UL 1638A

STANDARD FOR SAFETY

Visual Signal Appliances for General Signaling Use

UL Standard for Safety for Visual Signal Appliances for General Signaling Use, UL 1638A

First Edition, Dated June 22, 2016

Summary of Topics

This revision of ANSI/UL 1638A dated September 21, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated May 28, 2021.

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UL 1638A

Standard for Visual Signal Appliances for General Signaling Use

First Edition

June 22, 2016

This ANSI/UL Standard for Safety consists of the First Edition including revisions through September 21, 2021.

The most recent designation of ANSI/UL 1638A as a Reaffirmed American National Standard (ANS) occurred on September 21, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

INTRODUCTION

1 Scope

1.1 These requirements cover electrically-operated visual signaling appliances, rated 300 volts or less, and intended for indoor locations, outdoor locations, or both, in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover visual signaling appliances for use in ordinary locations. Visual signaling appliances for use in hazardous locations, as defined in the National Electrical Code, NFPA 70, are evaluated on the basis of their compliance with these requirements and further appropriate examination and tests to determine their acceptability for such use.

1.3 These requirements cover general signal use visual signaling appliances that are intended for non-emergency use. These visual signals do not contain any sensory functions and are intended to be connected to or controlled by other equipment.

1.4 When the appliance produces both a visual signal and an audible signal, the product shall also comply with the Standard for Audible Signal Appliances for General Signaling Use, UL 464A, or the Standard for Speakers for Commercial and Professional Use, UL 1480A, as appropriate.

1.5 These requirements do not cover visual signaling appliances intended for fire alarm use as defined in the National Fire Alarm Code, NFPA 72.

1.6 These requirements do not cover lamp or strobe-light assemblies intended for entertainment or room lighting.

1.7 These requirements do not cover emergency lighting or exit lighting visual signals.

1.8 These requirements do not cover annunciators that identify functions of a fire or emergency signaling system or relate information concerning portions thereof. Annunciators are covered under the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

2 General

2.1 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

2.3 Undated references

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

2.4 Electrical circuit terminology

2.4.1 For the purpose of these requirements, electrical circuit characteristics are defined as follows:

a) High-Voltage – A circuit classified as high-voltage is one having circuit characteristics in excess of those of a low-voltage circuit.

b) Low-Voltage – A circuit classified as low-voltage is one involving a potential of not more than 30 volts AC, 42.4 volts peak or DC.

2.4.2 The term "appliance" as used in these requirements refers to any equipment covered by this standard.

2.4.3 For purposes of this standard the terms “visual” and “visible” are interchangeable.

CONSTRUCTION

3 Enclosure

3.1 General

3.1.1 The enclosure of an appliance shall be sufficiently strong and rigid to resist the abuses likely to be encountered during intended service. The degree of resistance inherent in the appliance shall preclude total or partial collapse and the attendant reduction of spacings, loosening or displacement of parts, and other serious defects which alone or in combination constitute an increase in the risk of fire, electric shock, or injury to persons.

3.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with the requirement in 3.1.1.

3.1.3 Operating parts, such as gear mechanisms, light-duty relays, and similar devices, shall be protected against fouling by dust or other material that may impair their intended operation.

3.1.4 Electrical parts of an appliance shall be enclosed to provide protection against contact with uninsulated live parts.

3.1.5 An appliance intended to be installed on a flush-device box, cutout box, or similar device, is to be evaluated with regard to compliance of the combination with the requirement in 3.1.4.

3.1.6 The enclosure of an appliance shall be provided with means for mounting in the intended manner. Any fittings, such as brackets or hangers necessary for proper mounting shall be furnished with the appliance. The mounting means shall be accessible without disassembling any operating part of the

appliance. The removal of a completely assembled panel, cover, or equivalent, to mount the appliance is not considered to be disassembly of an operating part.

3.1.7 An enclosure shall have provision for the connection of metal-clad cable, conduit, or non-metallic sheathed cable. An enclosure without such provision may be used when instructions are furnished with it indicating the sections of the enclosure that are intended to be drilled in the field for the connection of raceways, or when the appliance is intended for mounting on an outlet box.

3.1.8 A cover or other detachable part of the enclosure shall be provided with means, other than snap-catch fastenings only, for firmly securing it in place. The removal of the cover or detachable part shall require the use of a common hand tool, such as a screwdriver or wrench.

3.1.9 Except as noted in 3.1.10, an appliance intended for either flush or surface mounting in a back box shall be provided with a back box of thickness as specified in Table 3.1.

Table 3.1
Thickness of sheet metal

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

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

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

[c] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (rain-tight) is required to be not less than 0.029 inch (0.074 mm) thick.

[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 not be less than 0.021 inch (0.53 mm) [0.025 inch (0.64 mm) when zinc coated]; and the thickness of copper, brass, or aluminum may be less than that specified in the table, but shall not be less than 0.029 inch (0.74 mm).

3.1.10 An appliance need not be furnished with a back box if:

a) Means are provided for attachment to a standard outlet box and

b) The required spacings as specified in Spacings, Section 10, are maintained when the appliance is mounted on such a box.

3.1.11 There shall be space 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 intended installation.

3.2 Cast metal enclosures

3.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 3.2. Cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in the table may be used when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape, size, or both, of the surface provides mechanical strength equivalent to the required thickness.

Table 3.2
Cast metal enclosures

Use, or dimensions of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less and not having any dimension greater than six inches (152 mm)	1/16	(1.6)	1/8	(3.2)
Area greater than 24 square inches (155 cm^2) or having any dimension greater than six inches (152 mm)	3/32	(2.4)	1/8	(3.2)
At a threaded conduit hole	1/4	(6.4)	1/4	(6.4)
At an unthreaded conduit hole	1/8	(3.2)	1/8	(3.2)

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

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

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

3.3 Sheet metal enclosure

3.3.1 The thickness of sheet metal used for the enclosure or mechanism cover of an appliance shall not be less than that indicated in Table 3.1.

3.3.2 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 will have a stiffness at least equivalent to that of an uncoated (No. 16 MSG) flat steel sheet having a minimum thickness of 0.053 inch (1.35 mm).

3.3.3 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.027 inch [not less than 0.032 inch (0.69 or 0.81 mm) when of nonferrous metal] for a hole having a 1-3/8 inch (34.9 mm) diameter maximum dimension.

3.3.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required for the enclosure of the appliance, or a standard knockout seal shall be used. Such closures shall be securely mounted.

3.3.5 A knockout in a sheet metal enclosure shall be secured but shall be capable of being removed without undue deformation of the enclosure.

3.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be located so that a bushing used at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated under Spacings, Section 10.

3.3.7 An enclosure intended for recessed mounting, and whose panel is to be flush with the surface of the wall, shall not have nonfunctional openings.

3.3.8 An appliance intended to be supported by rigid conduit shall be provided with conduit hubs, or the equivalent, having not less than five full threads.

3.4 Nonmetallic enclosures

3.4.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be so formed that the mechanical strength of the enclosure is at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 3.1.

3.4.2 Among the factors to be considered when evaluating the acceptability of a nonmetallic enclosure of parts are:

a) Flammability;

b) Mechanical strength;

c) Resistance to impact;

d) Moisture absorptive properties;

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

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

All these factors are to be considered with regard to aging. See the Tests of Polymeric Materials, Section 24.

3.4.3 When a polymeric enclosure is intended for connection of conduit, the connection shall comply with the appropriate requirements for torque, bending, and pullout described in the Standard for Industrial Control Equipment, UL 508.

3.5 Ventilating and acoustical openings

3.5.1 An opening in an enclosure (including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers) shall not permit passage of a 17/64-inch (6.7-mm) diameter rod.

3.5.2 The wires of a screen shall not be less than 16 AWG (1.3 mm^2). Except as noted in 3.5.3, perforated sheet steel and sheet steel used for expanded-metal mesh shall not be less than 0.042 inch (1.07 mm) in average thickness [0.046 inch (1.17 mm) thick when zinc coated].

3.5.3 When the indentation of a guard or enclosure will not alter the clearance between uninsulated live parts, or between uninsulated movable live parts and grounded metal, or reduce spacings below the minimum values given in Spacings, Section 10, 0.021 inch (0.53 mm) expanded-metal mesh [0.024 inch (0.61 mm) when zinc coated] may be used, if:

a) The mesh openings are not more than 1/4 square inch (1.6 cm^2) in area and

b) The maximum dimension of the overall opening so protected is not greater than 3 inches (76.2 mm).

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

4.1 To reduce the risk of unintentional contact that may involve a risk of:

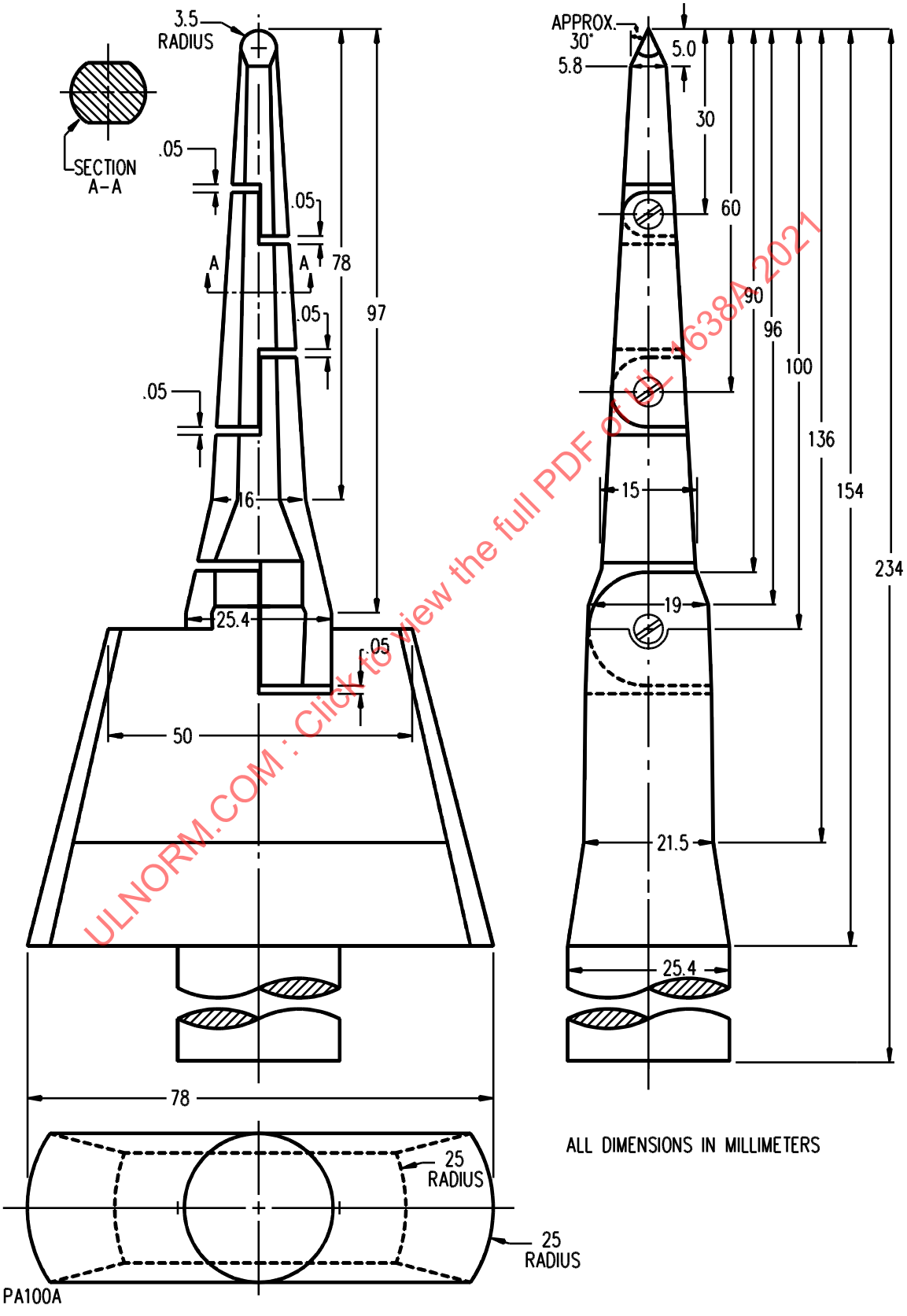
a) Electric shock from an uninsulated live part or film-coated wire or

b) Injury to persons from a moving part,

an opening in an enclosure shall have a minor dimension less than 1 inch (25.4 mm), and such a part or wire shall not be contacted by the probe illustrated in Figure 4.1.

Figure 4.1

Articulate probe with web stop



4.2 The probe mentioned in 4.1 and illustrated in Figure 4.1 is to be applied to any depth that the opening will permit; and is to be rotated or angled before, during, and after insertion through the opening to any position that is necessary in order to examine the enclosure. The probe illustrated in Figure 4.1 is to be applied in any possible configuration; and, when necessary, the configuration is to be changed after insertion through the opening.

4.3 The probe mentioned in 4.1 is to be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material; it is to be applied with the minimum force necessary to determine accessibility.

4.4 During the examination of a product to determine whether it complies with the requirements in 4.1, a part of the enclosure that may be opened or removed by the operator without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

5 Corrosion Protection

5.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

5.2 The requirement in 5.1 applies to all enclosures whether of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend. The requirement does not apply to minor parts, such as washers screws, bolts, and similar parts, when the corrosion of such unprotected parts would not result in a risk of fire or electric shock; or would result in unintended operation of the appliance.

5.3 Metal shall be used in combinations that are galvanically compatible.

5.4 Hinges and other attachments shall be resistant to corrosion.

5.5 Nonferrous cabinets and enclosures may be used without special corrosion protection.

6 Field Wiring Connections

6.1 General

6.1.1 An appliance shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the rating of the appliance.

6.2 Field wiring compartment

6.2.1 The field wiring compartment area shall be of sufficient size for completing all wiring connections without damage to wire insulation or to internal components. There shall be sufficient space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required for intended installation.

6.2.2 Protection for the internal components and wire insulation from sharp edges shall be provided by insulating or metal barriers having smoothly rounded edges or by a marking as specified in 29.8.

6.2.3 The location of an outlet box or compartment in which field wiring connections are to be made shall permit the connections to be inspected after the appliance is installed as intended. The removal of not more than two mounting screws, or equivalent arrangement, to view the field wiring connections, is considered to comply with this requirement.

6.3 Field wiring terminals or leads

6.3.1 The terminals to which wiring connections are made are to 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 when they are tested and are determined to be equivalent.

6.3.2 When a wire-binding screw is used at a field wiring terminal, the screw shall not be smaller than No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.1 mm^2) or smaller conductor. The screw shall thread into metal and shall be of a nonferrous metal or plated steel.

6.3.3 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) thick for a No. 6 (3.5 mm diameter) screw and shall have not less than two full threads in the metal. A terminal plate may have the metal extruded at the tapped hole for the binding screw in order to provide two full threads.

6.3.4 Leads provided for field connections shall not be less than 6 inches (152 mm) long, and shall be provided with strain relief. The leads may be less than 6 inches long when it is evident that the use of a longer lead may result in a risk of fire or electric shock. For all high voltage circuits, the leads shall not be smaller than 18 AWG (0.82 mm^2); the insulation shall not be less than 1/64 inch (0.4 mm) thick. For low voltage circuits, the leads shall not be less than 22 AWG (0.32 mm^2), and the insulation shall be minimum of 1/64 inch (0.4 mm) thick. The wire type must be rated for the current-carrying capacity of the circuit. The range of wire sizes shall be indicated in the installation wiring diagram.

6.3.5 For an appliance that is not intended for outlet-box mounting and is not provided with field wiring terminals or a field wiring compartment, the leads shall enter the enclosure:

a) When of metal, through separate holes in insulating material which provide a spacing of not less than 1/4 inch (6.4 mm) between the conductors, and not less than 1/2 inch (12.7 mm) between the conductors and the plane of support of the appliance or

b) The leads shall enter the enclosure through a nipple or other means for the attachment of conduit.

6.4 Grounding terminals and leads

6.4.1 When an appliance is intended for connection to a high-voltage source of supply only by means of other than a metal-enclosed wiring system, such as nonmetallic-sheathed cable:

a) An equipment grounding terminal or lead shall be provided. The size shall be the same as the supply terminal or lead, but in any case not less than 18 AWG (0.82 mm^2).

b) A marking shall be provided to indicate that the wiring system or systems has been determined to be suitable.

c) The grounding means shall be connected to all exposed dead-metal parts that are likely to become energized and to all dead-metal parts within the enclosure that are exposed to contact during servicing and maintenance.

6.4.2 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, and no other leads visible to the installer, other than grounding conductors, shall be so identified.

6.4.3 A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, such as being marked "G," "GR," "Ground," "Grounding," 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.

6.5 Grounded supply terminals and leads

6.5.1 A field wiring terminal for the connection of the grounded supply conductor of a high-voltage circuit shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached connection diagram.

6.5.2 A field wiring lead provided for connection of the grounded supply conductor of a high-voltage circuit shall be finished to show a white or gray color and shall be readily distinguishable from other leads and no other leads visible to the installer, other than grounded conductors, shall be so identified.

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

7 Internal Wiring

7.1 General

7.1.1 The internal wiring of an appliance shall consist of conductors having insulation rated for the potential involved and the temperatures to which it may be subjected, and having mechanical strength and current carrying capacity that has been evaluated and determined to be acceptable for the service. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string, ties, or equivalent, unless of sufficient rigidity to retain a shaped form.

7.1.2 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 equivalently arranged to prevent abrasion of insulation and jamming between parts of the enclosure.

7.1.3 When the use of a short length of insulated conductor is not feasible, for example, in the case of a short coil lead or the like, electrical insulating tubing may be used. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners. The wall thickness of the tubing shall comply with the requirements for such tubing, except that the wall thickness at any point for polyvinyl chloride tubing of 3/8 inch (9.5 mm) diameter or less, shall not be less than 0.017 inch (0.43 mm). For insulating tubing of other types, the wall thickness shall not be less than that required to at least equal the mechanical strength, dielectric properties, heat and moisture resistant characteristics of polyvinyl chloride tubing having a wall thickness of 0.017 inch (0.43 mm).

7.1.4 Internal wiring of circuits that operate at different potentials shall be separated by barriers or shall be segregated, unless the conductors in lower voltage circuits are provided with insulation equivalent to that required for the highest voltage involved. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means to maintain separation.

7.1.5 A stranded conductor clamped under wire-binding screws or are similarly connected shall have the individual strands soldered together or be equivalently arranged.

7.2 Aluminum terminations

7.2.1 The continuity of any grounding system to which an appliance can be connected shall not rely on the dimensional integrity of nonmetallic material.

7.2.2 An aluminum conductor, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts, shall be terminated at each end by a method that has been evaluated and determined to be acceptable for the combination of metals involved at the connection point.

7.2.3 With reference to 7.2.2, a wire-binding screw or a pressure terminal connector used as a terminating device shall be investigated and determined to be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and the like.

7.3 Wireways

7.3.1 A wireway shall be smooth and free from sharp edges, burrs, fins, and moving parts that may abrade the conductor insulation.

7.4 Splices

7.4.1 A splice or connection shall be mechanically secured and bonded electrically.

7.4.2 A splice shall be provided with insulation equivalent to that of the wires involved when permanence of electrical spacings between the splice and uninsulated metal parts is not provided.

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

7.5 Barriers

7.5.1 A metal barrier shall have a thickness at least equal to that required by Table 3.1 as determined by the size of the barrier. A barrier of insulation material shall not be less than 0.028 inch (0.71 mm) thick and shall be thicker when 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 not be more than 1/16 inch (1.6 mm).

7.6 Bushings

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

7.6.2 When the opening is in a phenolic composition or other nonconductive material or in metal of thickness greater than 0.042 inch (1.07 mm), a smooth surface having rounded edges is considered to be the equivalent of a bushing.

7.6.3 Ceramic materials and some molded compositions may be used for insulating bushings, but separate bushings of wood and of hot-molded shellac shall not be used.

7.6.4 Fiber may be used where:

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 3/64 inch (1.2 mm) thick, and

c) It will not be exposed to moisture.

7.6.5 When a soft rubber bushing or similar material that may deteriorate with age is used in a hole in metal, the hole shall be free from sharp edges, burrs, and projections to reduce the risk of abrading the bushing and wire insulation.

7.6.6 An insulated metal grommet may be used in lieu of an insulating bushing, when the insulating material is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

7.7 Strain relief

7.7.1 A strain relief means shall be provided for the field supply leads and for all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of an appliance to reduce the risk of mechanical stress from being transmitted to internal connections and terminals. Inward movement of a cord or leads that are provided with a ring-type strain relief means shall not damage internal connections or components, or result in a reduction of the electrical spacings required.

7.7.2 A lead used for field connections or an internal lead subjected to movement or handling during installation and servicing shall withstand for 1 minute a force of 10 pounds (44.5 N) without any evidence of damage or of transmission of stress to internal connections.

7.7.3 A cord shall be capable of withstanding for 1 minute, without displacement, a direct pull of 35 lbf (156 N) applied to the cord with the connections within the product disconnected.

7.7.4 A metal strain-relief clamp or band (without auxiliary protection) shall not be used with a cord other than a Type S, SJ, SJT, ST, or similar jacketed cord. A metal strain-relief clamp or band shall not be used with a Type SV, SP-2, SPT-2, or SVT cord unless nonconducting auxiliary mechanical protection is provided over the cord.

8 Components

8.1 Mounting of components

8.1.1 All parts of an appliance intended to be nonmoving and that support moving components shall be mounted in position to reduce the risk of loosening or turning by means other than friction between surfaces.

8.1.2 A toothed lock washer that provides both spring take-up and an interference lock may be used as a means to reduce the risk of loosening or turning of a part.

8.1.3 When a lens must be removed for mounting or connecting the appliance, the correct position of the unit with regard to its support shall be indicated on the appliance, unless the lens is keyed so that it can be installed only as intended.

8.1.4 An uninsulated live part shall be secured to the base or mounting surface to reduce the risk of turning or shifting in position, when such motion may result in a reduction of spacings below the minimum required values. Friction between surfaces shall not be used as a means to reduce the risk of shifting or

turning of live parts, but a toothed lock washer that provides both spring take-up and an interference lock may be used.

8.1.5 An uninsulated live part, such as a field wiring terminal, shall be secured to its supporting surface by a method other than friction between surfaces to reduce the risk of turning or shifting in position when such motion may result in reduction of spacings below the minimum required values. This may be accomplished by:

a) Two screws or rivets;

b) Square shoulders or mortises;

c) A dowel pin, lug, or offset;

d) A connecting strap or clip fitted into an adjacent part; or

e) Other equivalent method.

8.2 Operating components

8.2.1 Operating parts shall be located or protected so that they will be unaffected by any wiring within the enclosure.

8.2.2 A cam or similar part shall be securely fastened to reduce the risk of independent turning or loosening.

8.2.3 An operating component on an assembly, such as a switch, relay, or similar device, shall be protected against fouling by dust or by other material that may affect intended operation by use of an individual cover or dust tight cabinet.

8.2.4 A moving part shall have sufficient play at bearing surfaces to reduce the risk of binding.

8.2.5 An adjusting screw or similar adjustable part shall be located so that the risk of loosening under the conditions of intended use will be reduced.

8.2.6 Interrelated operating parts shall be formed and assembled so that their alignment will be maintained.

8.3 Current-carrying parts

8.3.1 A current-carrying part shall be of metal, such as silver, copper, copper alloy, or equivalent material.

8.3.2 Bearings, hinges, and the like, shall not be used for carrying current between fixed and moving parts.

8.4 Coil windings

8.4.1 The coil winding insulation of relays, transformers, solenoids, and similar components shall resist the absorption of moisture.

8.4.2 Film-coated wire is not required to be given additional treatment to reduce the risk of moisture absorption.

8.5 Connectors and receptacles

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

8.6 Electrical insulating material

8.6.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

8.6.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but shall not be used as the sole support for uninsulated current-carrying parts of other than low-voltage circuits.

8.6.3 Polymeric materials may be used for the sole support of uninsulated live parts if, after aging, they are evaluated and determined to have acceptable mechanical strength and rigidity, dielectric voltage withstand, resistance to heat, flame propagation, arcing, creep, and moisture. See the Tests on Polymeric Materials, Section 24.

8.6.4 The thickness of a flat sheet of insulating material, such as phenolic composition, used for panel mounting of parts shall not be less than that indicated in Table 8.1.

Table 8.1
Thickness of flat sheets of insulating material

Maximum dimension				Minimum thickness,	
Length or width,		Area,			
inches	(mm)	inches^2	(cm^2)	inch	(mm)
24	(610)	360	(2323)	3/8[a]	(9.5[a])
48	(1219)	1152	(7432)	1/2	(12.7)
48	(1219)	1728	(11148)	5/8	(15.9)
Over 48	(Over 1219)	Over 1728	(Over 11148)	3/4	(19.1)

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

8.6.5 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 restrained from loosening to reduce the risk of the parts and the ends of replaceable terminal screws from reducing spacings below the minimum required values.

8.6.6 A countersunk live part shall be sealed with a waterproof insulating compound not less than 1/8 inch (3.2 mm) thick.

8.7 Printed-wiring boards

8.7.1 The components of a printed-wiring board shall be mechanically secured and the spacings between circuits shall comply with the spacings requirements for rigidly-clamped assemblies. The board shall be mounted so that deflection of the board during servicing does not result in damage to the board or in a risk of fire or electric shock.

9 Adhesives Used to Secure Conductive Parts

9.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

9.2 The requirement in 9.1 applies to an adhesive used to secure a conductive part (including a nameplate) that is capable, when loosened or dislodged, of:

a) Energizing an accessible dead-metal part;

b) Making a live part accessible;

c) Reducing spacings below the minimum required values; or

d) Short-circuiting live parts.

9.3 Whether the conditions mentioned in 9.2 (a) – (d) can occur is to be considered with regard to parts both inside and outside of the device that are capable of affecting equipment in which the device is to be installed.

10 Spacings

10.1 An appliance shall provide spacings between uninsulated live parts and dead-metal parts and between uninsulated live parts of opposite polarity not less than those indicated in Table 10.1.

Table 10.1
Minimum spacings

Point of application	Voltage range	Minimum spacings[a,b]			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)
To walls of enclosure:[a]					
Cast metal enclosures	0 – 300	1/4	(6.4)	1/4	(6.4)
Sheet metal enclosures	0 – 300	1/2	(12.7)	1/2	(12.7)
Installation wiring terminals:					
With barriers	0 – 30	1/8	(3.2)	3/16	(4.8)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
Without barriers	0 – 30	3/16	(4.8)	3/16	(4.8)
	31 – 150	1/4	(6.4)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
Rigidly clamped assemblies:[c]					
100 volt-amperes maximum[d]	0 – 30	1/32	(0.8)	1/32	(0.8)
Over 100 volt-amperes	0 – 30	3/64	(1.2)	3/64	(1.2)
	31 – 150	1/16	(1.6)	1/16	(1.6)
	151 – 300	3/32	(2.4)	3/32	(2.4)
Other parts	0 – 30	1/16	(1.6)	1/8	(3.2)

Table 10.1 Continued on Next Page

Table 10.1 Continued

Point of application	Voltage range	Minimum spacings[a,b]			
		Through air,		Over surface,	
		inch	(mm)	inch	(mm)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)

[a] "To walls of enclosure" spacings apply between an uninsulated live part and:

1) A wall cover of a metal enclosure;

2) A fitting for conduit or metal-clad cable; and

3) A metal piece attached to a metal enclosure, where deformation of the enclosure is likely to reduce spacings.

These spacings are not to be applied to an individual enclosure of a component part within an outer enclosure.

[b] 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).

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

[d] Spacings less than those indicated, but not less than 1/64 inch (0.4 mm), may be provided for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

10.2 The spacing between an uninsulated live part and:

a) A wall or cover of a metal enclosure; and

b) A fitting for conduit or metal-clad cable

shall not be less than that indicated in Table 10.1.

10.3 The "Through air" and "Over surface" spacings in Table 10.1 measured at an individual component part are to be evaluated on the basis of the volt-amperes used and controlled by the individual component. However, the spacing from one component to another, and from any component to the enclosure or to other uninsulated dead-metal parts, excluding the component mounting surface, shall be evaluated on the basis of the maximum voltage and total volt-ampere rating of all components in the enclosure.

10.4 The spacing requirements in Table 10.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component provided as part of the appliance. Such spacings are to be evaluated on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete appliance, including clearances to dead metal or enclosures, shall be those indicated in Table 10.1.

10.5 The "To wall of enclosure" spacings in Table 10.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

10.6 Film-coated wire is considered an uninsulated live part, but film coating may be used as turn-to-turn insulation in coils.

PERFORMANCE

11 General

11.1 Test samples

11.1.1 Unless otherwise specified, the performance of a visual signaling appliance is to be investigated by subjecting a representative sample of each rating to the tests specified in this standard.

11.1.2 The samples listed in Table 11.1 shall be provided for the test program.

Table 11.1
Intended operating environment

Indoor locations	Outdoor locations
10 complete samples	12 complete samples
7 samples of polymeric lens and enclosures, when used	12 samples of polymeric lens and enclosures, when used
2 complete samples of each additional power, voltage, or current rating	2 complete samples of each additional power, voltage, or current rating

11.1.3 When a visual signaling appliance is used in conjunction with an audible signal appliance, the samples noted in Table 11.1 are to include representative samples of the audible appliance.

11.2 Test voltages

11.2.1 A signaling appliance evaluated to the requirements of this standard shall operate over the voltage range specified by the manufacturer and not exceed the marked current rating.

12 Electrical Measurements

12.1 A general signaling or visual appliance shall not exceed its marked RMS current rating. The current measurements shall be obtained within the marked voltage range of the appliance.

12.2 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 pre-adjusted to the rated voltage of the unit under test. The power source is then energized and the maximum RMS current is to be recorded.

13 Variable Voltage Operation Test

13.1 A visual appliance shall operate at 80 and then at 110 percent of rated voltage when operated as described in 12.2. There shall be no indication of a fire or shock hazard.

14 Temperature Test

14.1 The materials used in a visual signaling appliance shall not attain a temperature rise greater than those specified in Table 14.1 under any condition of intended operation. Temperatures are to be measured by thermocouples, except that the change-in-resistance method may be used to measure the temperature of motor windings or of coils.

Table 14.1
Maximum temperature rises

Material	Normal standby (continuous), °C	(°F)	Alarm condition (short term), °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				
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, U.S. 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 the Standard Test Methods for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

Table 14.1 Continued on Next Page

Table 14.1 Continued

Material	Normal standby (continuous), °C	(°F)	Alarm condition (short term), °C	(°F)
[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 MIL-STD-883E, Test Method Standard – Microcircuits, published by the U.S. Department of Defense. 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. The maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.				

14.2 The thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.06 mm^2). The thermocouples and related instruments are to be accurate and calibrated in accordance with standard laboratory practice. The thermocouple wire is to comply with the requirements for special thermocouples as specified in the Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

14.3 Thermocouples consisting of 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer type indicating instrument are to be used whenever referee temperature measurements by means of thermocouples are necessary.

14.4 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material whose temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place; but where a metal surface is involved, brazing or soldering the couple to the metal may be necessary.

14.5 When the temperature of a copper motor winding or coil is to be determined by the change-in-resistance method, the following formula is to be used:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in degrees C,

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

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

t is the known temperature in degrees C.

14.6 As it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of R at shutdown.

14.7 All values for temperature rises apply to equipment intended for use in ambient temperatures not higher than 25°C (77°F).

14.8 When equipment is intended specifically for use with a prevailing ambient temperature higher than 25°C (77°F), the test of the equipment is to be made at the higher ambient temperature, and the maximum temperature rises specified in the table are to be reduced by the amount of the difference between the higher ambient temperature and 25°C (77°F).

14.9 Temperature measurements on an appliance intended for recessed mounting shall be made with the appliance installed in an enclosure formed of nominal 3/4 inch (19.1 mm) wood having clearances of 2 inches (51 mm) on the top, sides and rear, and the front of the enclosure extended to be flush with the appliance cover.

14.10 A temperature is considered to be constant when three successive readings, measured at not less than 5-minute intervals, indicate no change.

14.11 The appliance under test is to be connected to a maximum source of supply voltage or power and operated for at least 1 hour or until stable temperatures are obtained under intended service conditions deemed likely to produce the highest temperatures.

14.12 An appliance intended to produce a signal as long as its energizing circuit is closed is to be operated for a continuous signal; except that an appliance marked to indicate intermittent duty cycles is to be operated at such duty cycles.

15 Endurance Test

15.1 A visual signaling appliance shall operate during and upon completion of the tests specified in 15.2 without risk of fire or shock hazard.

15.2 The appliance is to be operated for for 72 hours of alternate 5-minute periods of being energized and de-energized from maximum rated voltage or power.

16 Component Failure Test

16.1 The stress level of a component shall not exceed 90 percent of its rating. For capacitors, the voltage drop developed across the capacitor is to be measured and the stress level is to be obtained by dividing measured voltage by the rated voltage of the capacitor. All other type of components shall be evaluated for operation at 90 percent of the manufacturer's maximum power rating.

Exception: When an open or short in the capacitor has no effect upon proper operation of the appliance or would result in a system trouble signal, derating is not required.

16.2 An open or short-circuit malfunction of any component located in a high-voltage circuit (greater than or equal to 30 V rms or 42.4 V DC or peak) shall not introduce the risk of fire or electric shock. For multiport devices, the component shall be tested with each part individually faulted.

16.3 To determine compliance with 16.2, 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 14 – 15 square yards to the pound (26 – 28 m^2/kg) 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.

First, an open, and then a short-circuit, are to be individually applied to the component. Each fault condition is to be maintained until ultimate conditions are reached as determined by constant temperatures or burnout.

16.4 A product complies with 16.2 if, immediately following the test:

a) There is no charring or burning of the cheesecloth;

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

c) The appliance complies with the Dielectric Voltage-Withstand Test, Section 19.

17 Abnormal Operation and Burnout Test

17.1 A unit which is normally intended to be operated for a limited period, and is capable of being operated continuously under abnormal conditions, shall be capable of such extended operation without resulting in the risk of fire.

17.2 To determine when a unit complies with the requirement in 17.1, it is to be operated under the most severe abnormal conditions that will be encountered in service, and while connected to a maximum rated source of supply. The test shall not cause emission of flame or molten metal, or any other manifestation of a risk of fire.

17.3 In determining when a unit complies with the requirement with regard to installation-wiring circuit fault conditions, the fault conditions are to be maintained continuously until constant temperatures are attained, or until burnout occurs, when the fault does not result in the operation of an overcurrent-protective device.

17.4 There shall be no emission of flame or molten metal or other manifestation of a fire, or risk of electric shock, when each output circuit of the unit is individually shorted. Accessible, interchangeable-type fuses are to be replaced with a fuse of the size fitting the fuseholder but having the highest available current rating.

18 Dielectric Voltage-Withstand Test

18.1 A visual signal appliance shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead-metal parts, and between live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 18.2):

a) 500 volts (707 volts, when a DC potential is used), for a visual signal appliance rated 30 volts AC rms (42.4 volts DC or AC peak) or less.

b) 1000 volts (1414 volts, when a DC potential is used), for a visual signal appliance rated between 31 and 250 volts AC rms.

c) 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, when a DC potential is used), for a visual signal appliance rated more than 250 volts AC rms.

18.2 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 18.1 (a), (b), or (c) based on the highest voltage of the circuits under test instead of the rated voltage of the visual signal appliance. Electrical connections between the circuits are to be disconnected before the test potential is applied.

18.3 When an autotransformer is in the circuit, the primary of the transformer is to be disconnected and an AC test potential in accordance with 18.1(c) is to be applied directly to all wiring involving more than 250 volts.

18.4 When the charging current through a capacitor or capacitor type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 18.1.

18.5 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the potential is to be increased at a rate of approximately 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

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

19 Rain Test

19.1 An appliance intended to be exposed to weather shall withstand a rain exposure for 1 hour without creating a risk of electric shock or affecting its subsequent operation.

19.2 The appliance is to be operated with electrical components energized and the appliance is to be tested under the conditions most likely to cause the entrance of water into or on electrical components. It may be necessary to operate the appliance under various modes of operation or to de-energize the appliance when more adverse conditions could result. In any case, each exposure is to be for 1 hour, and, when more than one exposure is required, the appliance is to be examined as indicated in 19.4 before repeating the test.

19.3 Field wiring connections are to be made in accordance with the wiring method specified for the appliance. Openings intended to terminate conduit are to be sealed. Openings intended for the entry of a conductor or conductors for wiring in a low-voltage circuit are not to be sealed.

19.4 Except as indicated in 19.5, the appliance is to be examined to determine that all electrical parts, including motor windings, are not wetted and that there is no accumulation of water within the enclosures of electrical parts prior to rain exposure.

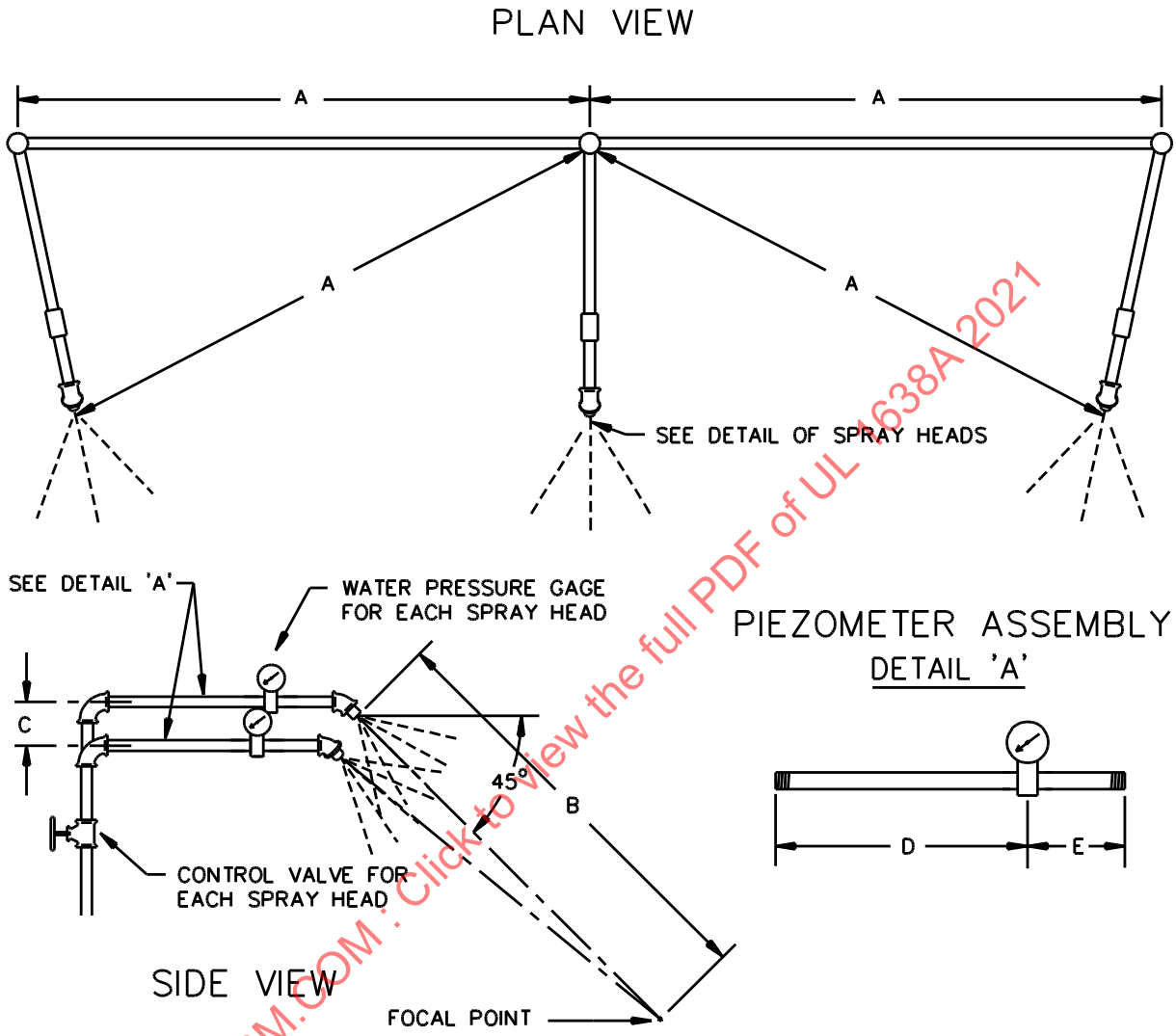
19.5 Drying of the appliance prior to the second or subsequent exposure is not required if, without such preparation, the appliance complies with the requirement in 19.6.

19.6 After each exposure, the appliance shall comply with the requirements in the Dielectric Voltage Withstand Test, Section 18.

19.7 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 19.1. Spray heads are to be constructed in accordance with Figure 19.2. The water pressure for all tests is to be maintained at 5 psi (34.5 kPa) at each spray head. The distance between the center nozzle and the appliance is to be approximately 3 feet (0.91 m). The appliance 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 product. The spray is to be directed at an angle of 45 degrees to the vertical toward appliance openings closest to live parts.

Figure 19.1

Rain test spray head piping



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

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