of an observation opening unless the material does not introduce a risk of fire, distort, or become less transparent when subjected to varying temperatures under either normal or abnormal service conditions.

5.2.8 Outdoor Use Enclosures

5.2.8.1 **(REV1)** The enclosure of an audible signaling device intended for outdoor use shall incorporate the following:

a) Means for mounting designed to prevent water spray from entering the enclosure. See Water Spray, 7.17;

b) A gasket shall be of material which will resist moisture and shall be cemented, pinned, or otherwise secured to one of the contacting surfaces, and

c) Holes for conduit that shall be threaded unless they are located below the lowest termination point or other live part within the enclosure. If knockouts or unthreaded holes are provided , there shall be provision for drainage of the enclosure.

5.2.8.2 A surface mount enclosure intended for outdoor use shall be provided with external means for mounting.

*Exception: Internal means for mounting may be employed if constructed so as to prevent water from entering the enclosure.*

5.2.8.3 For outdoor use, an enclosure of sheet steel less than 3.04 mm (0.12 in) in thickness, 3.18 mm (0.125 in) or less if zinc coated, shall be galvanized by the hot-dip process after forming and assembly, or shall be made from hot-dipped sheets, or shall be provided with a coating which is at least the equivalent, with respect to corrosion protection, of zinc applied by the hot-dip process.

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## 5.3 Corrosion Protection

5.3.1 Ferrous metal, iron and steel parts other than bearings and similar parts where such protection is impractical, shall be protected against corrosion by enamelling, galvanizing, plating, or other equivalent means. Refer to Accelerated Corrosion Tests, 7.16.

*Exception No. 1: This requirement does not apply to parts such as washers, screws, bolts, and the like, if failure of such unprotected parts would not be likely to result in a risk of fire or electrical shock, or affect the performance of the audible signaling device.*

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

5.3.2 The requirement of 5.3.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend.

5.3.3 Bearing surfaces shall be of such materials and design as to resist binding due to corrosion.

5.3.4 Metal shall not be used in combinations such as to cause galvanic action.

5.3.5 Cabinets and enclosures of corrosion-resistant material may be employed without special corrosion protection.

## 5.4 Field Wiring Connections

5.4.1 General

5.4.1.1 Wiring terminals or leads corresponding to the rating of the device shall be provided for connection of conductors of at least the size required by:

a) In Canada, CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, Section 32;

b) In the United States, the National Electrical Code, NFPA 70.

5.4.1.2 Wiring terminals shall be prevented from turning.

5.4.1.3 The terminals to which wiring connections are made shall consist of binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections may be provided if found to be equivalent.

5.4.1.4 Dual terminals, dual leads, or equivalent means to achieve electrical supervision, shall be provided for each incoming and each outgoing circuit connection. A common terminal may be used for connection of both incoming and outgoing wires, provided that the construction of the terminal does not permit an uninsulated section of a single conductor to be looped around the terminal and serve as two separate connections, thereby precluding supervision of the connection in the event that the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors of a notification appliance (signaling device) circuit are intended to be inserted in each notch, is acceptable, but this arrangement shall be supplemented by additional marking in the wiring area or on the installation wiring diagram specifying the intended connections to the terminals.

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5.4.2 Field Wiring Compartment

5.4.2.1 The field wiring compartment in which connections are made shall be of sufficient size for accommodating all wiring connections specified by the installation wiring drawing without damage to wire insulation or to internal components. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required.

5.4.2.2 The device wiring and internal components in the wiring area of an audible signaling device designed for mounting to an outlet box shall be so located or protected so that, they and the field wiring in the outlet box are not forced against sharp edges to prevent damage.

5.4.2.3 An outlet box or compartment in which field wiring connections are to be made shall be located such that the connections may be inspected after the audible signaling device is installed as intended. The removal of only field installed fasteners, or equivalent arrangement and dismounting of an assembly, of not more than 4.5 kg (10 lb) mass to view the field wiring connections, is deemed to comply with this requirement.

5.4.2.4 An audible signaling device without a field wiring compartment shall be constructed so that the following requirements are met:

a) Field wiring and leads shall be prevented from contacting moving parts of the audible signaling device when such contact would result in damage to the wire insulation or interfere with the operation of the device;

b) Field wiring and leads shall be prevented from contacting parts of the audible signaling device, which under any condition of operation may achieve a temperature exceeding the temperature rating of the wire or lead insulation. See Temperature Rise, 7.6; and

c) Field wiring and leads shall be prevented from contacting uninsulated live parts which under any condition of operation may be at a potential exceeding the voltage rating of the wire or lead insulation. Refer to Separation of Circuits, 5.5.2, and Spacings, 5.8.

5.4.3 Field Wiring Terminals and Leads

5.4.3.1 Types and Sizes

5.4.3.1.1 Terminals for field connection of conductors larger than 10 AWG (5.3 $mm^2$) shall consist of nonferrous soldering lugs or nonferrous solderless (pressure) wire connectors.

5.4.3.1.2 Terminals for field connection of conductors 10 AWG (5.3 $mm^2$) or smaller may consist of means for clamping the conductor if such means are constructed so that:

a) They will firmly grip the conductors and securely hold them in place; and

b) Solid conductors cannot come out from under the clamping means even though the latter is loosened sufficiently to allow lateral movement of the conductors with respect to the means.

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5.4.3.2 Size of Screws

5.4.3.2.1 If binding head screws or machine screws and washers are used as clamping means for conductors, the size of screw shall be not less than:

a) No. 8 or M4 if for use with conductors 14 AWG (2.1 $mm^2$) or larger;

b) No. 6 or M3.5 if for use with conductors 14 AWG (2.1 $mm^2$) or smaller and 18 AWG (0.82 $mm^2$)or larger; or

c) No. 4 or M3 if for use with conductors 18 AWG (0.82 $mm^2$).

5.4.3.3 Material for Terminal Parts

5.4.3.3.1 Binding head screws, bolts, studs, nuts and washers shall be of nonferrous metal except that in sizes 10 AWG (5.3 $mm^2$), M5 or larger, iron or steel may be used if:

a) Such parts are suitably protected with a plating of cadmium, zinc, or equivalent material; and

b) The conductor or terminal to be secured is clamped against a surface of nonferrous metal which will carry the greater part of the current.

5.4.3.4 Terminal Plates and Threading

5.4.3.4.1 Wiring terminal screws shall thread into metal.

5.4.3.4.2 The threading of binding head screws and machine screws, other than wiring terminal screws, into material other than metal are not prohibited from being used when determined to be equivalent in terms of mechanical secureness and conductivity.

5.4.3.4.3 Terminal plates through which binding head screws or machine screws are threaded shall have a thickness at least equal to twice the pitch of the thread of the screw, but not less than 0.762 mm (0.03 in), and shall have at least 2 complete clean-cut full threads.

5.4.3.4.4 Terminal plates for solderless connectors or solderless lugs shall:

a) Have a thickness of not less than 1.27 mm (0.050 in) for a No. 8, M4 or larger screw, and not less than 0.76 mm (0.030 in) thick for a No. 6 M3.5 screw;

b) Have at least 2 complete full threads, if threaded; and may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads; and

c) Provide contact areas, such that the full contact area of the tongue of the largest lug which would normally be used will be properly utilized.

5.4.3.4.5 Screws engaging threaded holes in plates shall have not less than two full threads engaging under any condition of service.

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5.4.3.4.6 If terminal screws do not pass entirely through threaded holes, they shall engage clean-cut full threads for a distance not less than the major diameter of the screw.

5.4.3.5 Grounding Terminals and Leads

5.4.3.5.1

For an appliance intended for connection to an AC Mains source of supply, only by means of other than a metal-enclosed wiring system such as nonmetallic-sheathed cable, all of the following shall be provided:

a) An equipment grounding terminal or lead, the size of which shall be the same as that of the supply terminal or lead, but in no case less than 18 AWG (0.82 $mm^2$),

b) A marking to indicate the system or systems for which it is intended, and

c) Reliable connection of the grounding means to all exposed dead metal parts that are likely to become energized, and all dead metal parts within the enclosure that are exposed to contact during servicing and maintenance.

5.4.3.5.2 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 leads visible to the installer, other than the grounding conductors, shall be so identified.

5.4.3.5.3 A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, with the marking “G”, “GR”, “GROUND”, “GROUNDING”, or by the graphic symbol 5019 from IEC publication 60417-1, ⏚ , or the equivalent, or by a marking on a wiring diagram provided on the appliance. The field wiring terminal shall be located so that it is unlikely to be removed during servicing of the appliance.

5.4.3.6 Grounded Supply Terminals and Leads

5.4.3.6.1 A field wiring terminal for the connection of the grounded supply conductor of a AC Mains supply circuit shall be identified by means of a white metallic-plated coating and shall be distinguishable from the other terminals. Otherwise, identification of the terminal for the connection of the grounded conductor shall be shown in some other manner, such as on an attached connection diagram.

5.4.3.6.2 A field wiring lead provided for connection of the grounded supply conductor of a AC Mains supply circuit shall be finished white or gray and shall be distinguishable from other leads. No other leads visible to the installer, other than grounded conductors, shall be so identified.

5.4.3.6.3 A terminal or lead identified for the connection of the grounded supply conductor shall not be electrically connected either to a single-pole manual switching device that has an ″off″ position or to a single-pole overcurrent (not thermal) protective device.

5.4.3.6.4 Terminals which are intended for direct connection to either a grounded conductor or a neutral conductor of a supply circuit shall be identified. They shall be substantially white in colour if colour coded, or be marked ″N″ or ″Neutral″, or ″W″ or ″White″, either on or adjacent to the terminal.

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5.4.3.7 Field Wiring Leads

5.4.3.7.1 Leads provided for field connections shall be:

a) Stranded copper bunch tinned in accordance with

1) In Canada, CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, Rule 32-100

2) In the United States, the National Electrical Code, NFPA 70;

b) Not less than 150 mm (6 in) in length;

c) Not smaller than 18 AWG (0.82 $mm^2$);

d) The insulation, if of rubber or plastic, not less than 0.8 mm (0.032 inch) in thickness; and

e) Provided with strain relief. See Strain Relief, 7.15.

5.4.3.7.2 Leads which are intended for direct connection to either a grounded conductor or a neutral conductor of a supply circuit shall be identified at the point of supply connection. Identification shall be a white or natural grey covering readily distinguishable from the finish on other leads and no other lead shall be so identified.

## 5.5 Internal Wiring

5.5.1 General

5.5.1.1 Wiring shall have insulation rated for the potential involved and the temperatures to which it may be subjected, and shall have adequate mechanical strength and current-carrying capacity for all conditions of service. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string, ties, or the equivalent, unless the wiring is capable of retaining a shaped form.

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

5.5.1.3 If the use of of an insulated conductor is not feasible (for example a coil lead), electrical insulating tubing complying with CSA 22.2 No. 198.1, or UL 224 , Extruded Insulating Tubing, may be employed. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners.

5.5.1.4 Insulation, such as coated fabric and extruded tubing, shall not be affected physically or electrically by the temperature or other environmental conditions to which the insulation may be subjected to during the intended use of the audible signaling device.

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5.5.1.5 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, which may cause abrasion of the conductor insulation.

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

5.5.1.7 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands bunch-tinned or equivalently arranged.

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

5.5.1.9 A splice shall be located, enclosed, and supported so that it is not subject to damage from flexing, motion, or vibration.

5.5.2 Separation of Circuits

5.5.2.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers, clamps, routing, spacing (refer to Table 4, Minimum Spacings), or other equivalent means, unless all conductors are provided with insulation rated for the highest potential involved.

5.5.2.2 A metal barrier used to provide separation between the wiring of different circuits shall have a thickness at least equal to that required by Table 2, Minimum Thickness of Sheet Metal, as determined by the size (width and length) of the barrier. A barrier of insulation material shall be not less than 0.71 mm (0.028 inch) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall be not more than 1.6 mm (0.063 inch).

## 5.6 Bonding for Grounding

5.6.1 An exposed dead metal part that could become energized shall be bonded to the point of connection of the equipment grounding terminal or lead and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connections.

*Exception No. 1: An adhesive-attached metal-foil marking, screw, handle, or similar material is not required to be bonded when located on the outside of an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that it is not likely to become energized.*

*Exception No. 2: An isolated metal part, such as a motor-controller magnet frame or armature or a small assembly screw, is not required to be bonded when positively separated from wiring and uninsulated live parts.*

*Exception No. 3: A panel or cover that does not enclose uninsulated live parts is not required to be bonded when wiring is separated from the panel or cover so that it will not become energized.*

*Exception No. 4: A panel or cover is not required to be bonded when it is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (1/32 inch) thick and secured in place.*

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5.6.2 An uninsulated dead metal part of a cabinet, electrical enclosure, motor-frame or mounting bracket, controller mounting bracket, capacitor or other electrical components, shall be bonded for grounding if it may be contacted by the user or by service personnel servicing the equipment.

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

5.6.4 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.

5.6.5 A bolted or screwed connection that incorporates a star washer or serrations under the screwhead is acceptable for penetrating nonconductive coatings where required for compliance with 5.6.1.

5.6.6 When the bonding means depends upon screw threads, the use of two or more screws or two full threads of a single screw engaging metal complies with 5.6.1.

5.6.7 A metal-to-metal hinge-bearing member of a door or cover is acceptable as a means for bonding the door or cover for grounding, provided that a multiple bearing-pin type (piano-type) hinge is employed.

5.6.8 The size of a copper or aluminum conductor employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device by which the appliance will be protected. The size of the conductor shall be in accordance with Table 5, Bonding Wire Conductor Size

5.6.9 A conductor, such as a clamp or strap, may be used in place of a separate wire conductor, provided that the minimum cross-sectional conducting area of the bonding means is not less than that of the wire indicated in Table 5, Bonding Wire Conductor Size.

5.6.10 A splice shall not be employed in a wire conductor used for bonding.

5.6.11 The grounding means shall be used for no other purpose.

**5.7 Components – Electrical**

5.7.1 Mounting of Components

5.7.1.1 All stationary parts of an audible signaling device, which support moving components, shall be securely mounted in position and prevented from loosening or turning.

5.7.1.2 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position, if such motion may result in a reduction of spacings below the minimum values required. Refer to Spacings, 5.8.

5.7.1.3 Friction between surfaces is not acceptable as a means to prevent turning, loosening, or shifting of a part as required in 5.7.1.1 and 5.7.1.2, but a toothed lock washer that provides both spring take-up and an interference lock or equivalent means is acceptable.

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5.7.1.4 An uninsulated live part, such as a field wiring terminal, shall be secured to its supporting surface or surfaces by methods other than friction between surfaces if turning or shifting in position may result in a reduction of spacings below the minimum values required. The part shall be secured by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

5.7.1.5 A plunger contact, diaphragm assembly, or other part intended to be non-moving while supporting components shall be mounted in position and prevented from loosening or turning by means other than friction between surfaces.

5.7.1.6 A gong shell, when provided, shall be mechanically secured, and the gong-shell mounting screw shall be prevented from loosening.

5.7.1.7 When a gong shell must be removed for mounting or connecting the appliance, the intended position of the shell with respect to its support shall be indicated on the appliance, unless either:

a) The gong-shell striking means engages the shell in any position of mounting, or

b) Means are provided to engage the gong shell in the intended position of mounting.

5.7.2 Insulating Materials

5.7.2.1 Materials used for the support of current-carrying parts shall be non-flammable, moisture-resistant insulating material, such as porcelain, phenolic or cold-moulded composition, or the equivalent.

5.7.2.2 Among the factors to be considered in judging electrical insulation are mechanical and electrical strength, resistance to burning, moisture, arcing, creep (flow due to stress), thermal endurance and resistance to temperatures encountered in intended use.

5.7.2.3 A terminal block mounted on a metal surface that may be grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base, unless the parts are staked, upset, sealed, or equivalently secured to prevent movement of the parts at the ends of replaceable terminal screws from reducing spacings below the minimum values required.

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

5.7.2.5 Polymeric materials may be used for the sole support of uninsulated live parts if found to be equivalent to the materials indicated in 5.7.2.4.

5.7.2.6 A countersunk sealed live part shall be covered with a waterproof insulating compound which will not melt at a temperature 15°C (59°F) higher than the maximum normal operating temperature of the assembly, and at not less than 65°C (149°F) in any case. The depth or thickness of sealing compound shall be not less than 3.2 mm (1/8 in).

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5.7.2.7 The thickness of a flat sheet of insulating material, such as impregnated asbestos-cement composition or phenolic composition employed for panel mounting of parts shall be not less than that specified in Table 6, Thickness of Flat Sheets of Insulating Material.

5.7.3 Current-Carrying Parts

5.7.3.1 A current-carrying part shall be of silver, copper, a copper alloy, or the equivalent.

5.7.3.2 Bearings, hinges, or similar parts are not acceptable for carrying current between interrelated fixed and moving parts.

5.7.3.3 Plated steel shall not be used for secondary-circuit parts nor for primary-circuit parts, such as capacitor terminals, unless a glass-to-metal seal is necessary, nor for leads or threaded studs of semiconductor devices. Blued steel or steel with corrosion resistance that has been determined to be equivalent is acceptable for the following:

a) The current-carrying arms of mechanically- or magnetically-operated leaf switches;

b) Within a motor and motor governor, including the motor terminals; or

c) When the temperatures exceed 100°C (212°F) during the intended operation.

5.7.4 Bushings

5.7.4.1 Where a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating bushing, or the equivalent, that shall be secured in place and have a smooth rounded surface against which the wire may bear.

5.7.4.2 If the opening is located in a phenolic composition or other equivalent nonconducting material or in metal of thickness greater than 1.07 mm (0.042 in), a smooth rounded surface having rounded edges is deemed to be the equivalent of a bushing.

5.7.4.3 Ceramic materials and some molded compositions are permitted for insulating bushings, but separate bushings of wood and of hot-molded shellac are not permitted.

5.7.4.4 A fiber bushing may be used if:

a) It will not be subjected to a temperature higher than 90°C (194°F) under intended operating conditions,

b) The bushing is not less than 1.2 mm (3/64 in) thick, and

c) The fiber will not be exposed to moisture.

5.7.4.5 Ordinary vulcanized fiber may be employed where it will not be subjected to a temperature higher than 90°C (194°F) under intended operating conditions if the bushing is not less than 1.2 mm (3/64 in) in thickness and if it will not be exposed to moisture.

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

5.7.4.7 An insulating-metal grommet is acceptable in lieu of an insulating bushing, provided that the insulating material used is not less than 0.8 mm (0.032 in) in thickness and completely fills the space between the grommet and the metal in which it is mounted.

5.7.5 Semiconductors

5.7.5.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. Refer to Performance Tests, Section 7.

5.7.6 Transformers, Relays, and Coils

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

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

5.7.7 Capacitors

5.7.7.1 Capacitors shall be rated for the intended application under all environmental conditions to which they may be exposed in service.

5.7.7.2 Capacitors shall be suitable for the purpose. There shall be no failure of the capacitors when the product is subjected to Temperature Rise, 7.6 and Endurance, 7.8. The measured peak voltage across the capacitor shall not exceed the voltage stress level as specified in Component Stress, 7.12.

5.7.8 Operating Parts

5.7.8.1 Operating parts of an appliance shall be located or protected so that their function is not impaired by any wiring operation within the enclosure.

5.7.8.2 A cam or similar part shall be mechanically fastened so that independent turning or loosening is prevented.

5.7.8.3 An operating component or assembly, such as a switch or relay, shall be protected by an individual cover or dust-tight cabinet against fouling by dust or by other material that may impair its operation. A relay using contacts having a wiping action does not require any special protection against fouling by dust.

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

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5.7.8.5 An adjusting screw or similar adjustable part shall be prevented from loosening under the conditions of actual use.

5.7.8.6 A manually operated part shall withstand the stresses to which it is subjected to in operation.

5.7.8.7 Interrelated operating parts shall be formed and assembled so that their alignment is maintained.

5.7.8.8 Gears shall have uniformly formed teeth with smooth engaging surfaces, and shall be reliably secured in place.

5.7.8.9 The assembly of an operating mechanism included as a part of a product shall be such that it will not be adversely affected by any condition of intended operation.

5.7.9 Connectors and Receptacles

5.7.9.1 A receptacle or connector shall be rated for the current and voltage to which it is subjected.

5.7.10 Printed Wiring Boards

5.7.10.1 Printed wiring boards shall comply with the Standard for Printed Wiring Boards, UL 796. The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements for rigidly clamped assemblies (see Table 4, Minimum Spacings). The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a reduction of electrical spacings to less than those required in this standard. 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.

5.7.11 Motors

5.7.11.1 A motor shall be protected against overheating under normal and abnormal operating conditions.

5.7.11.2 A motor shall be protected by thermal or overcurrent protective devices or shall be of the impedance-protected type. See the Locked Rotor Test, 7.26. A thermal or overcurrent protective device shall not open the circuit during the Temperature Rise, 7.6.

5.7.11.3 A motor having openings in the enclosure or frame shall be arranged so that flaming or glowing particles dropping out of the motor will not fall onto flammable material within or under the appliance.

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