UL 1638

STANDARD FOR SAFETY

Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories

UL Standard for Safety for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 1638

Sixth Edition, Dated April 27, 2023

Summary of Topics

This Sixth Edition of ANSI/UL 1638 dated April 27, 2023 has been issued to incorporate changes from proposals dated June 6, 2022 and November 4, 2022.

The new requirements are substantially in accordance with Proposal(s) on this subject dated June 6, 2022 and November 4, 2022.

No Text on This Page

ULC Standards
Normes ULC

ULC Standards
CAN/ULC 526:2023
Fifth Edition

ULSE Inc.
ANSI/UL 1638
Sixth Edition

VISIBLE SIGNALING DEVICES FOR FIRE ALARM AND SIGNALING SYSTEMS, INCLUDING ACCESSORIES

April 27, 2023

Approved American National Standard
ANSI

ANSI/UL 1638-2023

NATIONAL STANDARD OF CANADA
STANDARDS COUNCIL OF CANADA
CONSEIL CANADIEN DES NORMES
NORME NATIONALE DU CANADA

Commitment for Amendments

This Standard is issued jointly by ULSE Inc. (ULSE) and ULC Standards. Amendments to this Standard will be made only after processing according to the Standards writing procedures by ULSE and ULC Standards.

ISSN 0317-526X Copyright © 2023 ULC Standards

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

This ANSI/UL Standard for Safety consists of the Sixth Edition. The most recent designation of ANSI/UL 1638 as an American National Standard (ANSI) occurred on April 27, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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

For information on ULSE Standards, visit http://www.shopulstandards.com, call toll free 1-888-853-3503 or email us at ClientService@shopULStandards.com.

CONTENTS

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKINGS

INSTRUCTIONS

SPECIALIZED REQUIREMENTS/APPLICATIONS

ANNEX A (Normative) – STANDARDS FOR COMPONENTS

ANNEX B (Normative) – FRENCH TRANSLATIONS OF REQUIRED MARKINGS

ANNEX C (Informative) – TEST SAMPLE SEQUENCE

No Text on This Page

Preface

This is the common ULSE and ULC Standard for Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories. It is the fifth edition of CAN/ULC 526 and sixth edition of UL 1638.

This common Standard was prepared by UL Standards & Engagement Inc. (ULSE), ULC Standards, and the NEMA Technical Harmonization Committee on Notification Appliances. The standard was formally approved by the ULSE Technical Committee 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, ULSE Technical Committee, and 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.

Annex C is identified as informative and is for informational purposes only.

Annexes A and B 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.

No Text on This Page

INTRODUCTION

1 Scope

1.1 This Standard applies to visual signaling devices intended for indoor and/or outdoor installation:

a) In Canada only: in accordance with CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations; and with ULC-S524, Standard for Installation of Fire Alarm Systems.

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

1.2 These requirements cover visible signal devices for use in ordinary (non-hazardous) indoor locations and outdoor locations. This includes:

a) Flashing visual devices used for fire alarm or emergency signaling in both public mode and private mode as defined in the glossary;

b) Emergency warning used to notify occupants that an emergency exists; and

c) Informative type visual signaling devices connected to or controlled by fire alarm or other emergency signaling system equipment, or both.

1.3 This Standard also applies to protective covers and accessories used with visible signals.

1.4 This Standard does not apply to visual signaling devices not intended for emergency signaling applications and intended for operation on Class 2 signal circuits as defined in:

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

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

1.5 Visible 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 only: CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, with respect to the location hazard.

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

NOTE: In the United States, general signaling appliances are covered by UL 464A.

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

a) The Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, ULC 525 and UL 464; and

b) The Standard for Speakers for Fire Alarm and Signaling Systems, Including Accessories, ULC 541 and UL 1480.

2 Components

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

2.2 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.

2.3 A component shall be used in accordance with rating(s) established by its manufacturer for the intended conditions of use.

3 Units of Measurement

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

4 Referenced Publications

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

4.2 The following publications are referenced in this Standard:

ASTM B86, *Specifications for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings*

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

ASTM E28, *Standard Test Methods for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus*

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

CSA C22.2 No. 0.4, *Bonding of Electrical Equipment*

CSA C22.2 No. 0.15, *Adhesive Labels*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 77, *Motors with Inherent Overheating Protection*

CSA C22.2 No. 198.1, *Extruded Insulating Tubing*

CSA C22.2 No. 60065, *Audio, Video, and Similar Electronic Apparatus – Safety Requirements*

CSA C22.2 No. 60086-4, *Primary Batteries – Part 4: Safety of Lithium Batteries*

IEC 60417, *Graphical symbols for use on equipment*

NFPA 70, *National Electrical Code*

NFPA 72, *National Fire Alarm and Signaling Code*

UL 224, *Extruded Insulating Tubing*

UL 464A, *Audible Signal Appliances for General Signaling Use*

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 985, *Household Fire Warning System Units*

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

UL 1004-2, *Impedance Protected Motors*

UL 1004-3, *Thermally Protected Motors*

UL 1642, *Lithium Batteries*

UL 2054, *Household and Commercial Batteries*

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

UL 60086-4, *Primary Batteries – Part 4: Safety of Lithium Batteries*

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*

UL 464/ULC 525, *Audible Signal Devices for Fire Alarm and Signaling Systems, Including Accessories*

UL 1480/ULC 541, *Speakers for Fire Alarm and Signaling Systems, Including Accessories*

ULC-S142, *Fire Test for Heat and Visible Smoke Release for Discrete Products*

ULC-S524, *Installation of Fire Alarm Systems*

ULC 527, *Control Units for Fire Alarm Systems*

ULC-S545, *Residential Fire Warning System Control Units*

5 Glossary

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

5.1 CANDELA – For the purpose of this Standard, the light output of a flashing light is measured with an integration radiometer and the summation of light intensity over time (Idt) is used in the following equation to determine the effective light intensity. The candela (cd) value assigned to a flashing light is calculated and corresponds to the same value of candela of a fixed light operating under identical conditions of observation, color, size, and shape:

$$cd = \frac{(ldt)}{(0.2 + t_2 - t_1)}$$

In which:

Idt is the measured lumens recorded by the photometer over time for ten consecutive pulses

0.2 is two-tenths of 1 s, the value which represents night-time threshold effective illumination as specified in the Illuminating Engineering Society of North America Lighting Handbook

$t_2 - t_1$ represents the time period of the light pulse.

5.2 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.

5.3 CRITICAL ANGLE – The five-degree (5°) dispersion angle that has the lowest ratio of measured light output to minimum required light output for all five-degree increments within the plane of measurement. This angle is identified by comparison of all ratios of measurements obtained within the plane during the tests specified in Section 20, Measurement of Effective Luminous Intensity (Light Output). All ratios of measured light to required minimum light shall be equal to or greater than 1. For example:

Ratio = Measured light/minimum required light

15 cd / 12 cd

5/4 = 1.25

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

5.5 EFFECTIVE LUMINOUS INTENSITY – The quantity of directly perceived light produced by a visible signal device, measured in candela (cd).

5.6 EMERGENCY WARNING – A private mode visual signal used to indicate an emergency situation requiring attention, but not a fire evacuation.

5.7 FIRMWARE – A control program that is embedded in the notification appliance.

5.8 FLASH DURATION – The light pulse duration, as measured between the 10 % of peak amplitude for the leading and trailing edges of the light wave envelope in seconds.

5.9 INFORMATIVE – Textual, visual signaling controlled by fire alarm or other emergency signaling system equipment, or both.

5.10 LUMINANCE – The luminous intensity per unit area, measured in candela per square meter.

5.11 MANUFACTURER'S PUBLISHED INSTRUCTIONS – Published installation and operating documentation provided for each product or component. The documentation includes directions and necessary information for the intended installation, maintenance, and operation of the product or component.

(Reproduced with permission of NFPA from NFPA 72®, *National Fire Alarm and Signaling Code*, 2022 edition. Copyright© 2021, National Fire Protection Association. For a full copy of NFPA 72®, please go to www.nfpa.org.)

(NFPA 72® and *National Fire Alarm and Signaling Code*® are registered trademarks of the National Fire Protection Association, Quincy, MA. All rights reserved.)

5.12 PRIMARY BATTERY – A battery which can only be discharged once. It is not designed to be rechargeable and must be protected from a charging current.

5.13 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.

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

5.15 REFERENCE AXIS – The "reference axis" of a visible signaling device is a line passing through the reference point coincident with the geometrical axis of the light propagation pattern. For symmetrical structures, the reference axis is usually perpendicular to a plane passing through the edge of the light source.

5.16 REFERENCE POINT – The “reference point” of a visible signaling device is a point on the outside of the visible signal device in line with the geometrical center of the light source projected perpendicular to a plane passing through the edge of the light source.

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

5.18 SECONDARY BATTERY – A battery that is intended to be discharged and recharged many times in accordance with the manufacturer's recommendations.

5.19 SOFTWARE – A program that is used to program a notification appliance’s function and or its performance through the device’s firmware.

5.20 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.

5.21 TROUBLE SIGNAL – A visual, audible, or transmitted signal indicating a fault condition associated with a notification appliance.

6 Control Unit Interface

6.1 A visible signaling device incorporating circuitry for functional interfacing with a control unit for purposes such as supervision, point addressing, multiplexing, synchronization, wireless communication etc., shall also comply with the applicable functional requirements of standards such as:

a) In Canada only:

1) ULC 527; and

2) ULC-S545.

b) In the United States only:

1) UL 864; and

2) UL 985.

7 Visible Signal Pattern

7.1 Unless otherwise specified, the light output propagation pattern of a visible signaling device shall comply with the application requirements in Section 20, Measurement of Effective Luminous Intensity (Light Output).

CONSTRUCTION

8 General

8.1 The construction of a visible 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.

8.2 Unless otherwise indicated, the construction requirements specified for a product shall also apply to any accessories with which it is to be used.

9 Enclosures

9.1 General

9.1.1 The frame and enclosure of a visible 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 visible signaling device and increase the risk of fire or electrical shock. Refer to Mechanical Strength Tests for Enclosures, Section 38.

9.1.2 Electrical parts or hazardous moving parts of a visible signaling device shall be located or enclosed to provide protection from unintentional contact with uninsulated live parts.

9.1.3 A visible 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 9.1.1 and 9.1.2.

9.1.4 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.

9.1.5 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.

9.1.6 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 has been evaluated and or approved for the intended use.

9.1.7 A visible signaling device intended for either flush or surface mounting in a back box shall use a standard enclosure that has been evaluated for the intended use or an enclosure which complies with the requirements of this Standard.

9.1.8 A visible 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 Section 15, Spacings.

9.1.9 The mounting means of a visible signaling device to an enclosure shall be accessible without disassembly of any components not identified in the manufacturer's published instructions of the visible 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.

9.1.10 An enclosure shall be constructed to minimize the possibility of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See Section 28, Abnormal Operation and Burnout Test.

9.1.11 A visible signaling device of less than 23 kg (50.7 lb) mass may be arranged for mounting to an outlet box provided that, if the visible signaling device mass is more than 11 kg (24-1/4 lb), it is plainly marked as specified in Markings, Section 46.

9.1.12 A visible 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.

9.2 Cast metal enclosures

9.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 9.1.

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 Section 38, Mechanical Strength Tests for Enclosures.

Table 9.1
Cast Metal Enclosures

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

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

9.2.2 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.

9.2.3 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.

9.2.4 A visible 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 visible signaling device assembly and comply with Mechanical Strength Test for Enclosures, Section 38. When provided with a conduit hub, or the equivalent, the hub shall have not less than 5 full threads.

9.2.5 Die-cast metal for other than flush boxes is permitted when it complies with one of the alloy specifications given in ASTM B86.

9.3 Sheet metal enclosures

9.3.1 The thickness of sheet metal employed for the enclosure of a visible signaling device shall be not less than that indicated in Table 9.2.

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 Section 38, Mechanical Strength Tests for Enclosures.

Table 9.2
Minimum Thickness of Sheet Metal

Maximum dimensions of enclosure					Minimum thickness of sheet metal					
					Steel				Copper, brass or aluminum,	
Group	Length or width,		Area,		Zinc-coated,		Uncoated,			
	mm	(in)	cm^2	(in^2)	mm	(in)	mm	(in)	mm	(in)
A	76.2	(3)	39[a]	(6)	0.64[b]	(0.025)	0.53[b]	(0.021)	0.58[c]	(0.023)
B	203	(8)	232	(36)	0.76[b,d]	(0.030)	0.69[b,d]	(0.027)	0.91[d]	(0.036)
C	305	(12)	581	(90)	0.86[d]	(0.034)	0.81[d]	(0.032)	1.14[d]	(0.045)

[a] Volume of enclosure not more than 197 cm^3 (12 in^3).

[b] Sheet steel for an enclosure intended for outdoor use (rain-tight) is required to be not less than 0.91 mm (0.036 in) in thickness if zinc coated and not less than 0.81 mm (0.032 in) in thickness if uncoated.

[c] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (rain-tight) is required to be not less than 0.74 mm (0.029 in) in thickness.

[d] For a cover in Group B or C having a supporting frame or equivalent reinforcing and not intended for outdoor use, the thickness of sheet steel may be less than that specified in the table but shall be not less than 0.53 mm (0.021 in) [00.64 mm (0.025 in) if zinc coated], and the thickness of copper, brass, or aluminum may be less than that specified in the table but shall be not less than 0.74 mm (0.029 in).

9.3.2 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.

9.3.3 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 visible signaling device or shall have a standard knockout seal. Such plates or plugs shall be securely mounted.

9.3.4 A knockout in a sheet metal enclosure shall be secured but shall be capable of being removed without undue deformation of the enclosure. See Section 38, Mechanical Strength Tests for Enclosures.

9.3.5 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 Section 15, Spacings.

9.3.6 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 in) for galvanized steel, and not less than 1.14 mm (0.045 in) for nonferrous metal.

9.3.7 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).

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

9.4 Nonmetallic enclosures

9.4.1 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 9.2. Refer to Section 38, Mechanical Strength Tests for Enclosures.

9.4.2 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.

9.4.3 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 Section 37, Tests on Polymeric (Plastic) Materials.

9.5 Outdoor use enclosures

9.5.1 The enclosure of a visible signaling device intended for outdoor use shall incorporate the following:

a) Means for mounting designed to prevent water spray from entering the enclosure. See Section 34, Water Spray Test;

b) 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.

9.5.2 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.

9.5.3 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.

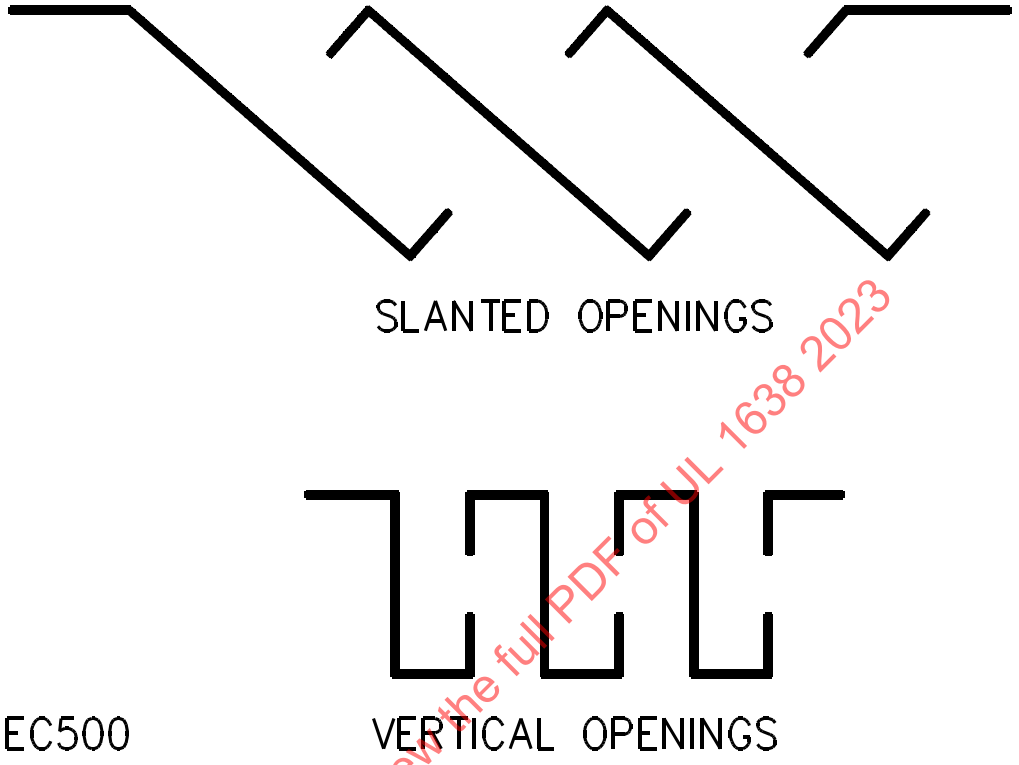
9.6 Openings

9.6.1 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.

9.6.2 To ensure compliance with 9.6.1, 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 9.1 for examples of acceptable top cover designs.

Figure 9.1

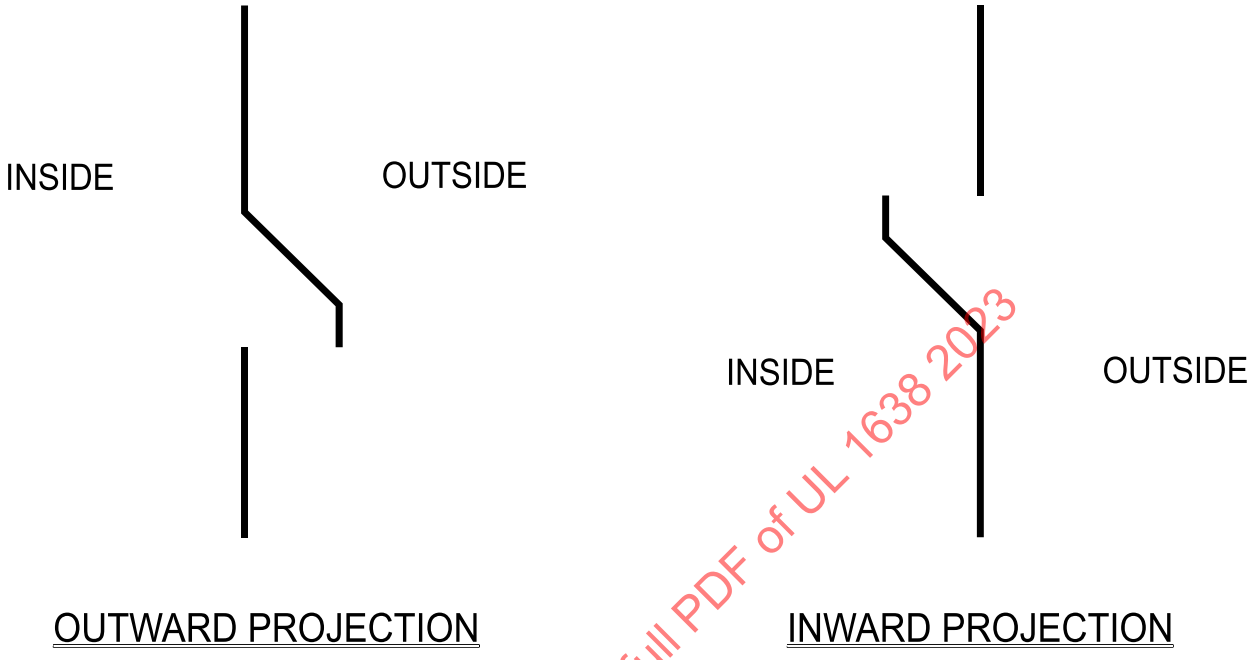
Cross-Sections of Top Cover Designs



9.6.3 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 9.2 for examples of acceptable louver designs.

Figure 9.2

Cross-Sections of Louver Designs



su1626

9.6.4 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:

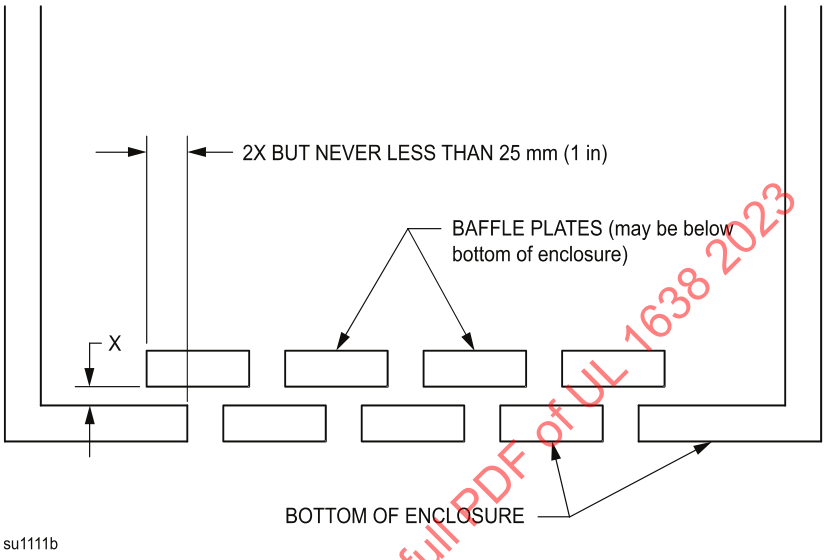
a) In Canada only: CSA C22.2 No. 0.17;

b) In the United States only: UL 746C.

Figure 9.3 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 notification appliance complies with Section 28, Abnormal Operation and Burnout Test.

Figure 9.3

Cross-Sections of Baffle Design



9.6.5 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).

9.6.6 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.

9.6.7 The requirement in 9.6.6 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);

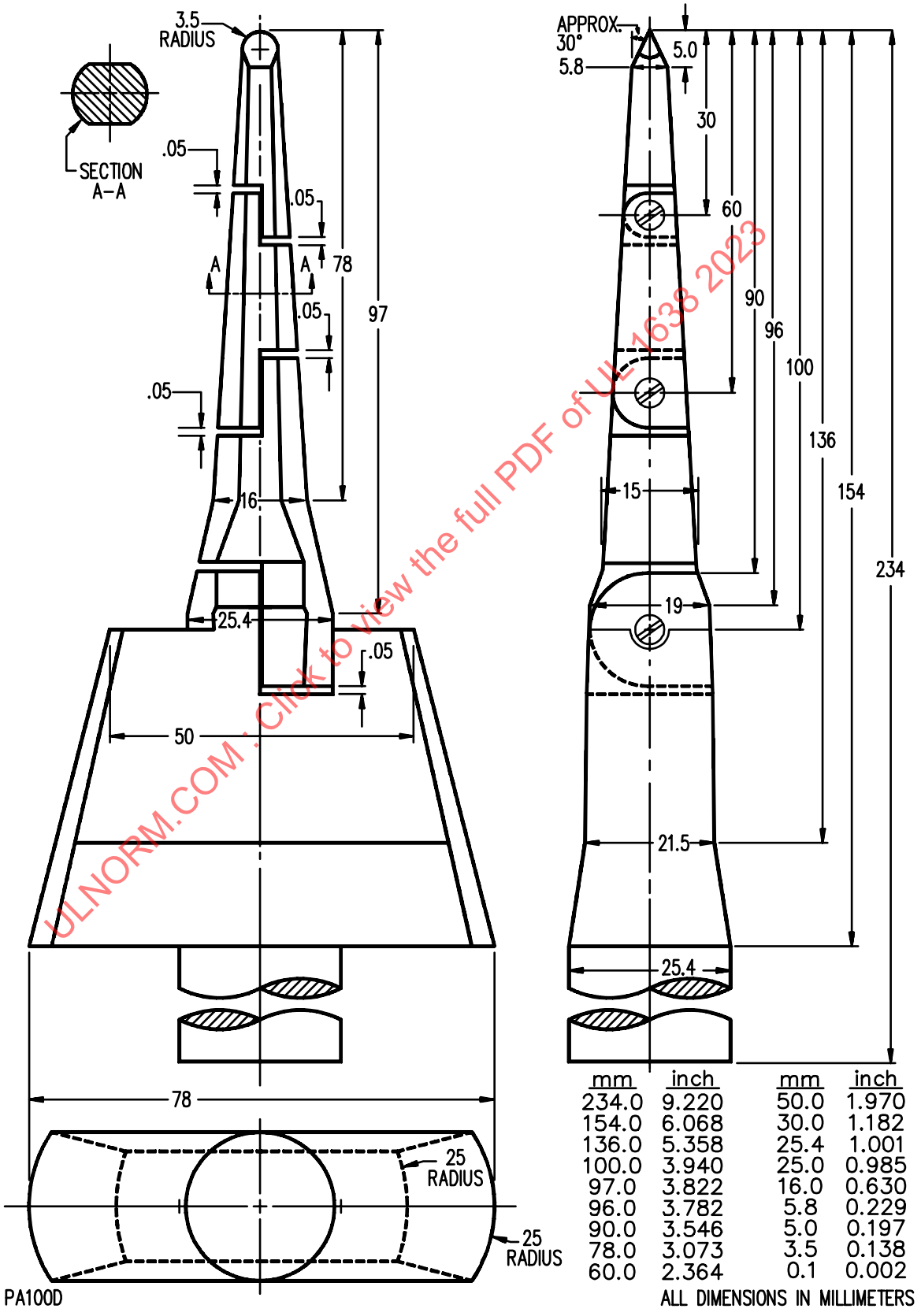
b) There is no more than one unused mounting screw hole for each 300 mm (11.8 in) of length of mounting surface, or fraction thereof; and

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.

9.6.8 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 9.4 cannot be made to contact any uninsulated live electrical part, when inserted through the opening in a straight or articulated position.

Figure 9.4

Accessibility Probe



mm	inch	mm	inch
234.0	9.220	50.0	1.970
154.0	6.068	30.0	1.182
136.0	5.358	25.4	1.001
100.0	3.940	25.0	0.985
97.0	3.822	16.0	0.630
96.0	3.782	5.8	0.229
90.0	3.546	5.0	0.197
78.0	3.073	3.5	0.138
60.0	2.364	0.1	0.002

ALL DIMENSIONS IN MILLIMETERS

9.6.9 In addition to the requirement of 9.6.8, 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 visible 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 visible signaling device.

9.6.10 Acoustical openings for a combination audible and visible vandal-resistant signaling device (see also Section 46, Markings) 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.

9.6.11 Openings in a combination audible and visible 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).

9.6.12 With reference to 9.6.11, the wires of a screen shall be not less than 16 AWG (1.3 mm^2). Except as noted in 9.6.13, 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.

9.6.13 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 specified in Section 15, Spacings, between uninsulated live parts, or between uninsulated movable parts.

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

9.7 Gaskets

9.7.1 A gasket used to seal an opening between two parts that are intended to be separated in the field for installation or maintenance shall comply with 37.2, Air-Oven Aging Test. The gasket shall be secured with adhesive or a mechanical means to one of the mating surfaces. The gasket and the securing means shall not be damaged when the joint is opened following the exposure in 37.2.

9.7.2 A gasket used as an environmental seal shall be of a material that is suitable for its application by complying with 37.2, Air-Oven Aging Test, and the requirements in this section. A gasket used exclusively as an acoustical seal on a combination audible and visible signaling device is not required to be subjected to the requirements in 9.7, Gaskets.

9.7.3 Complete assembled samples employing gaskets shall be evaluated for integrity by complying with the requirements in Section 26, Variable Ambient Temperature Test, Section 27, Humidity Test, and Section 33, Corrosion Tests. When intended for outdoor use, the sample shall also comply with Section 34, Water Spray Test.

9.8 Covers

9.8.1 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.

9.8.2 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.

9.8.3 The thickness of a glass cover shall not be less than that indicated in Table 9.3.

Table 9.3
Thickness of Glass Covers

Maximum size of opening,				Minimum thickness,	
Length or width,		Area,			
mm	(in)	cm^2	(in^2)	mm	(in)
102	(4)	103	(16)	1.6	(1/16)
305	(12)	929	(144)	3.2	(1/8)
Over 305	(Over 12)	Over 929	(Over 144)	See footnote a	

[a] The minimum thickness shall be 3.2 mm (1/8 in) or more, depending upon the size, shape, and mounting of the glass panel.

9.8.4 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.

9.8.5 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.

10 Corrosion Protection

10.1 Ferrous metal, iron and steel parts other than bearings and similar parts where such protection is impractical, shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. Refer to Section 33, Corrosion Tests.

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 notification appliance.

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

10.2 The requirement of 10.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend.

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

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

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

11 Field Wiring Connections

11.1 General

11.1.1 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 only: CSA C22.1, Section 32, Fire alarm systems, smoke alarms, carbon monoxide alarms, and fire pumps.

b) In the United States only: NFPA 70.

11.1.2 Wiring terminals shall be prevented from turning.

11.1.3 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.

11.1.4 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.

11.2 Field wiring compartment

11.2.1 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.

11.2.2 The device wiring and internal components in the wiring area of a notification appliance 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.

11.2.3 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 notification appliance 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.

11.2.4 A notification appliance 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 a notification appliance 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 visible signaling device, which under any condition of operation may achieve a temperature exceeding the temperature rating of the wire or lead insulation. See Section 22, Temperature Rise; 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 12.2, Separation of Circuits, and Section 15, Spacings.

11.3 Field wiring terminals and leads

11.3.1 Types and sizes

11.3.1.1 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.

11.3.1.2 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.

11.3.2 Size of screws

11.3.2.1 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).

11.3.3 Material for terminal parts

11.3.3.1 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.

11.3.4 Terminal plates and threading

11.3.4.1 Wiring terminal screws shall thread into metal.

11.3.4.2 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.

11.3.4.3 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.

11.3.4.4 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, or 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.

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

11.3.4.6 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.

11.3.5 Grounding terminals and leads

11.3.5.1 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.

11.3.5.2 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.

11.3.5.3 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 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.

11.3.6 Grounded supply terminals and leads

11.3.6.1 A field wiring terminal for the connection of the grounded supply conductor of an 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.

11.3.6.2 A field wiring lead provided for connection of the grounded supply conductor of an 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.

11.3.6.3 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.

11.3.6.4 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 color if color coded, or be marked "N" or "Neutral", or "W" or "White", either on or adjacent to the terminal.

11.3.7 Field wiring leads

11.3.7.1 Leads provided for field connections shall be:

a) Stranded copper bunch tinned in accordance with:

1) In Canada only: CSA C22.1, Rule 32-100;

2) In the United States only: 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 in) in thickness; and

e) Provided with strain relief. See Section 32, Strain Relief.

11.3.7.2 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.

12 Internal Wiring

12.1 General

12.1.1 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.

12.1.2 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.

12.1.3 If the use 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, 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.

12.1.4 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 visible signaling device.

12.1.5 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.

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

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

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

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

12.2 Separation of circuits

12.2.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers, clamps, routing, spacing (refer to Table 12.1), or other equivalent means, unless all conductors are provided with insulation rated for the highest potential involved.

Table 12.1
Minimum Spacings

Point of application	Minimum spacings				
	Voltage range, V	Through air, mm	(in)	Over surface, mm	(in)
To walls of enclosure[a]:					
Cast metal enclosures	0 – 300	6.4	(1/4)	6.4	(1/4)
Sheet metal enclosures	Power or non-power limited 0 – 50	6.4	(1/4)	6.4	(1/4)
	Power limited 51-300	6.4	(1/4)	6.4	(1/4)
	Non-power limited 51-150	12.7	(1/2)	12.7	(1/2)
	Non-power limited 300 – 600	12.7	(1/2)	12.7	(1/2)
Installation wiring terminals:					
With barriers	0 – 30	3.2	(1/8)	4.8	(3/16)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Without barriers	0 – 30	4.8	(3/16)	4.8	(3/16)
	31 – 150	6.4	(1/4)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Rigidly clamped assemblies:[b]					
Class 2, Power Limited	0 – 30	–	–	–	–

Table 12.1 Continued on Next Page

Table 12.1 Continued

Point of application	Minimum spacings				
	Voltage range, V	Through air, mm	Through air, (in)	Over surface, mm	Over surface, (in)
Non Class 2, Power Limited	0 – 30	1.2	(3/64)	1.2	(3/64)
	31 – 150	1.6	(1/16)	1.6	(1/16)
	151 – 300	2.4	(3/32)	2.4	(3/32)
	300 – 600	9.5	(3/8)	12.7	(1/2)
Other parts					
	0 – 30	1.6	(1/16)	3.2	(1/8)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
	300 – 600	9.5	(3/8)	12.7	(1/2)

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

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

12.2.2 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 9.2 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 in) 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 in).

13 Bonding for Grounding

13.1 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.

13.2 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.

13.3 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.

13.4 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.

13.5 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 13.1.

13.6 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 13.1.

13.7 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.

13.8 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 13.1.

Table 13.1
Bonding Wire Conductor Size

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

[a] Or equivalent cross-sectional area.

13.9 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 13.1.

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

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

14 Electrical Components

14.1 Mounting

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

14.1.2 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 Section 15, Spacings.

14.1.3 Friction between surfaces is not acceptable as a means to prevent turning, loosening, or shifting of a part as required in 14.1.1 and 14.1.2, but a toothed lock washer that provides both spring take-up and an interference lock or equivalent means is acceptable.

14.1.4 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.

14.2 Insulating materials

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

14.2.2 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.

14.2.3 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.

14.2.4 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.

14.2.5 Polymeric materials may be used for the sole support of uninsulated live parts if found to be equivalent to the materials indicated in 14.2.4.

14.2.6 A countersunk sealed live part shall be covered with a waterproof insulating compound which will not melt at a temperature 15 °C (27 °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).

14.2.7 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 14.1.

Table 14.1
Thickness of Flat Sheets of Insulating Material

Maximum dimensions				Minimum thickness,	
Length or width,		Area,			
mm	(in)	cm^2	(in^2)	mm	(in)
610	(24)	2323	(360)	9.5[a]	(3/8[a])
1219	(48)	7432	(1152)	12.7	(1/2)
1219	(48)	11,148	(1728)	15.9	(5/8)
1219	(Over 48)	11,148	(Over 1728)	19.1	(3/4)

[a] Material less than 9.5 mm (3/8 in) but not less than 3.2 mm (1/8 in) thick may be used for a panel if the panel is supported or reinforced to provide rigidity not less than that of a 9.5 mm (3/8 inch) sheet. Material less than 3.2 mm (1/8 in) may be employed for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

14.3 Current-carrying parts

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

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

14.3.3 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.

14.4 Bushings

14.4.1 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.

14.4.2 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.

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

14.4.4 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.

14.4.5 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.

14.4.6 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 vapor, 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.

14.4.7 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.

14.5 Semiconductors

14.5.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they may be exposed in service. Refer to Section 17, Performance Tests – General.

14.6 Transformers, relays, and coils

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

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

14.7 Capacitors

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

14.7.2 Capacitors shall be suitable for the purpose. There shall be no failure of the capacitors when the product is subjected to Section 22, Temperature Rise, and Section 25, Endurance. The measured peak voltage across the capacitor shall not exceed the voltage stress level as specified in Section 29, Component Stress.

14.8 Operating parts

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

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

14.8.3 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.

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

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

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

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

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

14.8.9 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.

14.9 Connectors and receptacles

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

14.10 Printed wiring boards

14.10.1 Printed wiring boards shall comply with UL 796, and CSA C22.2 No. 0.17. 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 12.1). 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.

14.11 Motors

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

14.11.2 A motor shall be protected by thermal or overcurrent protective devices or shall be of the impedance-protected type. See the Locked Rotor Test, Section 41. A thermal or overcurrent protective device shall not open the circuit during Section 22, Temperature Rise.

14.11.3 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.

14.12 Batteries

14.12.1 General

14.12.1.1 A battery or batteries used as primary or backup power shall comply with the applicable requirements in 14.12 and 42.1 – 42.6.

14.12.1.2 Batteries shall be located and mounted so that terminals meet the spacing requirements in 12.2, Separation of Circuits.

14.12.1.3 A notification appliance powered by replaceable batteries shall provide access to the battery compartment without disassembly of any part of the product except for a cover or similar parts as specified in the manufacturer's published instructions.

14.12.1.4 A notification device with replaceable batteries shall comply with 42.6, Battery Replacement Test and:

a) Be designed to prevent misalignment, reverse polarity, damage upon connection, and accessibility of uninsulated parts during use and replacement;

b) Provide a battery securement means to prevent disconnection or damage that impedes operation of the unit during use; and

c) Be prevented from coming into contact with terminals of adjacent batteries or with metal parts of the enclosure as a result of shifting of the batteries.

14.12.1.5 Removal of the notification appliance from a mounting support or bracket to replace a battery shall only be permitted when the mounting of the product is supervised. Wiring that is subjected to flexing or stress during the removal of a notification appliance shall comply with the requirements in Section 32, Strain Relief.

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

14.12.1.7 Connections to battery terminals shall be either by a lead terminating in a positive snap-action type clip, or a fixed butt-type connection which applies a minimum 6.6 N (1.5 lb) force to each battery contact, or another connection means that has been determined to be equivalent.

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

14.12.2 Primary batteries

14.12.2.1 A primary battery used to power a notification appliance shall meet the requirements of this section as well as the requirements for 42.1, Primary Battery Compatibility Tests, and 42.3, Battery Capacity Test.

14.12.2.2 Lithium batteries used as the primary source shall be protected from being charged and comply with the requirements in UL 1642.

14.12.3 Secondary batteries used as standby power source

14.12.3.1 Non-rechargeable secondary batteries shall be protected from being charged.

14.12.3.2 A rechargeable secondary battery used as standby power source for a notification appliance shall meet the requirements in this section as well as the requirement in 42.4, Rechargeable Batteries Used as a Standby Power Source.

14.12.3.3 A rechargeable secondary battery shall be sealed or be vented so that it does not adversely affect any part of the product.

14.12.3.4 The maximum charge rate as well as the maximum trickle charging current of a rechargeable secondary battery shall be limited so that it does not exceed the battery manufacturer's recommended rates.

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

14.12.3.6 The mounting arrangement for the batteries shall:

a) Permit access to the batteries for testing and maintenance;

b) Be provided with an integral meter; or

c) Be provided with readily accessible terminals to facilitate the connection of meters for determining battery voltage.

14.12.3.7 A notification appliance with a rechargeable secondary battery shall automatically test the condition of the battery at least once every 24 h. The test shall be conducted under a load sufficient to determine if the battery requires service or has been removed or disconnected. A battery requiring service is defined as a battery which is not capable of providing 5 min of alarm signaling at the level required to meet 42.4.4. A notification appliance with a battery requiring servicing or replacement shall send a trouble signal.

14.12.4 Rechargeable lithium-ion batteries

14.12.4.1 In addition to the requirements in 14.12.3.1 – 14.12.3.7, rechargeable lithium-ion batteries shall also comply with the requirements for secondary lithium batteries specified in the standards shown below:

a) UL 1642;

b) UL 2054;

c) UL 60086-4;

d) CSA C22.2 No. 60086-4.

14.12.4.2 A lithium-ion battery pack intended for installation and replacement by other than trained qualified personnel shall employ a rigid mechanical enclosure that complies with the enclosure construction and test requirements of UL 2054.

14.12.4.3 Lithium-ion batteries shall be specified only for installation and replacement by trained qualified personnel. Lithium-ion batteries shall not be accessible to the user.

14.12.4.4 Compatibility between lithium-ion batteries or battery packs, and the equipment including the charging system(s), shall be verified and documented in the manufacturer's published instructions. Verification documentation shall include:

a) The battery manufacturer's specifications noted in 14.12.4.5; and

b) A failure mode and effects analysis demonstrating that the battery manufacturer's specifications noted in 14.12.4.5 are not exceeded.

14.12.4.5 The following specifications from the lithium-ion battery manufacturer shall not be exceeded in the notification appliance:

a) Rated charging current, charging voltage and cutoff current, with compliance verified under normal and single fault conditions within the system;

b) Rated discharge current/rate and endpoint voltage, with compliance verified under normal and single fault conditions within the system;

c) Maximum charging current and charging voltage limit (established as part of the battery abnormal charging test of UL 2054), with compliance verified under fault conditions within the system; and

d) The upper and lower ambient temperature ranges for charging and discharging.

14.12.4.6 Equipment with a rechargeable lithium-ion battery pack, intended for installation and replacement by other than trained qualified personnel, shall:

a) Be designed to prevent misalignment, reverse polarity, damage upon connection, and accessibility of uninsulated parts during use; and

b) Provide a battery securement means to prevent inadvertent disconnection or damage during use.

14.12.4.7 Lithium-ion batteries required to provide a limited power source shall comply with the limited power test requirements of UL 2054.

15 Spacings

15.1 Spacings between uninsulated live parts, between uninsulated live parts and dead metal parts, and between uninsulated live parts of opposite polarity shall be not less than those indicated in Table 12.1.

Exception No. 1: The spacing requirements in Table 12.1, do not apply to the inherent spacings of a component which is provided as part of the unit. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures shall be those indicated in Table 12.1.

Exception No. 2: The "To Walls Of Enclosure" spacings indicated in Table 12.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

Exception No. 3: On printed-wiring boards having a flammability classification of V-0 in accordance with UL 94, spacings (other than spacings to dead metal traces, between primary and secondary circuits, and at field wiring terminals) are not specified between traces of different potential connected in the same circuit when:

a) The spacings are adequate to comply with the requirements in Section 24, Evaluation of Reduced Spacings on Printed-Wiring Boards; or

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

15.2 The spacings between an uninsulated live part and a wall or cover of a metal enclosure, a fitting for conduit or metal-clad cable, and a metal piece attached to a metal enclosure where deformation of the enclosure is liable to reduce spacings, shall be not less than those indicated in Table 12.1.

15.3 The "Through Air" and "Over Surface" spacings at an individual component part are to be judged on the basis of the apparent power (VA) available to the individual component.

15.4 The spacing from any component to the enclosure or to other uninsulated dead metal parts excluding the component mounting surface, shall be judged on the basis of the maximum voltage and total VA available to the entire assembly.

15.5 Film coated wire is considered an uninsulated live part in determining compliance with spacing requirements but is acceptable as turn-to-turn insulation in coils.

15.6 An insulating liner or barrier of vulcanized or impregnated fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall be not less than 0.7 mm (0.028 in) in thickness, except that a liner or barrier not less than 0.3 mm (0.012 in) in thickness may be used in conjunction with an air spacing of not less than 50 % of the “Through-Air” spacing required. The liner shall be located so that it will not be subjected to the direct effects of arcing.

15.7 Insulating material having a thickness less than that specified in 15.5 may be used if it has equivalent mechanical and electrical properties.

15.8 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 12.1.

16 Firmware Update (If Provided)

16.1 General

16.1.1 A firmware release level shall identify the firmware of a product. A new release level shall be assigned due to any changes in the firmware.

16.1.2 Program firmware and code shall not be accessible for unauthorized modification.

16.2 Firmware update

16.2.1 Products capable of receiving a firmware update shall provide a means of indicating the current firmware version of the unit.

16.2.2 The manufacturer shall provide documentation which details the differences:

a) From the original to each subsequent firmware version; and

b) Between subsequent versions (if applicable).

16.2.3 Firmware updates for notification appliances shall not occur when the battery (primary or secondary) supply associated with the device has been depleted to the trouble point (refer to 42.2, Battery Trouble Voltage Determination).

16.2.4 Products capable of receiving a firmware update shall be tested and evaluated for the following type of applicable firmware updates when the alarm device or accessory is subjected to the specified operating conditions:

a) Authentic firmware update:

1) Normal standby condition – notification appliance shall operate as intended after receiving an authentic firmware update.

2) Alarm condition – a firmware update shall not interfere with alarm signaling.

3) Loss of power – notification appliance shall comply with 16.2.6.

4) Firmware transmission (data) interruption – notification appliance shall comply with 16.2.6.

b) Duplicate firmware version update:

1) Normal standby condition – notification appliance shall operate as intended after receiving a duplicate firmware update.

c) Corrupt firmware update:

1) Normal standby condition – notification appliance shall comply with 16.2.6.

d) Unsigned manufacturer firmware update:

1) Normal standby condition – notification appliance shall comply with 16.2.6.

16.2.5 Successful firmware updates shall result in the notification appliance or accessory operating as intended following the update and comply with all applicable requirements as defined within this standard.

16.2.6 For products capable of receiving an automatic or user-initiated firmware update, failure to successfully update the firmware shall result in the notification appliance and accessory if provided, reverting to the previous firmware version and the notification appliance and accessory if provided shall operate as originally intended. Failure to update or revert to the previous firmware revision shall result in a trouble signal.

16.2.7 For products that are capable of receiving firmware updates, manufacturers shall provide a means for the user to obtain the manual for the updated firmware if any user discernible functionality has changed.

16.2.8 When firmware is received from an external source to the notification appliance, that firmware and the compatibility of the firmware shall also be controlled and evaluated to the requirement of this Standard and/or the control unit Standard as it relates to the performance of the notification appliance. Software used for programming a notification appliance's firmware shall be identified and controlled.

PERFORMANCE

17 General

17.1 Unless otherwise specified, the performance of a visible signaling device is to be investigated by subjecting samples of each rating that is representative of production to the tests specified in Performance Tests, Sections 17 – 42, as far as applicable and in the sequence presented. Refer to Annex C for illustration of test sequence.

18 Samples

18.1 The quantity of samples required for testing is as follows:

a) Devices intended for indoor-use only: 10 samples; and

b) Devices intended for outdoor-use: 12 samples.

18.2 Additional samples may be required for Section 37, Tests on Polymeric (Plastic) Materials, or Section 28, Abnormal Operation and Burnout Test.

18.3 Additional samples of visible signaling devices utilizing encapsulated or sealed assemblies will be required. These additional samples shall be submitted without being encapsulated or sealed.

18.4 Additional samples of visible signaling devices utilizing multiple voltage inputs, may be required for testing.

18.5 To reduce the number of samples required, the same samples may be used for multiple tests, other than as indicated in the test sequences shown in Annex C, when agreed upon between the testing organization and the manufacturer before testing starts. Reducing the number of samples may increase the length of time for an investigation.

18.6 If a product must be mounted in a specified position in order to function as intended, it is to be tested in that position.

18.7 Where the rated voltage is a voltage range, all outputs shall be maintained throughout the range or the worst-case rating shall be used

18.8 The input circuit of n visible signaling device assembly is considered to be the terminals or the field wiring leads that get connected to the control unit.

18.9 The following information is required for a visible signaling device that employs electronic components:

a) Vendor's rating for each component;

b) Maximum operating values for each component; and

c) General description of the circuit operation.

18.10 The effective luminous intensity (light output) rating shall be the lowest rating obtained during the performance tests.

19 Input Test

19.1 Test voltages

19.1.1 Unless otherwise specified, the test voltage for each test shall be as indicated in Table 19.1.

Table 19.1
Test Voltages

Voltage designation marked on unit	Voltage type	Operating limits	Maximum operating current	Test limits
		(V)	(A)	(V)
Regulated[a] 12	DC	8 – 17.5	Rated	8 – 17.5
Regulated[a] 24	DC	16 – 33	Rated	16 – 33
12 FWR[c]	FWR[c]	8 – 17.5	Rated	8 – 17.5

Table 19.1 Continued on Next Page

Table 19.1 Continued

Voltage designation marked on unit	Voltage type	Operating limits	Maximum operating current	Test limits
		(V)	(A)	(V)
24 FWR[c]	FWR[c]	16 – 33	Rated	16 – 33
Regulated[a] 120	AC	96 – 132	Rated	96 – 132
Regulated[a] 240	AC	192 – 264	Rated	192 – 264
Special Application[b]	Any type	Rated	Rated	Rated

[a] Regulated performance such that normal operation of the product has been verified to the limits in this table.

[b] Special application represents a product which does not meet regulated requirements but has been investigated to limits as described in the installation instructions or marked on the device.

[c] Full wave rectified.

19.2 Test currents

19.2.1 The measured current input to a device shall not be greater than the marked rating when the device is operated under the conditions of intended use while connected to a test voltage supply as indicated in Table 19.1.

19.2.2 For a "special application" device the operating RMS current, RMS surge currents, peak of the surge currents, and the time frame of the surge current time window shall be within the limits specified by the manufacturer over the voltage range of the visible signaling device. The methods for measuring current shall be as described in 19.2.3 – 19.2.5, except the surge current time window described in 19.2.5 shall be as specified by the manufacturer.

NOTE: "Special application" represents a product which does not meet regulated requirements but has been investigated to limits as described in the installation instructions or marked on the device.

19.2.3 The current measurements are to be recorded with a digital oscilloscope employing an RMS voltage display. The maximum operating RMS current obtained from testing shall not be greater than the marked rating of each visible signal device. When the unit is capable of being energized from either a dc or full-wave rectified (FWR) source of supply, the current rating of the visible signal device shall be expressed in the maximum operating RMS current, which occurs over the rated voltage range for each power source. Refer to Table 19.1 for definitions of the performance designations.

19.2.4 The unit under test is to be mounted in a position of normal use and electrically connected to a de-energized power source. The power source is to be preadjusted to the rated voltage of the unit under test. The oscilloscope is to be set for a sampling rate that is consistent with the values noted in 19.2.3 and 19.2.5. Upon energization the current measurements are to be recorded and stored. When each measurement is completed, the unit is to be de-energized for sufficient time to allow the temperature of the unit to return to a normal room ambient condition before additional measurements are obtained. Measurements for both "regulated" and "special application" devices are to be obtained for the maximum operating RMS current, maximum surge RMS current (initial and repetitive) and the maximum peak of the surge current (initial and repetitive).

19.2.5 To determine the maximum peak and RMS of the surge currents the oscilloscope is to be set to a free-running condition with a sampling rate of 2500 samples per second. The current waveform is to be visually monitored for large surge currents over the first 2 min from initial energization of the unit under test. More than one test trial may be necessary to verify that a repeatable pattern exists. Once identified, the oscilloscope is to be set to a triggering condition, the sweep reset for a sampling rate of 25,000 samples per second, and the largest of the surge currents is to be selected and stored in the oscilloscope. This surge event is to be designated the initial surge current and usually occurs when power is applied to the unit under test. The next largest reoccurring surge event over the first 2 min is to be selected and

stored and will be designated the repetitive surge current. A 16.7 ms window (surge current time window) is to be positioned over the stored surge events, using the oscilloscope cursors, to establish the window time limits. The maximum surge RMS current and the maximum peak of the surge current during the surge events is then to be measured.

19.2.6 The peak of the initial surge current shall not exceed 10 times the operating RMS current rating. The RMS of the initial surge current shall not exceed 5 times the operating RMS current rating. The peak of the repetitive surge current shall not exceed 5 times the operating RMS current rating. The RMS of the repetitive surge current shall not exceed 2.5 times of the operating RMS current rating.

19.2.7 The current input to a single-stroke solenoid-plunger device is deemed to be the value obtained with the plunger floating.

20 Measurement of Effective Luminous Intensity (Light Output)

20.1 General

20.1.1 Each visible signal device intended for public mode use shall produce a minimum effective luminous intensity of 15 cd. The flash rate shall lie between 1 and 2 flashes per second. The flash duration shall be 200 ms or less as measured between the 10 % amplitude values of the leading and trailing edges of the light pulse. Rated light output is to be based on a maximum 20 ms light pulse. For pulse durations between 20 ms and 200 ms, an effective candela equivalency to a 20 ms light output is determined by dividing the measured light output value by the corresponding multiplier in Table 20.1. Light output ratings for pulse widths less than 20 ms are the measured value obtained in 20.2, Light Output Measurements for Public Mode Signaling. The minimum effective luminous intensity shall correspond to the marked rating value as measured in 20.2.

Table 20.1
Effective Candela Rating

Light pulse duration (ms)	Device rating required effective candela multiplier	Light pulse duration (ms)	Device rating required effective candela multiplier
20	1.00	115	4.02
25	1.22	120	4.13
30	1.43	125	4.23
35	1.64	130	4.33
40	1.83	135	4.43
45	2.02	140	4.53
50	2.20	145	4.62
55	2.37	150	4.71
60	2.54	155	4.80
65	2.70	160	4.89
70	2.85	165	4.97
75	3.00	170	5.05
80	3.14	175	5.13
85	3.28	180	5.21
90	3.41	185	5.29
95	3.54	190	5.36
100	3.67	195	5.43
105	3.79	200	5.50
110	3.90		

20.1.2 Each visible signal device intended for private mode use shall produce a minimum effective luminous intensity as declared by the manufacture. The minimum effective luminous intensity shall correspond to the marked rating value as measured in 20.5, Light Output Measurements for Private Mode, Emergency, and Informative.

20.1.3 The flash rate for a visible signal device intended for private or informative mode shall be as declared by the manufacturer.

20.1.4 Each visible signal device intended for textual informative mode use shall meet the requirements of Section 21, Informative Textual Displays.

20.1.5 Visible signaling devices shall have an effective luminous intensity of not more than 1000 cd.

20.1.6 The light output of the visible signal device shall conform to the manufacturer's description of the signal shown in the installation and operations instructions for the device.

20.1.7 Two samples of a single visible signal device or two samples of a combination visible signal device are to be tested in the as-received condition. These visible signal devices or combination visible signal devices are to be mounted, electrically connected, and operated in accordance with the installation instructions provided with the equipment.

20.1.8 For the minimum signal strength, visible signal devices intended for emergency warning and public mode wall use shall produce a candela output in effective intensity in accordance with:

a) Table 20.2 ;

b) Table 20.3 ;

c) Figure 20.1 ; and

d) Figure 20.2 .

Table 20.2
Required Minimum Percentage for Horizontal Dispersion for Wall Visible Signal Devices

Degrees[a]	Percentage of candela rating
0	100
5 – 25	90
30 – 45	75
50	55
55	45
60	40
65	35
70	35
75	30
80	30
85	25
90	25
Compound 45° to the right	24
Compound 45° to the left	24

[a] Tolerance of ±1° is permitted.

Table 20.3
Required Minimum Percentage for Vertical Dispersion Wall to Floor

Degrees[a]	Percentage of candela rating
0	100
5 – 20	90
35	65
40	46
45	34
50	27
55	22
60	18
65	16
70	15
75	13
80	12
85	12
90	12

[a] Tolerance of ±1° is permitted.

Figure 20.1
Light Output – Horizontal Dispersion

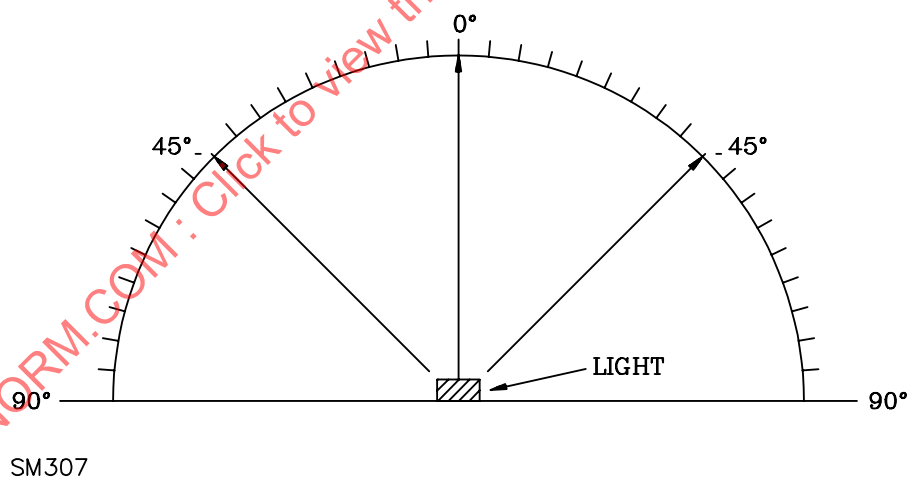
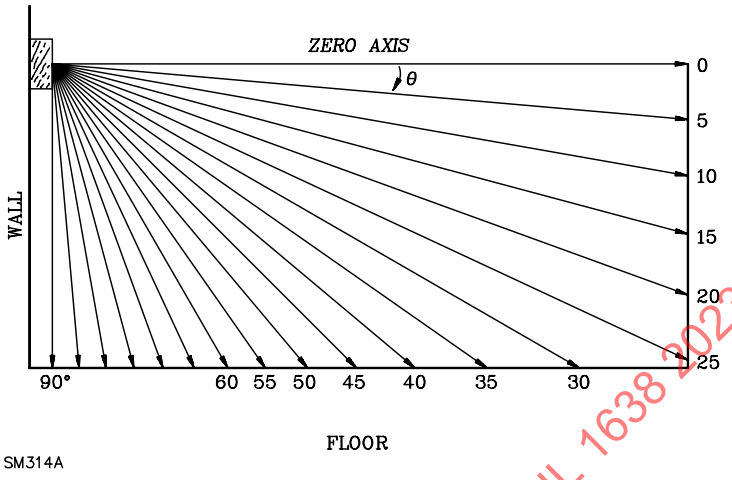


Figure 20.2

Light Output – Vertical Dispersion, Wall to Floor



20.1.9 Visible signal devices intended for public mode ceiling use shall produce a candela output in effective intensity in accordance with:

a) Table 20.4; and

b) Figure 20.3.

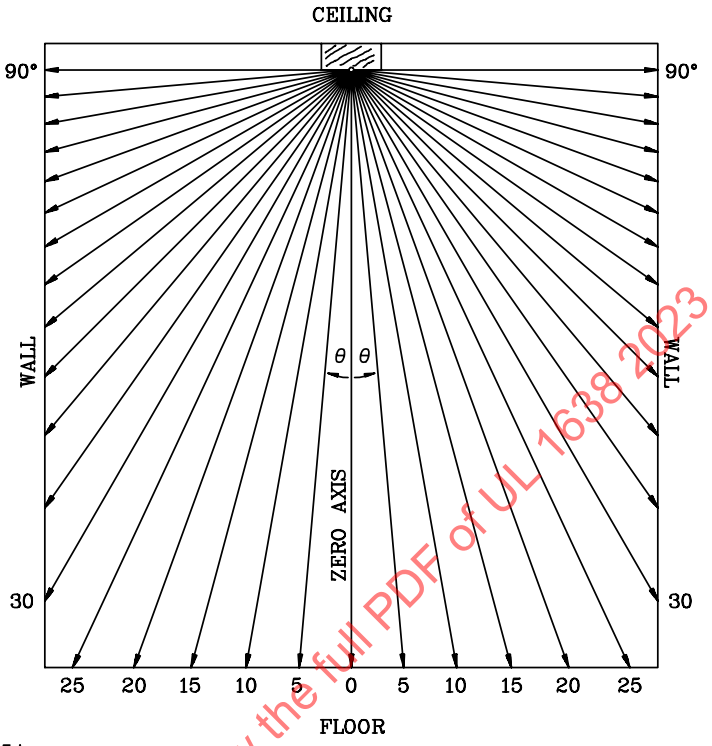
Table 20.4
Required Minimum Percentage for Vertical Dispersion in Both X And Y Planes Ceiling to Wall and Floor

Degrees[a]	Percentage of candela rating
0	100
5 – 25	90
30 – 45	75
50	55
55	45
60	40
65	35
70	35
75	30
80	30
85	25
90	25
Compound 45° to the right	24
Compound 45° to the left	24

[a] Tolerance of ±1° is permitted.

Figure 20.3

Light Output – Vertical Dispersion, Ceiling to Walls and Floor



20.1.10 The flash rate for Public Mode shall not be less than 1 Hz or greater than 2 Hz over the rated operating voltage range.

20.1.11 The measurement of light output for Public Mode shall be in accordance with the procedure described in 20.2, Light Output Measurements for Public Mode Signaling.

20.1.12 The light output:

a) Shall be white for public mode visible signal devices;

b) Can be any color for emergency warning visible signal devices;

c) Can be any color for private mode visible signal devices; and

d) Can be any color for informative visible signal devices.

20.2 Light output measurements for public mode signaling

20.2.1 To determine the light output, the device is to be mounted in its intended wall or ceiling position using a bracket that does not extend more than 25.4 mm (1 in) beyond each dimension of the visible signaling device. Each device is to be energized to its operational voltage range. The light output, I_e, is to be calculated by a summation procedure whereby a minimum of 10 pulses of light are to be measured and the total value of luminous intensity (Lm/ft^2), as measured by the radiometer, is inserted into the following equation:

$$I_e = d^2 \left[\frac{\int_{t_1}^{t_2} I dt}{0.2 + (t_2 - t_1)} \right]$$

Where:

I_e is the light output, in candela [reference HB-9, Illuminating Engineering Society of North America Lighting Handbook]

d is the distance from meter light sensor to the lens in feet

0.2 is the night-time threshold value for a steady light as indicated in the Illuminating Engineering Society of North America Lighting Handbook (the 0.2 value is used for specification purposes and to promote uniformity)

$t_2 - t_1$ is the light pulse duration, as measured between the 10 % of peak amplitude for the leading and trailing edges of the light wave envelope, in seconds

$\int_{t_1}^{t_2} I dt$ is the total value of luminous intensity measured, divided by the total number of pulses measured.

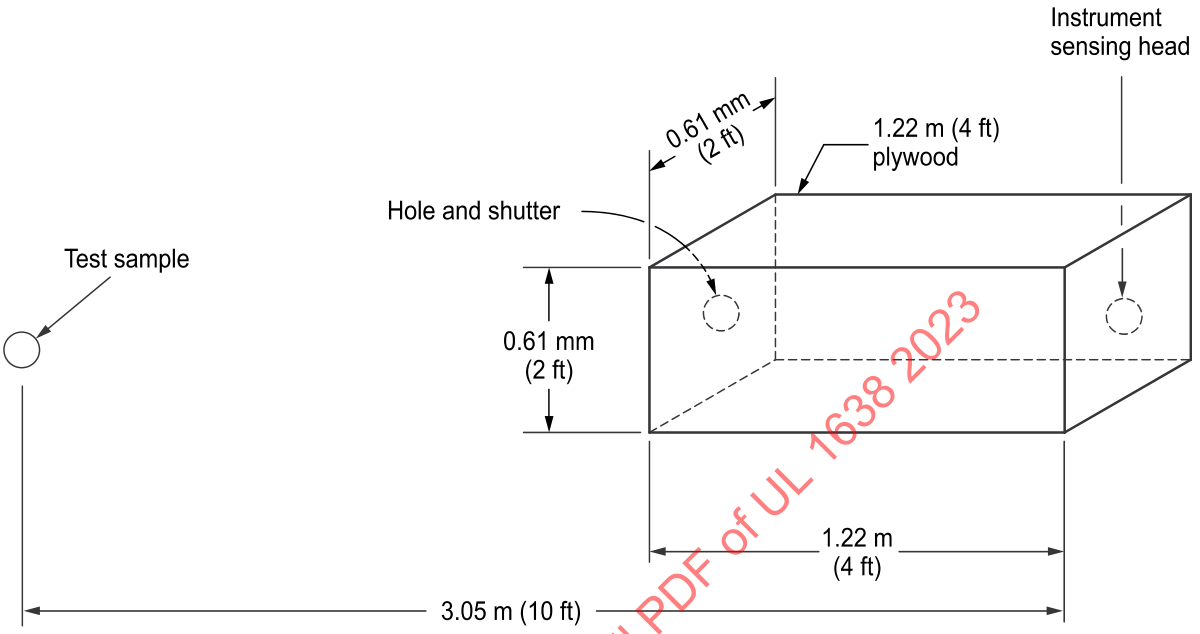
20.2.2 The alignment of the test sample's lens is accomplished by a low wattage laser beam that is passed through the viewing holes of the light box onto the surface of the lens to be viewed. To measure different angles, the sample is to be rotated to the desired position and aligned using the reference stationary laser beam.

20.2.3 In those cases where the light ambient exceeds 10 % of the total light output obtained during the light output measurement, the light ambient value is to be subtracted from the total value measured. The resulting value of light output is then considered the light output solely produced by the visible signal device. Light output produced by room ambient light is to be measured over the same time span (in seconds) as recorded to complete the test pulses. Light ambient is to be measured with the sample de energized.

20.2.4 The test chamber is to be constructed of 610 by 610 by 1220 mm (24 by 24 by 48 in), 19.1 mm (3/4 in) plywood. The inside is to be painted flat black. A hole and shutter are to be centrally located on one end of the chamber directly opposite the optical measuring instrument. The size of the hole is to be the same as that of the instrument sensing head. The distance between the test sample and the instrument sensing head is to be a minimum of 3050 mm (120 in). Refer to Figure 20.4.

Figure 20.4

Light Output Test Setup



Note: Box dimensions optional, suggested dimensions shown.

s2289a

20.3 Black box test procedure for public mode signaling

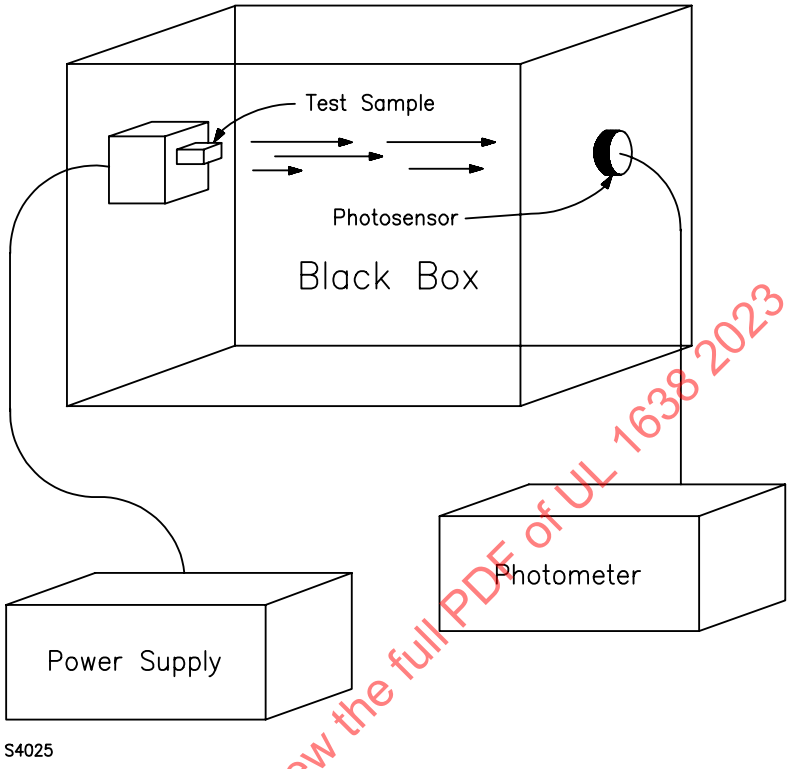
20.3.1 This method of testing is to be used during the endurance, transient, polarity reversal, and variable ambient tests. Any test that affects the physical properties of the sample is not to use this test procedure.

20.3.2 This test method is used to determine if any change in flash intensity has occurred. All components that make up the test fixture are to be fixed in place and the chamber is to be void of all measurable light except that produced by the sample under test. This test procedure is to be used only after the sample has been subjected to the other requirements in this section. Any percentage loss in light intensity is applied to the critical angle measurement obtained during horizontal, vertical, and compound angle light measurements.

20.3.3 The mounting and orientation of the sample with regard to the sensor of the meter is illustrated in Figure 20.5. The size of the enclosure is optional; however, the interior shall be free of any component, materials, or equipment that cannot be fixed permanently in place.

Figure 20.5

Light Intensity Black Box



20.3.4 The distance from the front center of the sample lens to the sensor is to be 305 mm (1 ft). The chamber is to be completely free of outside light during both the initial and final measurements. The interior of the box is to be painted with a flat-black paint along with any components or equipment mounted inside the box with the exception of the sensor and sample under test.

20.3.5 The box is to be secured in the closed position during the initial measurements, during the test conditioning, and upon final measurements. The box is to be vented to permit it to stabilize at the ambient to which the sample is being tested. The box is not to be disturbed at any time during the measurements or conditioning. Both the sample and sensor are to be secured in place by mechanical fasteners, such as wood screws, that require the use of a tool for removal.

20.4 Quadrant vector alignment for public mode signaling

20.4.1 To obtain the light output of the compound angles required for an emergency warning and public mode visual signal, the sample is to be mounted as shown in Figure 20.6 and Figure 20.7. When rotated between the angles of 35 and 45 degrees about the vertical axis of the center focal point (Figure 20.6) and rotated between the angles of 45 and 60 degrees about the horizontal axis of the center focal point (Figure 20.7), the light output of any one combination within these angles shall not be less than 24 % of the rated light output. This procedure is to be done for each of the lower left and right quadrants of a wall mounted sample and all four quadrants for a ceiling mounted sample.

Figure 20.6

Vertical Axis Center Focal Point

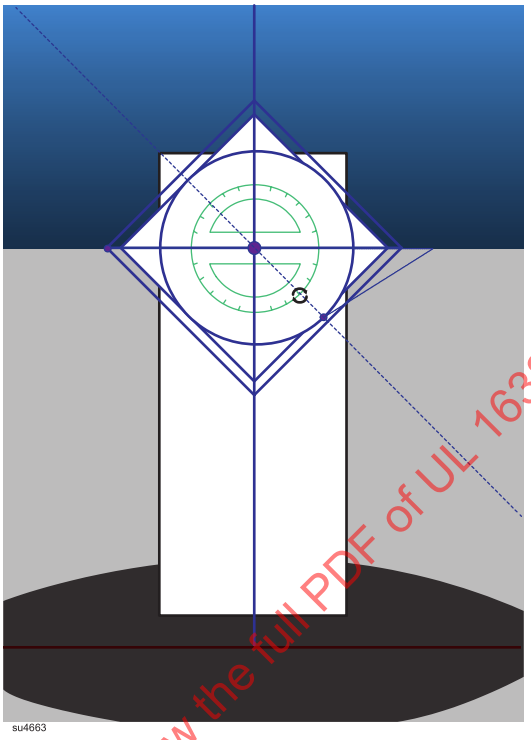
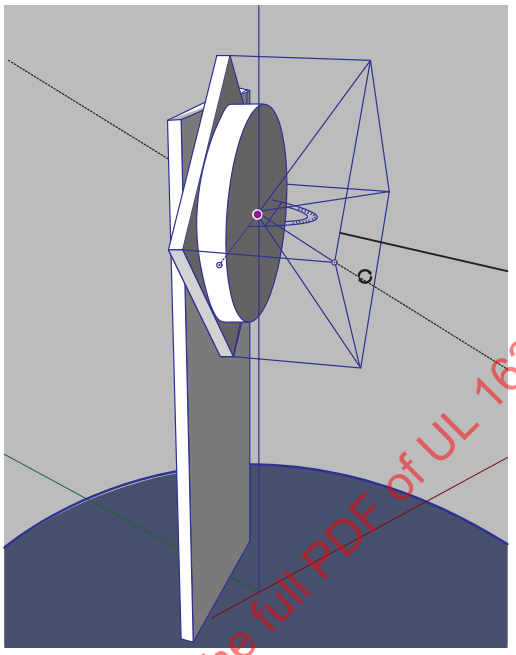


Figure 20.7

Horizontal Table Rotation



20.5 Light output measurements for private mode, emergency, and informative signaling

20.5.1 Private mode visible signal devices that comply with the requirements of 20.2 Light Output Measurements for Public Mode Signaling, and 20.4, Quadrant Vector Alignment for Public Mode Signaling, are not required to undergo additional Light Output Measurements specified in this section.

20.5.2 Each visible signal device shall be tested in the as-received condition and shall produce the light output marked on the visible signal device.

20.5.3 Each emergency or private mode visible signal device shall produce a light output not less than 80 percent of that marked on the visible signal device when tested after each of the following tests:

a) Section 25, Endurance;

b) Section 26, Variable Ambient Temperature;

c) Section 30, Jarring;

d) Section 31, Vibration;

e) Section 33, Corrosion Tests;

f) Section 34, Water Spray Test; (for outdoor use)

g) 37.5, Ultraviolet Light and Water Exposure; (for outdoor use)

h) Section 38, Mechanical Strength Tests for Enclosures; and

i) Section 39, Interference from Radio Frequency and Electromagnetic Radiation.

Refer to Annex C for test requirements and sample test sequence.

20.5.4 For a visible signal device using a lens having X, Y dimensions less than 100 mm, the value of light output is to be measured at least 3.05 m (10 ft) from the lens. For a visible signal device using a lens having X, Y dimensions greater than 100 mm (3.9 in), the value of light output is to be measured at a distance of 7.62 m (25 ft) from the lens.

20.5.5 An emergency or private mode visible signal device is to be tested for the light output at those angles in accordance with the manufacturer's specifications. (See 48.2). When this information is not available, samples are to be tested using at least the viewing angles illustrated in Figure 20.8 – Figure 20.10 as applicable.

Figure 20.8

Viewing Angles for Cube-Type Lenses

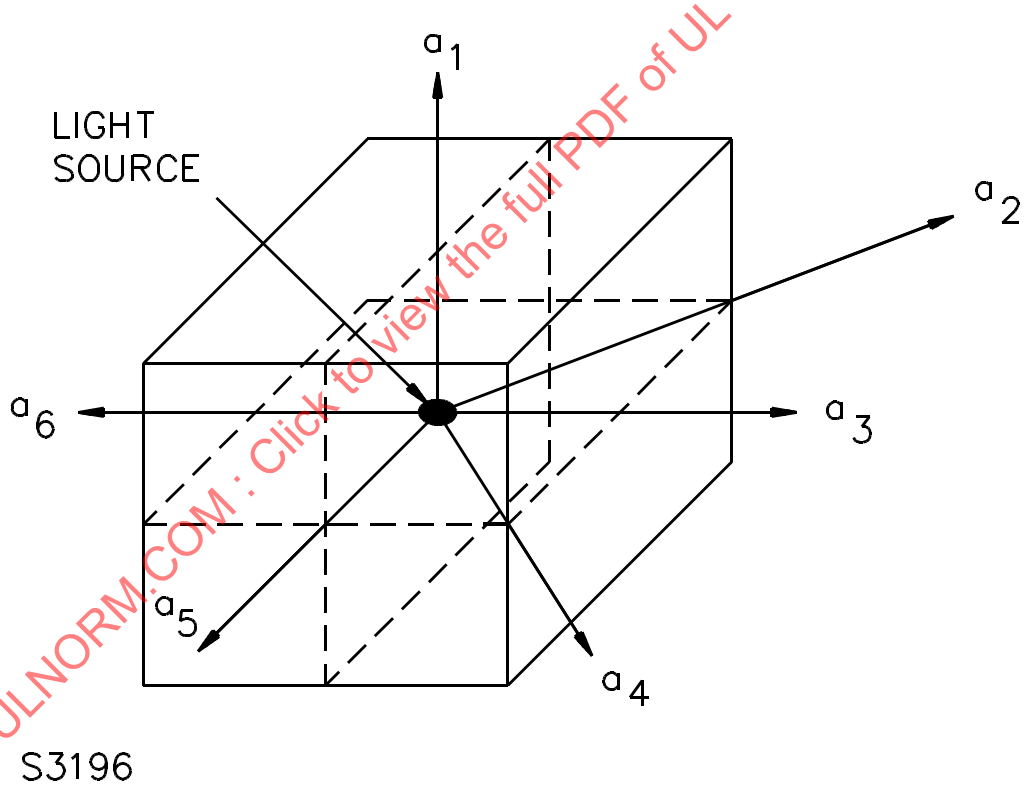


Figure 20.9

Viewing Angle for Dome-Type Lenses

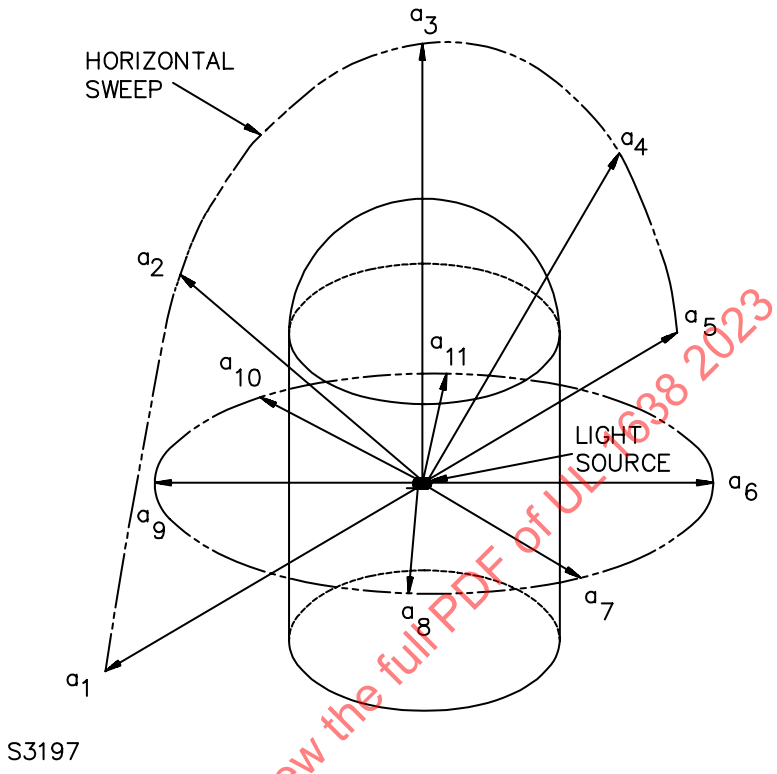
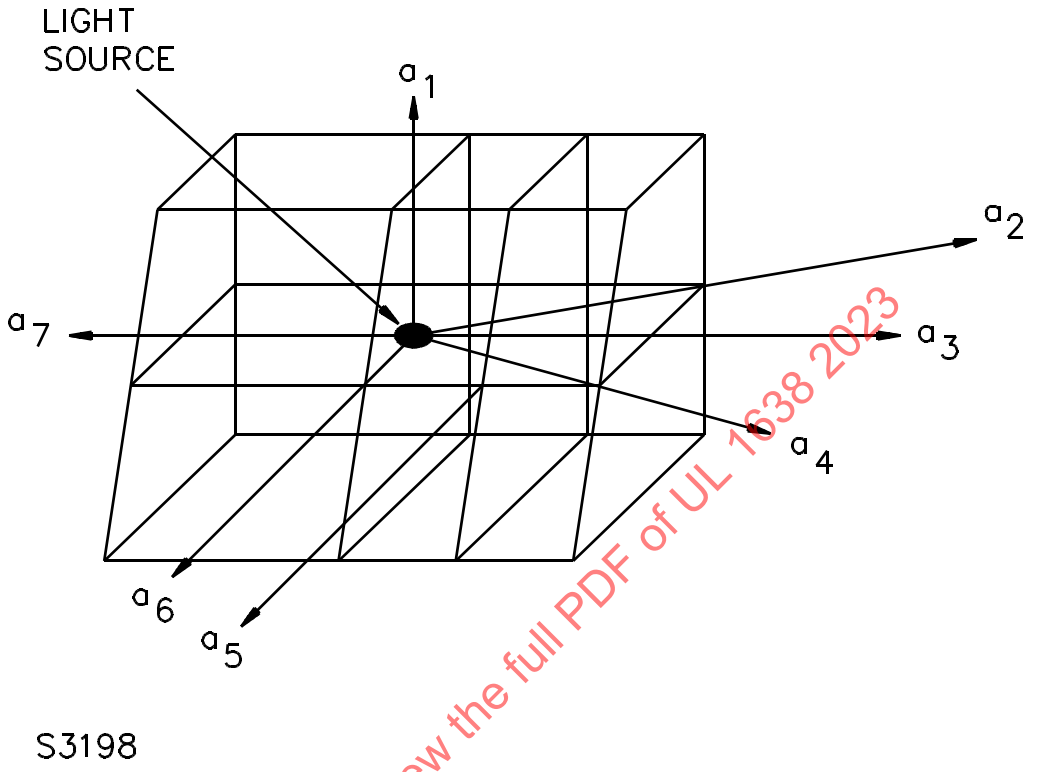


Figure 20.10

Viewing Angle for Trapazoidal-Type Lenses



20.5.6 The flash rate for a private mode visible signal device or informative signal visible signal device shall be as specified in 20.1.4 when tested:

a) In the as-received condition; and

b) Following each of the tests specified in 20.5.3.

20.5.7 A visible signal device intended to be cycled on and off by an external control, such as a fire alarm control panel, is to be operated at the frequency and duty cycle specified by the manufacturer and referenced in the marking on the visible signal device. When frequency and duty cycle are not specified, the visible signal device is to be tested while operating at a frequency of 60 cycles per minute and at a 50 % duty cycle.

20.6 Synchronization of light output test

20.6.1 A visible signal device having a synchronization feature shall be tested in accordance with 20.6.2 – 20.6.5.

20.6.2 A synchronization feature shall cause all the visible signal devices to flash within a 0.01 s time frame. Each device of the system shall operate synchronously for a minimum of 2 h, and the feature shall maintain a 1 to 2 Hz flash rate throughout the test.

20.6.3 The maximum number of visible signal devices, as indicated in the installation instructions, are to be interconnected together and each of the devices are to be placed in a position of normal use and positioned so that the light output of each visible signal device is directed at a photo transistor switch circuit. The leading edge of the first detected visible signal to flash to the trailing edge of the last visible

signal to flash, shall be within 10 ms of the pulse width of a single visible signal. The visible signal devices under test are to be operated in an area where the ambient light condition is less than 10 % of the effective illumination produced by any one visible signal device. During signal operation, the room is to be monitored for any abnormal light conditions.

20.6.4 The visible signal devices are to be electrically connected to a rated source of supply in accordance with the manufacturer's wiring instructions. Two test trials are to be conducted. The first trial is to be conducted with minimum wire impedance at maximum rated voltage. The second trial is to be conducted with maximum wire impedance at minimum rated voltage.

20.6.5 During each synchronization trial, each light flash event is to be monitored. The equipment used to sense the light is to be monitored using a chart recorder, computer, or any other system capable of recording pulse speeds greater than 1000 Hz. The data storage system is to be capable of a continuous 2 h operation. Following the test, the data is to be examined to verify that all flash events meet the requirements of 20.6.2.

21 Informative Textual Displays

21.1 Informative type visible signaling devices shall have characters of contrasting colors and be at least the size shown in 21.2 – 21.6. Character height is based on the uppercase “I”. The stroke thickness shall be no less than 10 % and no more than 30 % of the height of the uppercase ”I”. Fonts used shall have a width of no less than 55 % of the uppercase “O” and no more than 110 % of the uppercase ”I”. Spacing between characters shall be 10 % minimum and 35 % maximum of the character height. Character spacing is measured between the two closest points of adjacent characters.

21.2 Informative type visible signaling devices shall be visible at 3.05 m (10 ft) and legible at a distance of 0.8 m (2.6 ft) in any ambient light intensity between 50 and 1500 lx. The angle in which the information can be read relative to a line perpendicular to the mounting surface of the device shall be at least 22.5° if viewed from the side, at least 15° if viewed from above, at least 15° if viewed from below.

21.3 Informative textual displays intended for mounting at a minimum height above the finished floor of 1200 mm (40 in) but less than 1780 mm (70 in) with an intended viewing distance of less than 1830 mm (6 ft) shall have a character height of not less than 16 mm (5/8 in).

21.4 Informative textual displays intended for mounting at a minimum height above the finished floor of greater than 1200 mm (40 in) but less than 1780 mm (70 in) with an intended viewing distance of greater than 1830 mm (6 ft) shall have a character height of not less than 16 mm (5/8 in) plus 3 mm per 300 mm (plus 0.12 in per 1 ft) of horizontal viewing distance beyond 1800 mm (6 ft).

21.5 Informative textual displays intended for mounting at a height above the finished floor between 1780 mm (70 in) but less than 3050 mm (10 ft) with an intended horizontal viewing distance of less than 4570 mm (15 ft) shall have a character height of not less than 51 mm (2 in).

21.6 Informative textual displays intended for mounting at a height above the finished floor of greater than between 1780 mm (70 in) but less than 3050 mm (10 ft) with an intended horizontal viewing distance of greater than 4570 mm (15 ft) shall have a character height of not less than 51 mm (2 in) plus an additional 3 mm per 300 mm (0.12 in per 1 ft) of viewing distance beyond 4570 mm (15 ft).

21.7 Informative textual displays intended for mounting at a height above the finished floor of greater than 3050 (10 ft) with an intended horizontal viewing distance of less than 6400 mm (21 ft) shall have a character height of not less than 75 mm (3 in).

21.8 Informative textual displays intended for mounting at a height above the finished floor of greater than 6400 mm (21 ft) with an intended horizontal viewing distance of greater than 6400 mm (21 ft) shall

have a character height of not less than 75 mm (3 in) plus an additional 3 mm per 300 mm (plus 0.12 in per 1 ft) of viewing horizontal distance beyond 6400 mm (21 ft).

21.9 The requirements pertaining to measurement of effective luminous intensity covered in Section 20, Measurement of Effective Luminous Intensity (Light Output), installation drawings in 48.2(b), and the marking requirements in 46.1 do not apply to informative textual displays.

22 Temperature Rise

22.1 The materials and components employed in the construction of an visible signaling device shall not be impaired and shall not attain temperature rises greater than those indicated in Table 22.1 under any condition of intended operation.

Table 22.1
Maximum Temperature Rises

Material	Normal standby		Operating (Alarm) condition	
	°C	(°F)	°C	(°F)
A. COMPONENTS				
1. Capacitors[a]	25	(45)	40	(72)
2. Fuses	25	(45)	40	(72)
3. Relays, transformers, and other coils with:				
a) Class 105 insulated windings				
Thermocouple method	65	(117)	65	(117)
Resistance method	75	(135)	75	(135)
b) Class 130 insulated windings				
Thermocouple method	85	(153)	85	(153)
Resistance method	95	(171)	95	(171)
4. Resistors[b]				
a) Carbon	25	(45)	25	(45)
b) Wire wound	50	(90)	325	(585)
5. Sealing compounds	See footnote c		See footnote c	
6. Solid-state devices	See footnote a or d		See footnote a or d	
B. INSULATED CONDUCTORS[e]				
1. Appliance wiring material	25 °C (45 °F) less than the established temperature rating of the wire		25 °C (45 °F) less than the established temperature rating of the wire	
2. Flexible cord – Types SJO, SJT	35	(63)	35	(63)
C. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	(45)	125	(225)
2. Phenolic composition used as electrical insulation or as parts where failure will result in a hazardous condition	25	(45)	65	(117)
3. Printed-wiring boards	Based on maximum use temperature rating of printed-wiring board material		Based on maximum use temperature rating of printed-wiring board material	
D. GENERAL				

Table 22.1 Continued on Next Page

Table 22.1 Continued

Material	Normal standby		Operating (Alarm) condition	
	°C	(°F)	°C	(°F)
1. Mounting surface	25	(45)	65	(117)
2. Wood or other combustible material	25	(45)	65	(117)
3. Enclosure surfaces:				
a) Metal	40	(72)	40	(72)
b) Plastic	60	(108)	60	(108)
c) Glass	50	(90)	50	(90)

[a] These components are not required to comply with these temperature limits when they have been evaluated in accordance with the appropriate sections in the Reliability Toolkit: Commercial Practices Edition, published by Reliability Information Analysis Center, US Department of Defense Information Analysis Center.

[b] A resistor is not required to comply with these temperature limits if it dissipates not more than one-half of its maximum power rating under the test conditions specified.

[c] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25 °C (77 °F) ambient temperature, is 15 °C (27 °F) less than the softening point of the compound as determined by ASTM E28.

[d] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits) shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation that produces the maximum temperature dissipation of its components. For reference purposes, 0 °C (32 °F) is to be considered as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

a) The component complies with the requirements in US Department of Defense, MILSTD – 883E, Test Method Standard – Microcircuits.

b) A quality control program is established by the manufacturer consisting of inspection and test of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

c) Each assembled production unit is subjected to a burn-in test, under the condition that results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49 °C (120 °F) followed by an operation test for normal signaling performance.

[e] For standard insulated conductors other than those mentioned, reference shall be made to the National Electrical Code, NFPA 70, in the United States, or the Canadian Electrical Code C22.1, in Canada. The maximum allowable temperature rise in any case is 25 °C (45 °F) less than the temperature limit of the wire in question.

22.2 For this test the visible signaling device shall be driven until constant temperatures (see 22.4) are attained but not less than 1 h at intended service conditions per Table 19.1 considered to produce the highest temperatures.

22.3 Temperature measurements on equipment intended for recessed mounting shall be made with the unit installed in an enclosure of nominal 19 mm (3/4 in) thick wood having clearances of 50 mm (2 in) on the top, sides and rear, and the front extended to be flush with the enclosure cover.

22.4 The values for temperature rises in Table 22.1 are based on an assumed ambient temperature of not more than 25 °C (77 °F). 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.

22.5 If equipment is intended for use with a prevailing ambient temperature higher than 25 °C (77 °F), the test is to be conducted at the intended 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 25 °C (77 °F).

22.6 Thermocouples used for temperature measurement shall consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.06 mm^2). Temperature measurement may be by the

resistance method or by the thermocouple method as appropriate. When supplementary thermal insulation or wrapping is employed, the temperature measurement point shall be under such material when measurement is by the thermocouple method.

22.7 The temperature rise of a coil winding may be determined by the resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the formula:

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

In which:

t = Temperature rise in °C

t_1 = Room temperature at beginning of test in °C

t_2 = Room temperature at end of test in °C

R = Resistance at the end of the test, in Ω

r = Resistance at the beginning of the test, in Ω

k = 234.5 for copper, or 225.0 for electrical conductor grade aluminum

22.8 The circuit of a current regulating resistor or reactor shall be adjusted for the maximum heating effect condition which may occur in service. Current, voltage and power regulating components shall be set for the worst-case heating effect service condition.

22.9 A visible signaling device that is intended to produce a signal when its energizing circuit is closed is to be operated continuously. An visible signaling device which is marked to indicate intermittent duty cycles is to be operated at such duty cycles.

22.10 A visible signaling device that is designed to operate when its energizing circuit is to intermittent shall be operated at the rate that produces the maximum temperature rise.

23 Dielectric Voltage-Withstand

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

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

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

c) For circuits rated more than 150 V AC rms (212 V DC) – 1000 V AC plus twice the rated voltage (1414 V plus 2.828 times the rated AC rms voltage, when a DC potential is used). See 23.3 – 23.5.

NOTE 1: Exposed dead-metal parts are non-current-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure of a product.

NOTE 2: A reference or component ground is to be disconnected prior to the test applications.

23.2 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 23.1 (a), (b) or (c), based on the highest voltage of the circuits under test. Electrical connections between the circuits are to be disconnected before the test potential is applied.

23.3 Where the charging current through a capacitor or capacitor-type filter connected across-the-line, or from line-to-earth ground is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 23.1.

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

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

b) Maintained at the test potential for 1 min without an indication of a breakdown or leakage of greater than 0.5 mA. Manual or automatic control of the rate of rise is not prohibited.

23.5 A printed-wiring assembly or other electronic circuit component that is capable of short-circuiting (or being damaged by) the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly is then to be tested instead of an entire unit. Rectifier diodes in the power supply may be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

23.6 If an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 23.1(c) is to be applied directly to all wiring involving more than 250 V.

24 Evaluation of Reduced Spacings on Printed-Wiring Boards

24.1 In accordance with the Exception of 15.1, printed-wiring board traces of different potential having reduced spacings shall comply with:

a) The dielectric voltage-withstand test described in 24.2 and 24.3; or

b) The shorted trace test described in 24.4 and 24.5.

24.2 A printed-wiring board, as specified in 24.1(a) shall withstand for 1 min without breakdown the application of a dielectric withstand potential between the traces having reduced spacings, in accordance with Section 23, Dielectric Voltage-Withstand, as appropriate.

24.3 Power-dissipating component parts, electronic devices, and capacitors connected between traces having reduced spacings, are to be removed or disconnected so that the spacings and insulations, rather than these component parts, are subjected to the full dielectric voltage-withstand test potential.

24.4 Printed-wiring board traces, as specified in 24.1(b), are to be short-circuited, one location at a time, and the test is to be conducted as described in 28.1 (Abnormal Operation and Burnout – General). As a result of this test:

a) The overcurrent protection associated with the branch circuit to the unit shall not open; and

b) A wire shall not open.

When the circuit is interrupted by opening of a component, the test is to be repeated twice, using new components when required. When a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur, and the procedure is to be repeated for each occurrence of a trace opening.

Exception: After opening of an internal overcurrent protective device, the test is not required to be repeated.

24.5 The test of 24.4 is to be continued for 1 h or until one of the conditions described below occurs. When, at the end of 1 h, no condition described below has occurred, and it is indicated that such a condition is imminent, the test is to be continued until ultimate results are obtained (usually 7 h).

24.6 Immediately following each fault described in 24.4, within one minute of the conclusion of the test, the product shall be subjected to Section 23, Dielectric Voltage-Withstand Test.

25 Endurance

25.1 A visible signaling device shall perform as intended when endurance tested as specified in 25.2 – 25.3, as applicable. There shall be no electrical or mechanical malfunction of the device, and the device shall comply with the requirements of Section 20, Measurement of Effective Luminous Intensity (Light Output), upon completion of the test specified in 26.2, Effect of Shipping/Storage Temperature. All tests shall be conducted at maximum rated voltage and maximum rated light output.

25.2 Two samples are first to be operated for alternate 5 min periods of energization and de-energization until 48 cycles have been completed. Following the 48 cycles, the device is to be operated continuously for 72 h. Overcurrent protection and thermal protection devices shall remain inactivated during the endurance.

25.3 Following the endurance conditioning and tests in 26.2, Effect of Shipping/Storage Temperature, the visible signaling device shall be allowed to stabilize to room temperature and the samples shall be examined for damage and then subjected to the applicable tests in Section 20, Measurement of Effective Luminous Intensity (Light Output) or 20.3, Black Box Test Procedure for Public Mode Signaling.

26 Variable Ambient Temperature

26.1 General

26.1.1 As a result of the exposure to 26.2, Effect of Shipping and Storage Temperature, 26.3, High and Low Ambient Temperature, and Section 27, Humidity:

a) Visible signaling devices shall not present a risk of shock;

b) Light output shall not be less than rated; and

c) A wireless notification appliance shall send and receive alarm and trouble signals while in 26.3, High and Low Ambient Temperature, and Section 27, Humidity. The trouble signal must individually identify the affected device as required in Section 6, Control Unit Interface.

26.2 Effect of shipping/storage temperature

26.2.1 The performance of a visible signaling device shall not be adversely affected by exposure to temperatures anticipated during shipping and storage. The exposure shall not result in warping, cracking, discoloration or any other damage that would impair its operation in any way or its suitability for the intended use.

26.2.2 A sample, as normally shipped, shall be subjected to a temperature of 70 ±5 °C (158 ±9 °F) for a period of 24 h, allowed to stabilize to room temperature, subjected to a temperature of -40 ±5 °C (-40 ±9 °F) for 3 h, and then allowed to stabilize to room temperature.

26.2.3 Following the exposures of 26.2.2, the samples shall be examined for damage, and then subjected to the tests in 26.3, High and Low Ambient Temperature.

26.3 High and low ambient temperature

26.3.1 Low temperature test

26.3.1.1 A visible signaling device shall be operational during and following the exposure to the low temperature test.

26.3.1.2 A visible signaling device intended for indoor use in dry locations, is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber and then the sample is momentarily energized to verify operation. The environmental chamber is then turned on and adjusted to the lower of the following temperatures:

a) 0 ±5 °C (32 ±9 °F); or

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

During the exposure the signaling device is not energized except as noted in between exposures. The exposure time is to be 3 h or longer if required to achieve thermal equilibrium.

26.3.1.3 A visible signaling device intended for indoor use in damp locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then momentarily energized to verify that it is operational before being 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 % R.H. to the lower temperature indicated in 26.3.1.2 for a period of 30 min, and back to a temperature of 25 ±5 °C (77 ±9 °F) at a humidity of 95 ±5 % R.H. The rate of change is to be 2 ±1 °C (3.6 ±1.8 °F) per min. During the exposure the signaling device is not energized except as noted between exposures.

26.3.1.4 A signaling device intended for outdoor use in damp or wet locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then momentarily energized to verify that it is operational before being 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 % R.H. to the lower the temperature indicated below for a period of 30 min, and back to a temperature of 25 ±5 °C (77 ±9 °F) at a humidity of 95 ±5 % R.H. The rate of change is to be 2 ±1 °C (3.6 ±1.8 °F) per min. During the exposure the visible signaling device is not to be energized, except as noted between exposures.

a) -40 ±5 °C (-40 ±9 °F); or

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

26.3.1.5 At the completion of the appropriate low temperature exposure, and while at the low temperature, the environmental chamber is to be de-energized and the visible signaling device is to be momentarily energized to verify that it is operational and then subjected to the applicable tests in 20.3, Black Box Test Procedure for Public Mode Signaling.

26.3.1.6 Following the low temperature exposures, the samples shall be allowed to stabilize to room temperature and then examined for damage before being subjected to the tests in 26.3.2, High Temperature Test.

26.3.2 High temperature test

26.3.2.1 A visible signaling device shall operate as intended during and following exposure to the high temperature test.

26.3.2.2 A signaling device intended for indoor use in dry locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then momentarily energized to verify that it is operational. The environmental chamber is then turned on and adjusted to maintain 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 visible signaling device is not to be energized except as noted in between exposures. The exposure time is to be 3 h or longer if required to achieve thermal equilibrium.

26.3.2.3 A visible signaling device intended for indoor use in damp or wet locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then momentarily energized to verify that it is operational before being 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 % R.H. to the higher temperature indicated in 26.3.2.2 for a period of 30 min, and back to a temperature of 25 ±5 °C (77 ±9 °F) at a humidity of 95 ±5 % R.H. The rate of change is to be 2 ±1 °C (3.6 ±1.8 °F) per min. During exposure the signaling device is not energized, except as noted between exposures.

26.3.2.4 A visible signaling device intended for outdoor use in damp or wet locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then momentarily energized to verify that it is operational before being 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 % R.H. to the higher of the temperatures indicated below for a period of 30 min, and back to a temperature of 25 ±5 °C (77 ±9 °F) at a humidity of 95 ±5 % R.H. The rate of change is to be 2 ±1 °C (3.6 ±1.8 °F) per min. During exposure the signaling device is not energized except as noted between exposures.

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

b) The highest ambient operating temperature specified in the manufacturer's published instructions or on its marking.

26.3.2.5 At the completion of the appropriate high temperature exposure, while at the high temperature, the environmental chamber is to be de-energized and the signaling device is to be momentarily energized to verify that it is operational and then subjected to the applicable tests in the Black box test procedure for public mode signaling, 20.3, Black Box Test Procedure for Public Mode Signaling.

26.3.2.6 Following the high temperature exposures the samples shall be allowed to stabilize to room temperature before being examined for damage and then subjected to Section 27, Humidity Test.

27 Humidity Test

27.1 Following the exposures in Section 26, Variable Ambient Temperature, a visible signaling device shall operate as intended during and following exposure to high humidity without risk of fire or electric shock.

27.2 A visible signaling device intended for indoor use only in dry locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environmental chamber. The sample is then to be momentarily energized to verify that it is operational before being subjected to relative humidity of 93 ±2 % and a temperature of 32 ±2 °C for a period of 24 h. During the exposure the signaling device is not to be energized except as noted between exposures.

27.3 A visible signaling device intended for indoor or outdoor use in damp or wet locations is to be mounted as described in 20.3, Black Box Test Procedure for Public Mode Signaling, and the black box placed in an air circulating environment chamber. The sample is then momentarily energized to verify that it is operational before being subjected to relative humidity of 95 ±5 % and a temperature of 60 ±5 °C (140 ±9 °F) and maintained for 240 h. During the exposure the signaling device is not to be energized except between exposures.

27.4 At the completion of the humidity exposure, the environmental chamber is to be de-energized and the signaling device is to be momentarily energized to verify that it is operational. It shall then be allowed to stabilize to room temperature and subjected to the applicable tests in 20.3, Black Box Test Procedure for Public Mode Signaling.

27.5 Following the operational check in the humidity environment, the visible signaling device shall be removed from the humidity chamber and within 5 min it shall be subjected to and meet the requirements of Section 23, Dielectric Voltage-Withstand.

28 Abnormal Operation and Burnout

28.1 General

28.1.1 A visible signal device shall not present a fire hazard or an electrical shock hazard as a consequence of an electrical fault or overload.

28.1.2 The devices under test shall be mounted as in normal service and oriented so as to represent the worst case with respect to the emission of glowing particles, flame or molten metal. Five layers of bleached cheesecloth, having an area of 26 to 28 m^2/kg (14 – 15 square yards to the pound) and a count of 32 by 28, are to be located as close as possible below the sample under test.

28.1.3 Additionally, all openings of the unit enclosure are to be covered with a single layer of bleached cheesecloth as described in 28.1.2.

28.1.4 For each of the test conditions described in following sections, the test voltage is to be applied and maintained until constant device temperature is attained, or until burnout, or until a catastrophic failure occurs. During the test, exposed dead metal parts of the appliance are to be connected to ground through a 15-ampere fuse.

28.1.5 When the unit provides for selection of several operating modes, during this test the unit shall be set for the operation mode that normally would require the maximum current consumption.

28.1.6 In the case where a device under test employs interchangeable-type fuses, for the purpose of this test these fuses are to be replaced with a fuse of the size fitting the fuseholder but having the highest available current rating.

28.2 Abnormal supply line

28.2.1 A visible signaling device shall not present a fire hazard or an electrical shock hazard as a consequence of the application of an abnormal supply.

28.2.2 The device shall be driven by a 60 Hz supply having a capacity of 1000 VA or greater. The test voltage shall be 120 V rms or 2 times rated voltage, whichever is greater.

28.3 Abnormal duty cycle

28.3.1 A visible signaling device intended to produce a flash rate intended for intermittent duty shall withstand continuous energization at maximum rated voltage without the emission of flame or molten metal from the enclosure and without any other manifestation of risk of fire, electric shock, or injury to persons.

28.3.2 The device shall be continuously driven by a 60 Hz supply having a capacity of 1000 VA. The test voltage shall be 2 times rated voltage.

28.4 Compliance

28.4.1 The visible signaling device shall be considered in compliance with the tests described in this section when the following requirements are met:

a) No emission of flame or molten metal;

b) The cheesecloth shall not be ignited by emitted material;

c) The maximum external enclosure temperature shall not exceed 90 °C (194 °F);

d) No exposure of energized uninsulated parts at potential above 30 V after the input to the visible signaling device has been reduced to rated voltage;

e) The dead metal parts and enclosure grounding fuse shall not open as a result of this test; and

f) The requirements of Dielectric Voltage-Withstand, Section 23.

29 Component Stress

29.1 The stress level of a component shall not exceed 90 % of its rated voltage The voltage drop developed across each component is to be measured, and the stress level is to be obtained by dividing measured voltage by the rated voltage of the component.

29.2 If the stress level of the component exceeds 90 % of its rated voltage, the component shall be examined to determine whether open-circuit or short-circuit conditions introduce a risk of fire or electric shock.

29.3 To determine compliance with 29.2 the product is to be conditioned as follows:

a) Energized from maximum rated voltage;

b) Any interchangeable fuse replaced with a fuse of the highest available current rating which fits the fuseholder;

c) The appliance covered with a single layer of bleached cheesecloth fabricated at 26 – 28 m^2/kg (14 – 15 yd^2/lb) and having a thread count of 32 by 28, loosely draped over the product; and

d) The enclosure, when of metal, connected to ground through a fuse rated to correspond to the input rating of the appliance.

29.4 A product complies with 29.2 if, immediately following the test:

a) There is no burning of the cheesecloth;

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

c) The signaling device complies with Section 23, Dielectric Voltage-Withstand Test.

30 Jarring

30.1 The visible signaling device shall withstand jarring resulting from impact anticipated in the intended application without dislodgement of any parts, including covers or grills, and without impairing its subsequent intended operation. The device shall be mounted in the position of intended use. A visible signaling device intended for wall or ceiling mounting shall be tested in the wall-mounted position.

30.2 One impact is to be applied with the visible signaling device de-energized and one impact is to be applied with the device driven at rated voltage. The impacts shall not result in:

a) Unintended operation;

b) Inhibition of intended operation; and

c) Damage that exposes high-voltage un-insulated current carrying parts.

NOTE: Falling off of the sample's cover shall be permitted only when parts operating at a potential greater than 30 Vac or 42.4 Vdc are not exposed, operation is not affected, and the cover can be replaced as intended

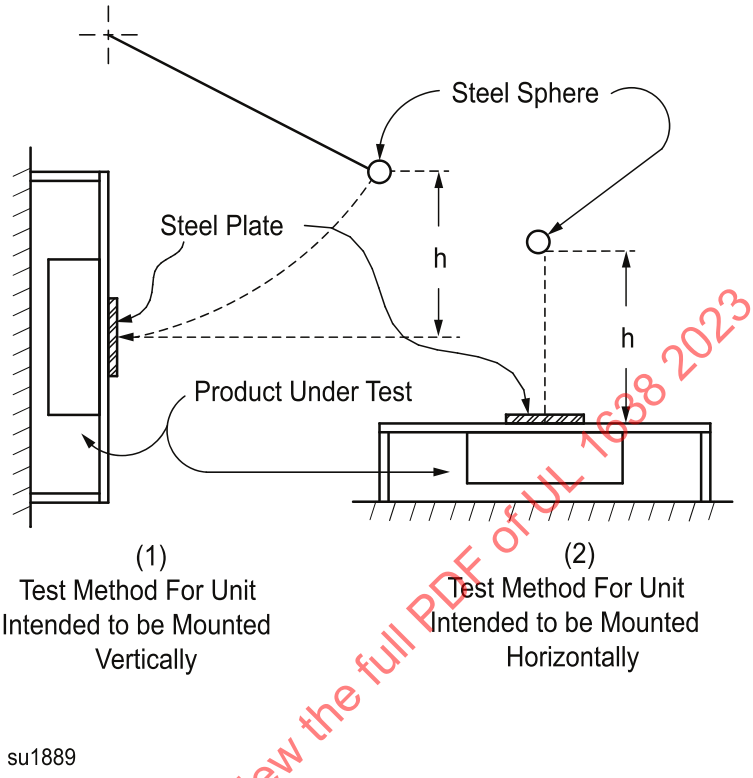
30.3 The visible signaling device shall be mounted in the position of intended use to the center of a 1800 by 1200 mm (72 by 48 in), 19 mm (3/4 in) thick plywood board which is secured in place at the four corners. See Figure 30.1. A 105 mm (4 in) square steel plate, 3.2 mm (1/8 in) thick, shall be rigidly secured to the center of the reverse side of the board. A 4.08 J (3 ft-lb) impact is to be applied to the center of the steel plate by means of a 540 g (19 oz), 50 mm (2 in) diameter steel sphere which is either:

a) Swung through a pendulum arc from a height (h) of 775 mm (30.5 in) in order to apply 4.08 J (3 ft-lb) of energy; or

b) Dropped from a height (h) of 775 mm (30.5 in) to apply 4.08 J (3 ft-lb) energy depending upon the mounting of the equipment.

Figure 30.1

Jarring Test



30.4 Following the jarring, the visible signaling device shall be examined for dislodgement of parts and then subjected to Section 31, Vibration Test.

31 Vibration Test

31.1 A visible signaling device shall withstand vibration without breakage or damage to parts, and without development of any condition, which would impair its intended operation.

31.2 The sample used in the jarring test, in the de-energized state, shall be mounted as in normal service to a 19 mm (3/4 in) thick fir plywood sheet, 460 by 460 mm (18.1 by 18.1 in), which, in turn, shall be securely fastened to a variable speed vibration machine having an amplitude of 0.25 mm (0.009 in). An visible signaling device intended for wall or ceiling mounting shall be tested in the wall-mounted position. The frequency of vibration shall be varied from 10 Hz to 35 Hz until resonance is obtained. The sample shall then be vibrated at the resonant frequency for 15 min. If no resonance is obtained, the sample shall be vibrated at 35 Hz for 4 h.

31.3 For these tests, amplitude is defined as the maximum displacement for sinusoidal motion from a position of rest, or 50 % of the total table displacement.

31.4 Following vibration, the sample shall be examined for dislodgment of parts and shall comply with the following without replacement of parts:

a) Section 20, Measurement of Effective Luminous Intensity (Light Output); and

b) Section 23, Dielectric Voltage-Withstand Test.

32 Strain Relief

32.1 Each lead used for field connections or an internal lead subjected to movement or handling during installation and servicing shall be capable of withstanding for 1 min. a pull of 44.5 N (10 lb-f) without any evidence of damage or of transmitting the stress to internal connections.

32.2 A cord provided for field wiring shall withstand for 1 min, 156 N (35 lb-f) without any evidence of damage, or transmittal of the stress, to internal connections.

32.3 The cord shall also be provided with means to prevent the cord from being pushed inside the enclosure if, 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 sharp or moving parts capable of damaging the insulation of the cord or affecting the performance of a fire or emergency warning visible signaling device; or

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

32.4 To determine compliance with 32.3, the supply cord or lead is to be held 25.4 mm (1 in) from the point where the cord or lead emerges from the product and then pushed back into the product. When a removable bushing which extends further than 25 mm is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 25.4 mm increments until the cord buckles or the force to push the cord into the product exceeds 26.7 N (6 lb-f).

33 Corrosion Tests

33.1 General

33.1.1 The performance of a visible signaling device shall not be adversely affected following exposure to the tests specified in 33.2, Hydrogen Sulphide, and 33.3, Sulphur Dioxide – Carbon Dioxide. Visible signaling devices intended for outdoor-use shall also not be adversely affected following exposure to the test specified in 33.4, Salt Spray.

33.1.2 Four as-received samples are to be tested for indoor-use and six as-received samples are to be tested for outdoor-use. Two samples are to be subjected to the corrosion conditions specified in 33.2, Hydrogen Sulphide, and the other two samples are to be subjected to the conditions specified in 33.3, Sulphur Dioxide-Carbon Dioxide. Two visible signaling devices intended for outdoor-use shall also be subjected to a salt spray specified in 33.4, Salt Spray. The exposures shall be with the sample in the de-energized state.

33.1.3 Following exposure to the environment, the sample shall be allowed to stabilize to room conditions and then shall comply with the following:

a) Section 23, Dielectric Voltage-Withstand;

b) The applicable tests in Section 20, Measurement of effective luminous intensity (light output); and

c) A wireless notification appliance shall not be reduced in performance when tested in accordance with 50.3 following each exposure.

33.2 Hydrogen sulphide

33.2.1 The test samples are to be supported vertically for 10 d in a closed chamber having openings for gas inlet and outlet. The chamber is to be maintained at room temperature during the test.

33.2.2 For an indoor-use visible signaling device, two samples are to be exposed to a moist hydrogen sulphide-air mixture in a closed glass chamber as described in 33.2.1. The hydrogen sulphide is to be supplied to the test chamber from a commercial cylinder containing this gas under pressure. On the first through fourth, and seventh through tenth days, an amount of hydrogen sulphide equivalent to 0.1 % of the volume of the chamber is to be introduced into the chamber from a commercial gas cylinder, and the volume required is to be measured with a flow meter and stopwatch. Before each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed, and no purging or introduction of gas is to be conducted. During the exposure, the gas-air mixture is to be gently stirred by means of a small motor-driven fan located in the upper-middle portion of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

33.2.3 For an outdoor-use visible signaling device, two samples are to be exposed to a moist hydrogen sulphide-air mixture in a closed glass chamber as described in 33.2.1. The hydrogen sulphide is to be supplied to the test chamber from a commercial cylinder containing this gas under pressure. On the first through fourth, and seventh through tenth days, an amount of hydrogen sulphide equivalent to 1.0 % of the volume of the chamber is to be introduced into the chamber from a commercial gas cylinder, and the volume required is to be measured with a flow meter and stopwatch. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed and no purging or introduction of gas is to be conducted. During the exposure, the gas-air mixture is to be gently stirred by means of a small motor-driven fan located in the upper-middle portion of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) to be maintained at the bottom of the chamber for humidity.

33.3 Sulphur dioxide – carbon dioxide

33.3.1 The test samples are to be supported vertically for 10 d in a closed chamber having openings for gas inlet and outlet. The chamber is to be maintained at room temperature during the test.

33.3.2 For an indoor-use visible signaling device, two samples are to be exposed to a moist carbon dioxide-sulphur dioxide-air mixture in a closed glass chamber as described in 33.3.1. The sulphur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. On the first through fourth, and seventh through tenth days, an amount of carbon dioxide equivalent to 1.0 % of the volume of the chamber, plus an amount of sulphur dioxide equivalent to 0.5 % of the volume of the chamber, is to be introduced. On the fifth and sixth day of the exposure period, the chamber is to remain closed and no purging or introduction of gas is to be conducted. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

33.3.3 For an outdoor-use visible signaling device, two samples are to be exposed to a moist carbon dioxide-sulphur dioxide-air mixture in a closed glass chamber as described in 33.3.1. The sulphur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. On the first through fourth, and seventh through tenth days, an amount of carbon dioxide equivalent to 1.0 % of the volume of the chamber, plus an amount of sulphur dioxide equivalent to 1.0 % of the volume of the chamber, is to be introduced. On the fifth and sixth day of the exposure period, the chamber is to remain closed and no purging or introduction of gas is to be conducted. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

33.4 Salt spray

33.4.1 For an outdoor-use visible signaling device, each sample is to be subjected to salt-spray (fog) for 240 h in accordance with ASTM B117, except that the salt solution is to consist of 5 % by weight of common salt (sodium chloride) and distilled water. The pH of the collected solution is to be between 6.7 – 7.2, with a specific gravity between 1.0255 and 1.0400 at 25 °C (77 °F).

33.5 Alternative indoor corrosion test (21-day)

33.5.1 The 21-day corrosion test outlined in 33.5.2 – 33.5.4 may be conducted in lieu of the Corrosion Test in 33.2 and 33.3.

33.5.2 Two samples are to be placed in a 200 L or larger test chamber on a platform approximately 50.8 mm (2 in) above the bottom of the chamber. The temperature in the chamber shall be maintained at 30 ±2 °C (86 ±3 °F) and the relative humidity at 70 ±2 % (measured directly in the chamber). The temperature and humidity are to be checked daily. Because of the corrosive atmosphere a set of wet and dry bulb thermometers shall be used for measurement of relative humidity.

33.5.3 The following gas mixture in air is to be supplied to the chamber at a rate sufficient to achieve an air exchange in the chamber of about five times per hour, for a period of 3 weeks: 100 ±10 parts per billion (ppb) (parts per billion = parts per 109 by volume) hydrogen sulfide (H_2S) plus 20 ±5 ppb chlorine (Cl_2) plus 200 ±50 ppb nitrogen dioxide (NO_2). The air inside the chamber is to be circulated by a single fan, with flow upwards from the bottom.

33.5.4 Following exposure to the environment, the sample shall be allowed to stabilize to room conditions and then shall comply with 33.1.3.

34 Water Spray Test

34.1 A visible signaling device intended for outdoor-use or use in a wet environment shall operate as intended and shall be free from shock exposure during and after exposure to water spray for 1 h. An outdoor-use visible signaling device intended for mounting in such a manner and location that it would not be exposed to rain or water seepage, need not be subjected to this test providing the visible signaling device is appropriately marked and the exception detailed in the installation instructions.

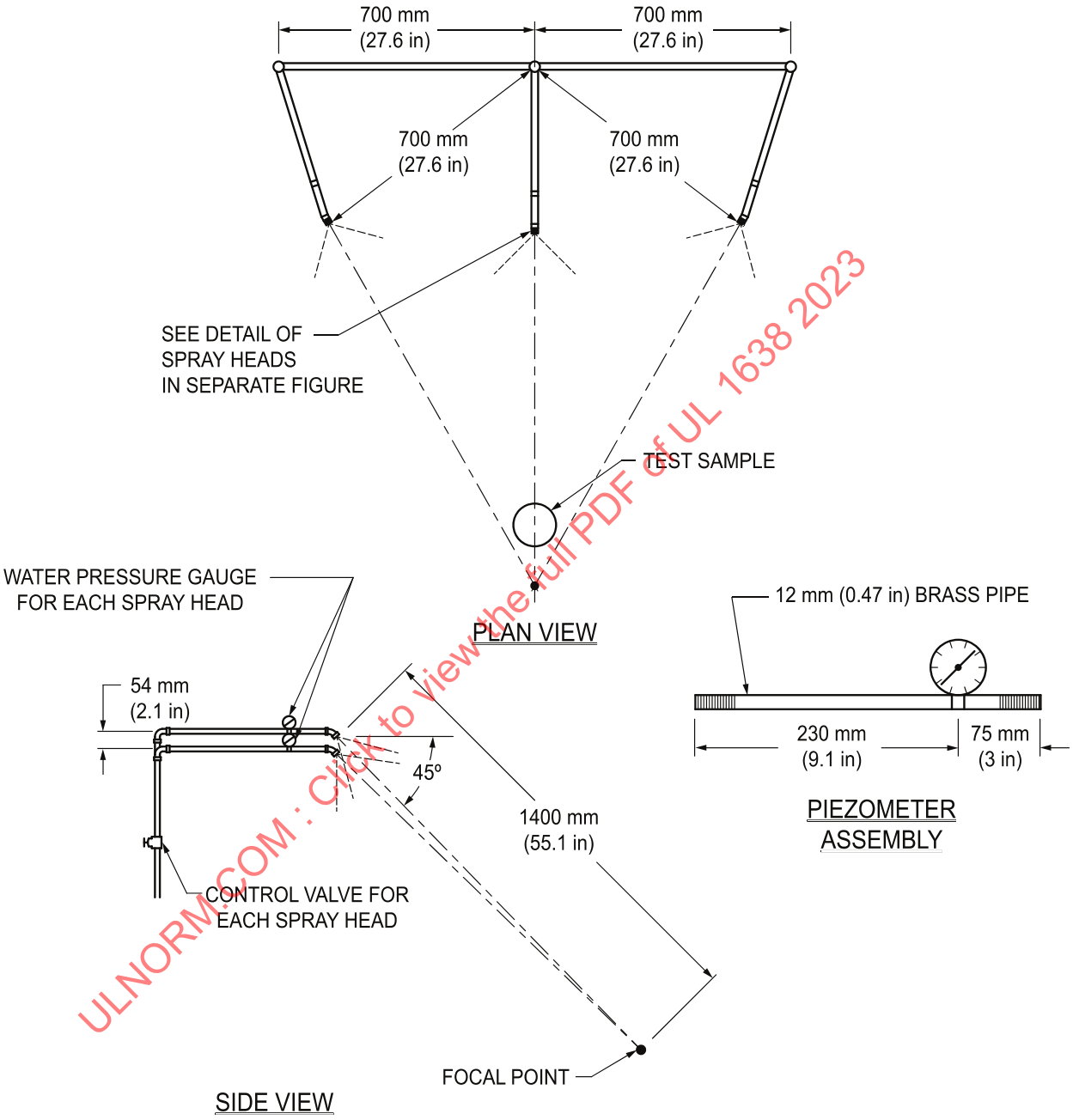
34.2 An enclosure constructed from a polymeric material shall be conditioned for 7 h at 70 °C (158 °F) prior to the application of water spray.

34.3 The visible signaling device shall be mounted in accordance with the installation instructions to simulate an installation as in normal service and shall be complete with external wiring and conduit connection. The orientation of the assembly shall be one permitted by the installation instructions which would most likely result in the entrance of water into the enclosure or affect the operation of the visible signaling device.

34.4 The water test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 34.1. Spray heads are to be constructed in accordance with Figure 34.2. The water pressure for all tests is to be maintained at 35 kPa at each spray head. The distance between the center nozzle and the visible signaling device is to be approximately 1 m. The visible signaling device 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 visible signaling device enclosure or other parts of the assembly where the presence of water would impair the visible signaling device operation. The spray is to be directed at an angle of 45° to the vertical toward openings closest to live and operational parts.

Figure 34.1

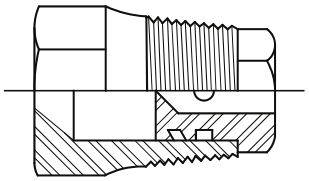
Water Spray-Head Piping



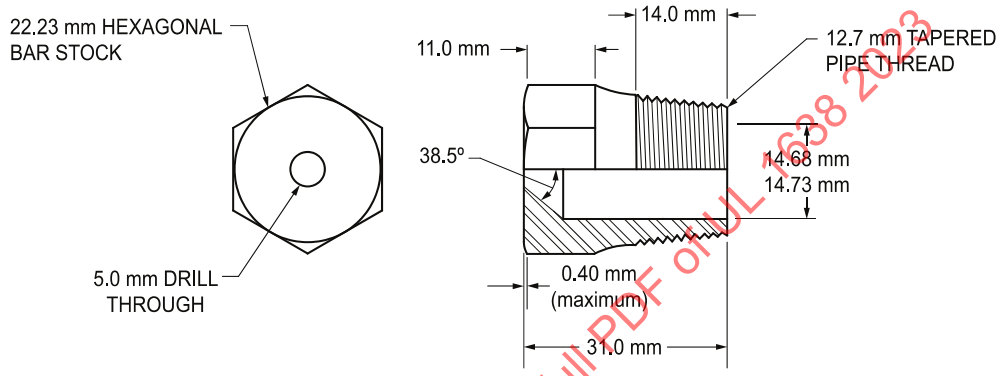
su1629a

Figure 34.2

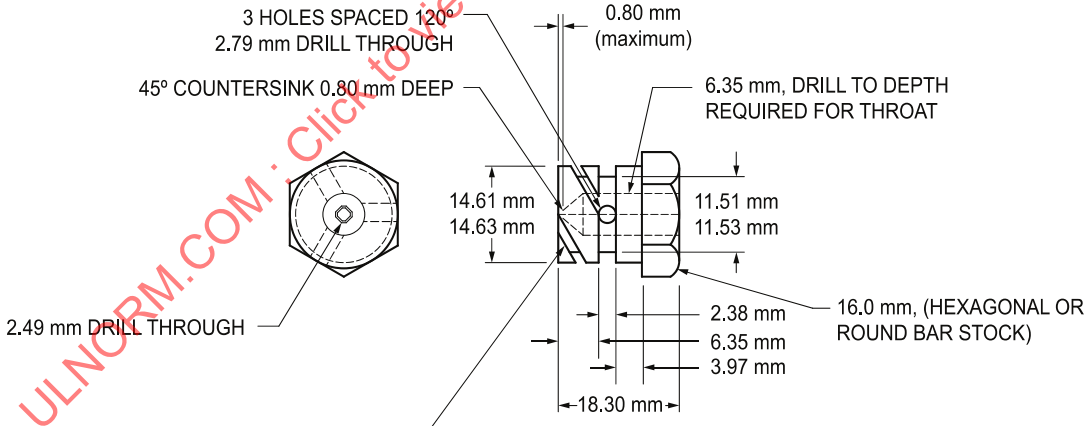
Water Spray Head



ASSEMBLY



BODY DETAIL



INSERT DETAIL

su1628

mm	(in)	mm	(in)	mm	(in)	mm	(in)
152	(6)	31	(1.22)	22.23	(0.87)	16	(0.63)
14.73	(0.580)	14.68	(0.578)	14.63	(0.576)	14.61	(0.575)
14	(9/16)	11.53	(0.454)	11.51	(0.453)	11	(7/16)
6.35	(1/4)	5	(0.20)	3.97	(5/32)	2.79	(0.11)
2.49	(0.098)	2.38	(3/32)	0.80	(1/32)	0.40	(0.015)

34.5 The test set-up shall be arranged so that the visible signaling device shall be driven at maximum input power before the application of the water spray.

34.6 The visible signaling device shall be driven at maximum input power for 5 min immediately before the water spray application.

34.7 The visible signaling device shall be subjected for 1h of water spray. The visible signaling device shall not be powered during the test.

34.8 The visible signaling device shall be removed from test set-up and subjected to a dielectric voltage-withstand test in accordance with Section 23, Dielectric Voltage-Withstand, within 5 min following the water spray application.

34.9 Immediately following the Dielectric Voltage-Withstand the visible signaling device shall be driven at the maximum input power for 5 min, and then the effective luminous intensity shall be measured in accordance with the applicable tests in Section 20, Measurement of Effective Luminous Intensity (Light Output).

34.10 The visible signaling device shall be considered in compliance with this test when the following requirements are met:

a) No dielectric breakdown as tested per 34.8;

b) There shall be no signs of water in the enclosure capable of wetting uninsulated electrical components; and

c) The light output does not decrease beyond the limits specified in Section 20, Measurement of Effective Luminous Intensity (Light Output).

35 Polarity Reversal

35.1 A visible signaling device, intended to be connected to a specific polarity, shall operate for its intended signaling performance after being connected to each polarity of the supply source at the voltage indicated. The reversed polarity is to be applied for at least 1 h and then the visible signaling device is to be connected to a source of supply having the correct polarity.

35.2 The test shall not:

a) Cause unintended operation;

b) Inhibit intended operation;

c) Damage any part; and

d) Adversely affect subsequent normal operation.

35.3 Before and at the end of the test, the visible signal device is to be subjected to Section 20, Measurement of Effective Luminous Intensity (Light Output), or 20.3, Black Box Test Procedure for Public Mode Signaling.

36 Electric Shock Current

36.1 Any part that is exposed only during operator servicing shall not present a risk of electric shock. A shock hazard from contact with a live part is considered to exist if the open circuit potential of the part to

earth ground or any other exposed accessible part exceeds 42.4 V (peak) and the available current or stored energy exceeds the values specified in 36.2, 36.3 and 36.5.

36.2 The continuous current flow through a 500 Ω resistor connected between the part and earth ground or any other exposed accessible part shall not exceed the values specified in Table 36.1.

Table 36.1
Maximum Acceptable Continuous Current

Frequency (Hz)[a]	Maximum acceptable current through a 500 Ω resistor (mA) Peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum acceptable current corresponding to frequencies not shown. The Table applies to repetitive nonsinusoidal or sinusoidal waveforms.

36.3 The duration of a transient current flowing through a 500 Ω resistor connected between the part and earth ground or other exposed accessible part shall not exceed the following:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I} \right)^{1.43}$$

Where:

I = The peak current in milliamperes; and

T = The interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 mA and the time that the current falls below 7.1 mA for the last time; or

b) 809 mA, regardless of duration.

36.4 The interval between occurrences shall be equal to or greater than 60 s if the current is repetitive. Typical calculated values are shown in Table 36.2.

Table 36.2
Maximum Acceptable Transient Current Duration

Maximum peak current (I) through 500-ohm resistor, amperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.22 s
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	13
700.0	10
809.0	8.3

36.5 The maximum capacitance between the accessible terminals of the capacitor shall not exceed the values given by the following equations:

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

or:

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

Where:

C = The maximum capacitance of the capacitor in microfarads, and

E = The potential in volts across the capacitor prior to discharge. *E* is to be measured 5 s after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like.

36.6 Typical calculated values of maximum capacitance are shown in Table 36.3.

Table 36.3
Electric Shock – Stored Energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.7
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124
45	150
42.4	169

36.7 With reference to the requirements of 36.2 and 36.3, the current is to be measured while the resistor is connected between ground and each accessible part individually, and all accessible parts collectively, if the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

36.8 With reference to the requirements of 36.7, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is considered to be able to contact parts simultaneously if the parts are within a 100 by 200 mm (4 by 8 in) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 1800 mm (71 in) apart.

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

36.10 If the visible signaling device has a direct-current rating, measurements are to be made with the visible signaling device connected in turn to each side of a 3-wire, direct current supply circuit.

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

36.12 Each terminal provided for the connection of an external antenna shall be conductively connected to the supply circuit grounded conductor. The conductive connection shall have a maximum resistance of 5.2 MΩ, a minimum wattage rating of 1/2 W, and shall be effective with the power switch in either the on or off position.

Exception: The conductive connection is not required to be provided if such a connection is established in the event of electrical breakdown of the antenna isolating means, the breakdown does not result in a risk of electric shock and, in a construction employing an isolating power transformer, the resistance of the conductive connection between the supply circuit and chassis does not exceed 5.2 MΩ.

36.13 The maximum value of 5.2 MΩ specified in 36.12 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 MΩ with 20 % tolerance or a resistor rated 4.7 MΩ with a 10 % tolerance is acceptable. A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements of CSA C22.2 No.1 and UL 60384, may be rated a minimum of 1/4 W.

37 Tests on Polymeric (Plastic) Materials

37.1 General

37.1.1 Polymeric materials used for the sole support of current-carrying parts, or for all or part of an enclosure of a visible signaling device, shall be subjected to the tests in 37.2, Air-Oven Aging (Temperature)and Flame, 37.3 and 37.4. Where possible, a complete visible signaling device shall be used.

37.1.2 A visible signaling device molded from polymeric material rated Flammability class 5VA in accordance with:

a) In Canada only: CSA C22.2 No. 0.17; or

b) In the United States only: UL 94;

is considered to comply with the requirements of 37.3 and 37.4 without the necessity of further tests.

37.2 Air-oven aging test (temperature)

37.2.1 There shall not be warping that impairs intended operation; exposes high-voltage uninsulated current carrying parts or affect the enclosures environmental integrity when representative samples of a polymeric material are aged as described in 37.2.2.

37.2.2 At least three representative samples shall be mounted on supports in an air circulating oven maintained at 90 ±2 °C (194 °F) for 7 d or at 70 ±2 °C (158 °F) for 28 d. Following the aging period, the sample shall be removed from the oven and permitted to cool to room temperature before being examined as described in 37.2 for any distortion which exposes high-voltage uninsulated current carrying parts. Falling off of the sample's cover shall be permitted only when parts operating at a potential greater than 30 Vac or 42.4 Vdc are not exposed, operation is not affected, and the cover can be replaced as intended. Gaskets on samples intended for outdoor use shall be visually examined for evidence of deterioration

such as cracking, shrinkage, distortion, or similar deterioration to an extent that it affects the integrity of the seal. If visual evidence exists, a sample shall be subjected to Section 34, Water Spray Test, followed by light output measurements as described in Section 20, Measurement of Effective Luminous Intensity (Light Output). Where the conditioning process has damaged electronic components, it is permissible to replace them.

37.2.3 The effective luminous intensity output shall not be less than applicable minimum in accordance with Section 20, Measurement of Effective Luminous Intensity (Light Output).

37.3 Flame test – 19 mm (3/4 in)

37.3.1 When tested in accordance with 37.3.2 – 37.3.6, a polymeric (plastic) material employed as part of a visible signaling device rated 30 Vac (42.4 V DC or AC peak) or less and used for the sole support of current-carrying parts or as an enclosure shall not flame for more than 1 min after two 30 s applications of a test flame, with an interval of 1 min between applications of the flame. The sample shall not be completely consumed.

37.3.2 Three samples of the equipment are to be conditioned by placing them in a forced draft circulating air oven maintained at a uniform temperature not less than 10 °C (18 °F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70 °C (158 °F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 h, the samples are to be tested as described in 37.3.3 – 37.3.6.

Exception: Unconditioned test samples may be used when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging; and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

37.3.3 Three samples of the part are to be subjected to the Flame Test described in 37.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. Each sample is to be tested with the flame applied to a different location.

Exception: Unconditioned test samples may be used when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging; and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

37.3.4 With reference to 37.3.3, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing parts.

37.3.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 9.5 ±0.3 mm (0.374 ±0.12 in) and an inside diameter of 100 ±10 mm (3.94 ±0.39 in) is to be adjusted to have a 19 mm (3/4 in) height of yellow flame with no blue cone. Two 30 second applications of the tip of the flame are to be made to each section of the equipment specified as indicated above, with 1 min intervals between the applications. A supply of technical-grade methane gas (minimum 98 % pure) is to be used with a regulator and meter for uniform gas flow.

Exception: Natural gas having a heat content of 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C (73 °F) has been found to provide similar results and is appropriate for use.

37.3.6 When one sample from a set of three does not comply with 37.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with 37.3.1.

37.4 Flame test – 127 mm (5 in)

37.4.1 When tested in accordance with 37.4.2 – 37.4.6, a plastic material employed as part of a visible signaling device rated greater than 30 Vac (42.4 V DC or AC peak) and used for the sole support of current-carrying parts or as an enclosure all of the following results shall be obtained:

a) The material shall not continue to burn for more than 1 min after the fifth 5 s application of the test flame, with an interval of 5 s between applications of the flame;

b) Flaming drops or flaming or glowing particles that ignite surgical cotton 305 mm (12 in) below the test specimen shall not be emitted by the test sample at any time during the test; and

c) The material shall not be destroyed in the area of the test flame to such an extent that the integrity of the part is affected with regard to containment of fire or exposure of high voltage parts.

37.4.2 Three samples of the complete equipment or three test specimens of the molded part shall be subjected to this test. Consideration is to be given to leaving in place components and other parts that influence the performance. The test samples are to be conditioned in a full draft circulating air oven for 7 days at 10 °C (18 °F) greater than the maximum use temperature and not less than 70 °C (158 °F) in any case. Prior to testing, the samples are to be conditioned for a minimum of 40 h at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 % relative humidity. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. When more than one part is near a source of ignition, each sample is to be tested with the flame applied to a different location.

Exception: Unconditioned test samples may be used when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging; and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

37.4.3 The three samples shall perform as described in 37.4.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All the new specimens shall comply with 37.4.1.

37.4.4 The Bunsen or Tirrill burner with a tube length of 9.5 ±0.3 mm (0.374 ±0.12 in), and an inside diameter of 100 ±10 mm (3.94 ±0.39 in), is to be placed remote from the specimen, ignited, and adjusted so that when the burner flame is 127 mm (5 in), the height of the inner blue cone is 38 mm (1-1/2 in). The tube is not to be equipped with end attachments, such as stabilizers.

37.4.5 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service, as long as it does not impair the flame testing, in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 305 mm (12 in) below the point of application of the test flame. The 127 mm (5 in) flame is to be applied to any portion of the interior of the part judged as capable of being ignited (by its proximity to live or arcing parts, coils, wiring, or other possible sources of ignition) at an angle of 20° from the vertical so that the tip of the blue cone touches the specimen. The test flame is to be applied to three different locations on each of the three samples tested. A supply of

technical-grade methane gas (minimum 98 % pure) is to be used with a regulator and meter for uniform gas flow.

Exception No. 1: The flame shall be applied to the outside of an enclosure when the equipment is of the encapsulated type, or of a size that prohibits the flame being applied inside.

Exception No. 2: Natural gas having a heat content of 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C (73 °F) has been found to provide similar results and is appropriate for use.

37.4.6 The flame is to be applied for 5 s and removed for 5 s. The operation is to be repeated until the specimen has been subjected to five applications of the test flame.

37.5 Ultraviolet light and water exposure test

37.5.1 The polymeric enclosure of a high-voltage visible signaling device intended for outdoor use shall not show visible signs of deterioration, such as crazing, cracking, or dimensional change after being subjected to the Ultraviolet Light Exposure Test and Water Exposure and Immersion Test in accordance with the following standards:

a) In Canada only: CSA C22.2 No. 0.17;

b) In the United States only: UL 746C.

37.5.2 An outdoor-use visible signaling device molded from polymeric material rated class f1 or f2, in accordance with CSA C22.2 No. 0.17 and UL 746C is considered to comply with the requirements of this section without the necessity of further tests.

37.5.3 Samples that show visible signs of deterioration, such as crazing, cracking, or dimensional change shall be subjected to the tests described in Section 34, Water Spray Test.

37.5.4 Following this test, samples shall also be subjected to the tests in Section 20, Measurement of Effective Luminous Intensity (Light Output) to verify that light output does not decrease beyond the limits specified in Section 20.

38 Mechanical Strength Tests for Enclosures

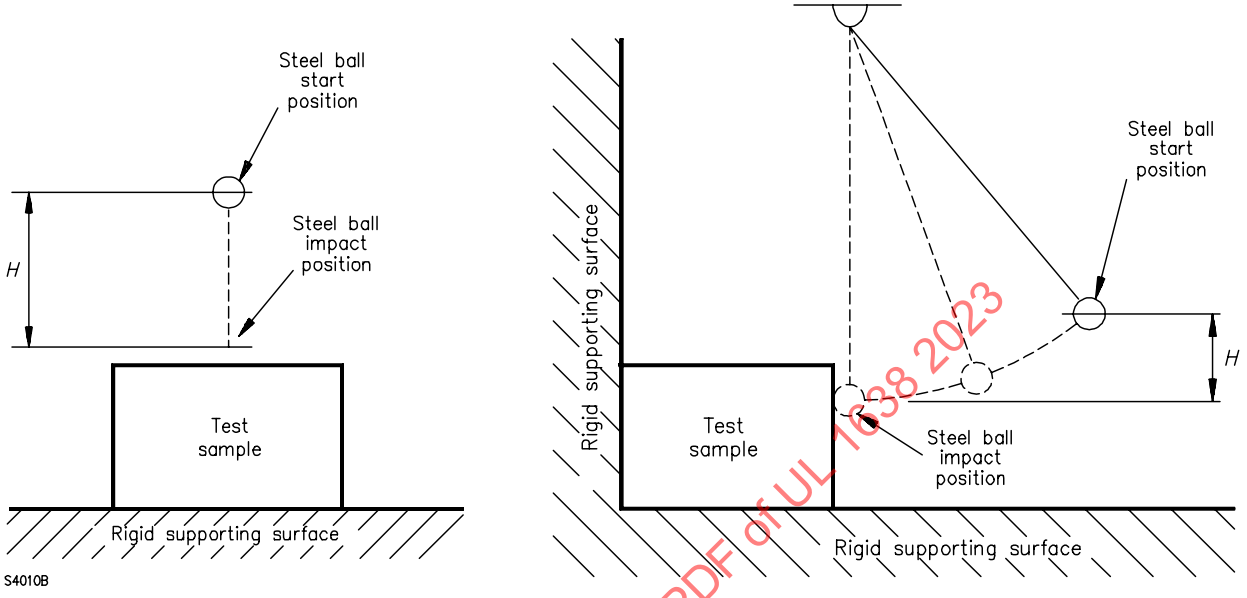
38.1 A visible signaling device enclosure assembly shall be of sufficient mechanical strength to withstand abuse anticipated in shipping, installation and service.

38.2 A sample shall be mounted in accordance with the installation instructions. A push force of 110 N shall be gradually applied and maintained for 1 min by means of a 12.7 mm (1/2 in) diameter steel hemisphere to the external surface most likely to impair the operation of the device or create a risk of fire or electric shock.

38.3 A sample shall then be mounted in accordance with the installation instructions and Figure 38.1. Three impacts of 7 J (5 foot pounds) shall be applied by means of a solid, smooth, steel sphere 50 mm (2 in) in diameter, with a mass of 540 g (1.19 lbs). The sphere shall either be dropped from a sufficient height (usually 1300 mm from the bottom of the ball to the surface to be impacted) or swung through a pendulum arc from a sufficient height to apply an impact force of 7 J of energy to the external surface most likely to impair the operation of the device, or create a risk of fire or electric shock.

Figure 38.1

Mechanical Strength Tests for Enclosures



38.4 When the visible signaling device is intended for indoor use, the impacts specified in 38.3 are to be conducted at room temperature. When the device is intended for outdoor use, the impacts are to be conducted after the units have been conditioned at least minus 40 °C (minus 40 °F) for 3 hours.

NOTE: For 38.2 – 38.4, unless specified, the same sample may be reused for each of the above applied forces. It is not prohibited to use a different sample for the application of each force in 38.2 and 38.3.

38.5 As a result of the tests specified in 38.2 – 38.4, there shall be no exposure of live parts, impairment of the operation of the speaker, or creation of a risk of electric shock.

38.6 A bending force created by a 3.0 m (118-7/64 in) minimum length of conduit of the intended size shall be installed:

a) In a hub or an opening if provided as part of the enclosure; or

b) If a hub or opening is not provided, in the center of the largest unreinforced surface intended for the connection of conduit.

38.7 The enclosure shall be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 in). If a weight is necessary to cause the conduit end to deflect, the test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 in) or once a bending moment of 33.9 N-m (300 lb-in) is achieved. The magnitude of the weight shall be determined from the equation:

$$W = (0.1\ M - 0.5\ CL) / L$$

In which:

W is the weight to be hung at the end of the conduit, in kg or lb

L is the length of the conduit from the wall of the enclosure to the point at which the weight is suspended, in m or in

C is the weight of the conduit, in kg or lb

M is the bending moment required, in Nm or lb-in

38.8 Following the application of each force, the visible signaling device is to be examined for damage and energized from a source of rated voltage and frequency to check for intended operation. Cracking of the enclosure is permitted if it does not impair intended operation, but is not when a dust- or moisture-tight enclosure is used.

38.9 There shall be no reduction in electrical spacings, no exposure of uninsulated energized parts at potential above 30 Vac (42.4 volts DC or AC peak), and no impairment of performance during and after the application of the forces and impacts of 38.2. The integrity of the conduit termination shall not be reduced as a consequence of the test of 38.2. Falling off of the sample's cover shall be permitted only when circuits operating at greater than 30 Vac (42.4 volts DC or AC peak) are not exposed, operation is not affected, and the cover can be replaced as intended. A dielectric withstand test of the sample shall be conducted in accordance with Section 23, Dielectric Voltage-Withstand. The visible signal device shall be subjected to the tests in Section 20, Measurement of Effective Luminous Intensity (Light Output).

38.10 A pull force of 890 N (200 lb) shall be applied to raceway terminations. The force shall be applied in a static manner and maintained for 5 min to a sample length of terminated conduit.

39 Interference from Radio Frequency and Electromagnetic Radiation

39.1 General

39.1.1 Prior to the tests specified below, the device is to be subjected to the tests specified in Section 20, Measurement of Effective Luminous Intensity (Light Output).

39.1.2 Visible signaling devices shall not be adversely affected and shall operate as intended after being subjected to the tests specified in:

a) 39.2, Extraneous Radio Frequency Transients;

b) 39.3, Supply-Line Transients;

c) 39.4, Internally Induced Transients; and

d) 39.5, Signal-Line Transients.

39.2 Extraneous radio frequency transients

39.2.1 Visible signaling devices incorporating circuitry for functional interfacing with a control unit for purposes such as supervision, point addressing, multiplexing, etc., shall be capable of withstanding extraneous transients generated by the equipment described in 39.2.2 and 39.2.3 without:

a) Causing unintended operation;

b) Inhibiting intended operation;

c) Damaging any part; or

d) Adversely affecting its subsequent normal operation.

39.2.2 Two visible signaling devices shall be energized from a source of rated voltage and frequency and subjected to transients generated from transmitters located 300 mm (11.8 in) from the visible signaling device. The 300 mm (11.8 in) distance is to be measured from the transmitter antenna to the nearest edge of the signaling device under test.

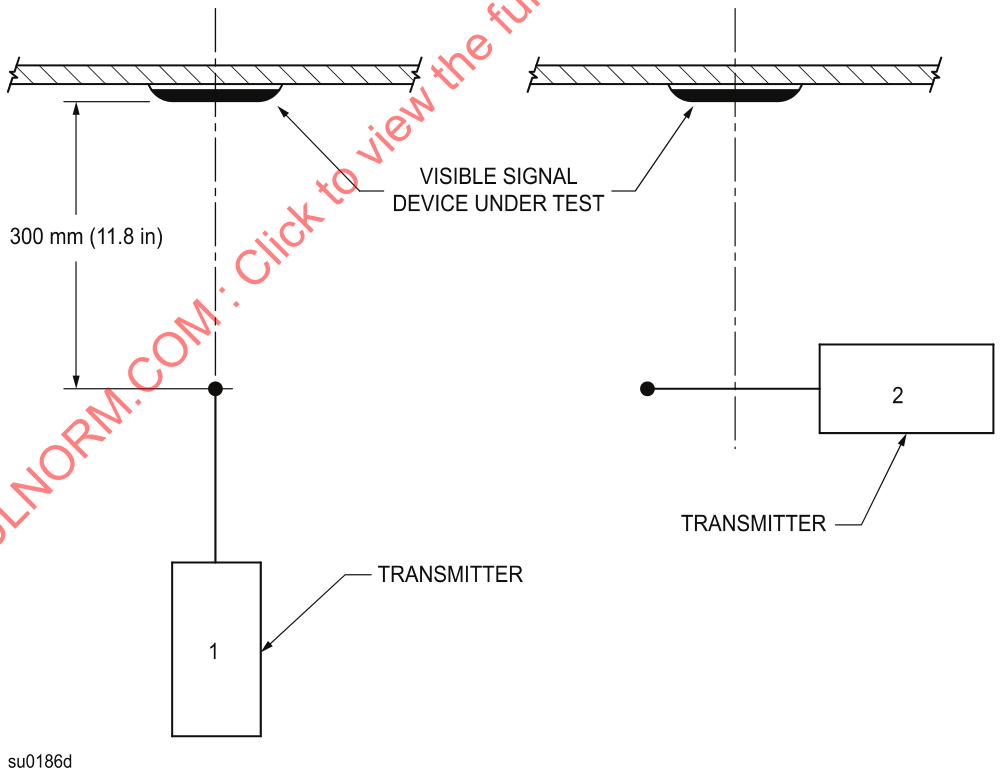
39.2.3 Five separate transmitter units shall be energized in turn, each having a 5 W output using random voice messages, and operating at the nominal frequencies (±2 %) of 27 MHz, 150 MHz, 450 MHz, 866 MHz, and 910 MHz. A total of six energizations are to be applied from each transmitter, five to consist of 5 s 'on' and 5 s 'off', followed by one consisting of a single 15 s energization. For this test, the transmitter is to be in the same room as the visible signaling device under test. The tests are to be performed with the:

a) Antenna tip pointed directly at the signaling device; and

b) Antenna at right angles to the direction (a) and centered on the signaling device. Refer to Figure 39.1.

Figure 39.1

Extraneous Radio Frequency Transients



39.3 Supply-line transients

39.3.1 An ac-operated visible signaling device rated at greater than 30 Vac shall operate as intended after being subjected to transients induced directly into the power supply circuit.

39.3.2 For this test, the visible signaling device is to be connected to a transient generator capable of producing the transients described in 39.3, Supply-Line Transients. The output impedance of the transient generator is to be 50 Ω.

39.3.3 The transients produced are to be oscillatory at 100 kHz and are to have an initial peak voltage of 6000 V. The rise time is to be less than 0.5 µs. Successive peaks of the transient are to decay to a value of not more than 60 % of the value of the preceding peak.

39.3.4 The visible signaling device is to be subjected to 500 transient pulses induced at a rate of 6 transients per min. Each transient pulse is to be included 90° into the positive half of the 60 Hz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

39.4 Internally induced transients

39.4.1 The visible signaling device is to be energized while connected to a rated source of supply, which is to be interrupted for approximately 1 s at a rate of not more than 6 cycles/min for a total of 500 cycles.

39.5 Signal-line transients

39.5.1 Visible signaling devices rated at less than 30 Vac (42.4 V DC or AC peak) intended to be connected to Signal-line circuits of control units shall operate as intended after being subjected to transients induced into the visible signaling device.

39.5.2 For this test, each circuit is to be subjected to five different transient waveforms having peak voltage levels in the range of 100 to 2400 V, as delivered into a 200 Ω load. A transient waveform at 2400 V shall have a pulse rise time of 100 V/µs, a pulse duration of approximately 80 µs, and an energy level of approximately 1.2 J. Other applied transients shall have peak voltages representative of the entire range of 100 to 2400 V, with pulse durations from 80 to 110 µs, and energy levels not less than 0.3 J or greater than 1.2 J.

39.5.3 The visible signaling device is to be subjected to 60 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 39.5.2) between each circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses); and

b) Twenty pulses (two at each transient voltage level specified in 39.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

39.5.4 Following the test specified above, the visible signaling device is to be subjected to the test specified in Section 20, Measurement of Effective Luminous Intensity (Light Output) or 20.3, Black Box Test Procedure for Public Mode Signaling. The light output of the visible signal device shall not be reduced from the light output rating determined above in the tests of Section 20 or 20.3.

40 Evaluation of Conformal Coatings on Printed Wiring Boards

40.1 Evaluation of conformal coatings shall be in compliance with UL 746E, and/or CSA C22.2 No. 0.17, and the combination of the conformal coating and the printed wiring board shall be investigated for flammability in accordance with UL 94, and/or CSA C22.2 No. 0.17. The coating shall not be less than 0.2 mm (0.008 inch) thick.

40.2 Three samples of the printed wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to Section 23, Dielectric Voltage-Withstand.

40.3 There shall not be peeling, crazing, chipping, or other visual evidence of deterioration or separation of the coating from the board as a result of the conditioning. There shall be no indication of a dielectric breakdown.

41 Locked Rotor Test

41.1 General

41.1.1 This test shall be applied only to those devices having electrical motors. A motor provided with thermal or impedance protection complying with the standards referenced below is considered to comply without the necessity of further tests:

a) In Canada only: CSA C22.2 No. 77;

b) In the United States only: UL 1004-1, UL 1004-2, or UL 1004-3.

41.1.2 The rotor of the motor is to be locked in a stationary position. The motor is to be mounted on wood or other relatively effective thermal insulating material. Blades or other motor attachments are to be removed from the motor, but integral mounting brackets are to be left in place. The frame of the motor is to be connected to ground by means of a solid conductor (that is, with no fuse in the grounding conductor). A 30 A time-delay fuse is to be connected in each ungrounded conductor of the supply cord.

41.1.3 At the conclusion of the first 72 h of the Locked Rotor Test, the motor shall comply with the requirements of Section 23, Dielectric Voltage-Withstand.

41.1.4 At the conclusion of the 15-day test, a potential of twice the marked rated voltage of the motor is to be applied between the windings and the frame to determine whether or not the winding has become grounded.

41.1.5 During the test, a motor in an appliance having a nominal rating of 115 V is to be connected to a circuit having a voltage of 120 V, and a motor in an appliance having a nominal rating of 230 V is to be connected to a circuit having a voltage of 240 V. A motor having any other voltage rating is to be connected to a circuit having a voltage of 100 – 105 % of the voltage rating of the motor.

41.1.6 To determine if a motor complies with the requirements in this section, temperature readings are to be taken as follows:

a) For a totally enclosed motor – a motor whose outer metal enclosure is complete – the temperature is to be measured by means of a thermocouple on the enclosure;

b) For any other motor, the temperature is to be measured by means of a thermocouple on the integrally applied insulation of the winding under the coil wrap, if such is present; and

c) If the coil is encapsulated, the winding temperature is to be determined by the change-in-resistance method.

41.2 Thermal or overcurrent protection

41.2.1 When the rotor of the motor is locked, the maximum temperature on a motor winding shall not exceed the temperature limits specified in Table 41.1.

Table 41.1
Maximum Temperatures – Locked Rotor Temperature Test for Motor with Thermal or Overcurrent Protection

Protector type	Motor insulation class													
	A		E		B		F		H		N		R	
	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
1. Automatically reset:														
a) During 1st hour [i]	200	(392)	215	(419)	225	(437)	250	(482)	275	(527)	295	(563)	315	(599)
b) After 1st hour a)	175	(347)	190	(374)	200	(392)	225	(437)	250	(482)	270	(518)	290	(554)
c) Average [ii]	150	(302)	165	(302)	175	(347)	200	(392)	225	(437)	248	(473)	265	(509)
2. Manually reset, single operation, Self-holding;	200	(392)	215	(419)	225	(437)	250	(482)	275	(527)	295	(563)	315	(599)
3. Thermal cutoff:														
a) During 1st hour	200	(392)	215	(419)	225	(437)	250	(482)	275	(527)	295	(563)	315	(599)
b) After 1st hour	150	(302)	165	(302)	175	(347)	200	(392)	225	(437)	245	(473)	265	(509)

[i] The temperatures are to be recorded for:

a) The second hour of operation or until the temperatures stabilize, whichever is longer; and

b) The seventy-second hour of the test.

Stabilized temperatures are obtained when the maximum temperatures readings of three successive cycles are within 2 °C (3.6 °F) of each other and are not showing a successive increase or a successive decrease in temperature.

[ii] The average temperature referenced in Table 22.1 is to be determined for both the second and seventy-second hours. For each of these periods, the average temperature is to be determined by taking the arithmetic mean of the trip temperature and reset temperature. The temperatures of the hottest thermocouple are to be used.

41.2.2 Temperatures are to be measured by thermocouples on the surface of coils of the motor. The test on a manually reset protective device is to be continued for four operations of the device, with the device being reset as quickly as possible after it has opened. For an automatically reset device, the locked-rotor test is to be continued for 72 h unless the signaling device includes another control (such as a timer) that will limit the duration of the operation to a shorter interval. During the test, the motor is to be connected to a source of supply as specified in Table 19.1.

41.2.3 An automatic-reset thermal protector of a motor shall perform as intended when operated for 15 d with the rotor of the motor locked, and with the motor connected to a supply circuit having a voltage of 100 – 110 % of the rated voltage of the motor. There shall not be any permanent damage to the motor (including excessive deterioration of the insulation). Reset thermal protector that permanently opens the circuit prior to the end of 15 d is not required to be tested for the full 15 d test period.

41.2.4 There shall not be any ignition of cotton surrounding the enclosure of a thermal protector of a motor when three samples of the device are subjected to limited short-circuit currents. For a motor rated at 373 W output (0.5 hp), or less, and 250 V or less, the current is to be 200 A. For a motor having other ratings, but not more than 746 W output (1 hp), the current is to be 1000 A. The power factor of the test circuit is to be between 0.9 – 1.0, and the circuit capacity is to be measured without the device in the circuit. A non-renewable cartridge fuse is to be connected in series with the device under test. The fuse rating is to be not less than four times the rated current of the signal appliance except that the fuse rating is not to be less than 20 A for a signaling device rated 150 V or more but not more than 600 V. The test on one sample is to be made by closing the device on the short circuit, and, if the device permanently opens the circuit, it shall do so without grounding to the motor frame, damage to the motor, or resulting in a risk of fire. A manual-reset thermal protector of a motor shall interrupt for 50 operations, without damage to itself, the locked-rotor current of the motor.

Exception: A signaling device that includes another control, such as a timer, which will positively and reliably limit the operation to a shorter interval, or an automatic-reset thermal protector that permanently opens the circuit prior to the end of 15 d, is not required to be tested for the full 15 d test period.

41.3 Impedance protection

41.3.1 When operated under locked-rotor conditions for 15 days:

a) A motor shall not exceed the temperature limits specified in Table 41.2, during the first 72 h of operation;

b) The motor winding shall not burn out or become grounded to the frame, nor shall there be any evidence of excessive deterioration of insulation; and

c) The supply-circuit fuses shall not open.

Exception: The test is not required to be continued longer than necessary for the windings of the motor (of either the open or totally enclosed type) to reach constant temperature, if this constant temperature is not more than 100 °C (212 °F).

Table 41.2
Maximum Temperatures – Locked Rotor Temperature Test for Impedance Protected Motors

Motor insulation system	Maximum temperature	
	°C	(°F)
Class A	150	(302)
Class E	165	(329)
Class B	175	(347)
Class F	200	(392)
Class H	225	(437)
Class N	245	(473)

42 Battery-Powered Units

42.1 General

42.1.1 A notification appliance that uses a battery as the main source of supply shall be capable of producing an alarm signal for at least 5 min at the battery voltage at which a trouble signal is obtained, followed by a minimum of 7 days of trouble signal indication.

42.1.2 To determine compliance with 42.1.1, two samples of a notification appliance shall be equipped with batteries that have been depleted and stabilized at a level just at the trouble signal level. The samples are then to be placed in alarm and the light output monitored and measured every minute and the light output shall not have decrease beyond the limits specified in Section 20, Measurement of Effective Luminous Intensity (Light Output). At the end of the 5 minutes of alarm, the alarm shall be reset and the samples monitored for the presence of a trouble signal for a minimum of seven days.

42.1.3 It is possible to deplete a fresh battery by applying a 1 % or smaller loading factor based on the ampere hour rating of the battery. For example, to deplete a 1000 milliampere-hour rated battery, allow a 10 milliampere (1 % load) or less drain, continuously, until the battery voltage reaches the predetermined test level. It is permitted to add an electronic load set for a constant voltage to be applied to the battery should the battery voltage creep up above the trouble level detection after the removal of the 1 % load.