UL 38

STANDARD FOR SAFETY

Manual Signaling Boxes for Fire Alarm Systems

UL Standard for Safety for Manual Signaling Boxes for Fire Alarm Systems, UL 38

Eighth Edition, Dated July 3, 2008

Summary of Topics

This revision of ANSI/UL 38 is being issued to reflect the reaffirmation of the ANSI approval of the Standard. No technical changes have been made to the document.

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 July 13, 2018.

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The most recent designation of ANSI/UL 38 as a Reaffirmed American National Standard (ANS) occurred on September 4, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover manual signaling boxes for fire alarm systems intended for permanent installation and used in ordinary locations in accordance with the National Electrical Code, NFPA 70, and the National Fire Alarm Code, NFPA 72.

1.2 A manual signaling box is an assembly of a mechanism having electrical contacts designed to transmit a signal when an integral part is operated manually. The signaling contacts are intended to be connected to circuits of fire alarm systems. The types of boxes covered by these requirements are coded boxes and non-coded boxes, including signaling boxes, fire and guard's tour reporting stations, and guard's tour reporting stations for suppressed-signal tour combinations.

1.3 A manual signaling box having a pre-wound signaling mechanism and equipped with a tripping electromagnet to permit automatic actuation by separate detectors, and similar combination devices, shall be evaluated with regard to compliance with the applicable requirements for both manual signaling boxes and electrically-actuated transmitters.

1.4 A manual signaling box shall be constructed for use with system-control units, electrically-actuated transmitters, or similar units that will permit its application in compliance with applicable codes and standards of the National Fire Protection Association.

1.5 These requirements do not cover electrically-actuated transmitters.

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 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.

CONSTRUCTION

3 Enclosures

3.1 General

3.1.1 Electrical parts of a signaling box shall be located or enclosed so as to provide protection against contact with uninsulated live parts.

3.1.2 Operating parts, such as contacts, gear mechanisms, and similar devices, shall be protected against mechanical damage and fouling by dust or other material that may impair their intended operation.

3.1.3 Provision shall be made for mounting a signaling box in position. Bolts, screws, or other parts used for mounting a signaling box shall be independent of those used for securing component parts of the assembly.

3.1.4 An opening for a winding shaft or similar part shall not be larger than is necessary (with sufficient clearance) for the intended operation of the signaling box.

3.1.5 Except as noted in 3.1.6, a signaling box intended for either flush or surface mounting in a back box shall be provided with a back box that has provision for the connection of metal-clad cable or conduit. A back box without provision for the connection of metal-clad cable or conduit may be used if:

a) Definite instructions are furnished with the box indicating the sections of the unit that are intended to be drilled in the field for the connection of raceways or

b) The unit is intended for mounting on an outlet box.

3.1.6 A signaling box is not required to be furnished with a back box if:

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

b) The spacings required in this standard are provided while the signaling box is mounted in such a back box.

See Spacings, Section 10.

3.1.7 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, if a bushing would be required for installation.

3.1.8 The operating lever of a signaling box shall be guarded by a door, recess, or by some equivalent arrangement. A door provided to protect a pull lever or similar part shall be held closed by a latch, catch, spring, or similar device. The device used shall not interfere with the operation of the box in accordance with the instructions marked upon it.

3.1.9 A signaling box using a part intended to be broken during its operation shall be equipped with a breaking device. A door held closed by a break-glass type of latch and intended to be opened during operation of the signaling box shall have a handle, tab, spring, or similar part to facilitate opening the door after the glass is broken.

3.2 Cast metal enclosures

3.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 3.1.

Exception: Cast metal of lesser thickness may be used if, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. See the Impact Test for Enclosures, Section 27.

Table 3.1
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 having no dimension greater than 6 inches (152 mm)	1/16	(1.6)	1/8	(3.2)
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	(2.4)	1/8	(3.2)
At a threaded conduit hole	1/4	(6.4)	1/4	(6.4)
At an unthreaded conduit hole	1/8	(3.2)	1/8	(3.2)

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

3.2.2 Die-cast metal for other than flush boxes may be used if it complies with one of the alloy specifications given in Specification for Zinc-Alloy Die Castings, ASTM B86-88.

3.2.3 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is used, there shall not be less than 3-1/2 nor more than five threads in the metal, and the constructions shall be such that a standard conduit bushing can be attached.

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

3.3 Sheet metal enclosures

3.3.1 The thickness of sheet metal used for the enclosure of a signaling box shall not be less than that indicated in Table 3.2, except that sheet metal of two gauge sizes lesser thickness may be used if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape, size, or both shape and size of the surface is such that equivalent mechanical strength is provided.

Table 3.2
Sheet-metal electrical enclosures

Minimum average thickness of sheet metal					
Uncoated steel,[a]		Zinc-coated steel,[a]		Aluminum, copper, or brass,[a]	
inch	(mm)	inch	(mm)	inch	(mm)
0.053	(1.35)	0.057	(1.42)	0.075	(1.91)
(16)		(16)		(12)	

[a] The figures in parentheses are the Galvanized Sheet Gage numbers (GSG) (for zinc-coated steel), the Manufacturer's Standard Gage numbers (MSG) (for uncoated steel), and the American Wire Gage (AWG) numbers (for a nonferrous metal) which provide the required minimum average thickness of metal.

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

3.3.3 A plate or plug closure for an unused conduit opening or other hole in the ultimate enclosure shall not be less than 0.027 inch (0.69 mm) thick if of steel, or 0.032 inch (0.81 mm) thick if of nonferrous metal, for a hole having a 1-3/8 inch (35 mm) maximum dimension.

3.3.4 A closure for a hole larger than 1-3/8 inch (35 mm) diameter shall have a thickness equal to that required for the enclosure of the device; otherwise, a standard knockout seal shall be used. Such plates or plugs shall be mechanically secured.

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

3.3.6 A knockout shall be provided with a flat surrounding surface intended for seating of a conduit bushing and shall be located so that installation of a bushing 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 in Spacings, Section 10.

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 formed so that operating parts will be protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 3.2. See the Impact Test for Enclosures, Section 27, and the Polymeric Materials Test, Section 28.

3.4.2 Among the factors to be taken into consideration when determining the acceptability of a nonmetallic enclosure or parts are:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Combustibility 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 under conditions of normal or abnormal usage.

All these factors are to be considered with regard to aging.

3.4.3 The continuity of the grounding system shall not rely on the dimensional integrity of the nonmetallic material.

4 Electric Shock

4.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See the Electric Shock Current Test, Section 21.

4.2 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 megohms, a minimum wattage rating of 1/2 watt, and shall be effective with the power switch in either the on or off position.

Exception: The conductive connection need not be provided if:

a) Such a connection is established in the event of electrical breakdown of the antenna isolating means;

b) The breakdown does not result in a risk of electric shock; and

c) In a construction using an isolating power transformer, the resistance of the conductive connection between the supply circuit and chassis does not exceed 5.2 megohms.

4.3 The maximum value of 5.2 megohms specified in 4.2 is to include the maximum tolerance of the resistor value used; that is, a resistor rated 4.2 megohms with 20 percent tolerance or a resistor rated 4.7 megohms with a 10 percent tolerance may be used. A component comprised of a capacitor with a built-in shunt resistor that complies with the requirements for antenna isolating capacitors may be rated a minimum of 1/4 watt.

5 Corrosion Protection

5.1 An iron or steel part, other than a bearing or similar part for which such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means. Parts such as washers, screws, bolts, and similar parts shall be protected against corrosion, if corrosion of such unprotected parts is likely to result in a risk of fire, electric shock, or unintentional contact with moving parts that can cause injury to persons.

Exception: Parts made of stainless steel, polished or treated, if necessary, do not require additional protection against corrosion.

5.2 The requirement of 5.1 applies to all enclosures of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation may depend. Bearing surfaces shall be of materials and construction that reduce the risk of binding due to corrosion.

6 Field-Wiring System Connection

6.1 General

6.1.1 A wiring terminal or lead shall be used for the connection of conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70, corresponding to the electrical rating of the unit.

6.1.2 Duplicate terminals or leads, or equivalent means to achieve electrical supervision, shall be provided for each incoming and outgoing alarm-initiating-circuit connection. A common terminal may be used for connection of both incoming and outgoing wires, when 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, in each notch of which separate conductors of an initiating circuit are intended to be inserted, may be used, 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.

6.2 Field-wiring compartment

6.2.1 The field-wiring compartment to which connections are to be made shall provide sufficient space to complete all wiring connections specified by the installation wiring diagram.

6.2.2 Protection for internal components in the wiring area and wire insulation from sharp edges shall be provided by insulating or metal barriers having smooth, rounded edges or by the word ″CAUTION″ and the following or equivalent instructions located in the wiring area: ″When Making Installation, Route Field Wiring Away From Sharp Projections, Corners and Internal Components.″

6.2.3 The wiring terminals of a signaling box constructed for mounting in an outlet box shall be located or protected so that, upon installation, the wiring in the outlet box is not forced against the terminals so as to damage the conductor insulation.

6.3 Field-wiring terminals or leads

6.3.1 Terminal parts to which field connections are to be 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 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 single 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 Except as noted in 6.3.4, 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 not have less than two full threads for brass and other nonferrous metals and three full threads for aluminum.

6.3.4 A brass terminal plate may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions may be used if they provide equivalent security.

6.3.5 Leads provided for field connections shall not be less than 6 inches (152 mm) long, provided with strain relief, and not smaller than 18 AWG (0.82 mm^2). Rubber or thermoplastic insulation shall not be less than 1/32 inch (0.8 mm) thick.

6.4 Grounding terminals and leads

6.4.1 In an appliance 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 no case smaller than 18 AWG (0.82 mm^2).

b) A marking shall be provided to indicate the system or systems with which it is intended to be used.

c) The grounding means shall be acceptably connected to all exposed dead-metal parts which are likely to become energized and 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 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 on an attached connection diagram or in an equivalent manner.

6.5.2 A field wiring lead provided for connection of the grounded supply conductor of a high-voltage 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.

6.5.3 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.

6.6 Strain relief

6.6.1 A strain-relief means shall be provided for the field supply leads and for all internally connected wires subject to movement during installation, operation, or servicing of a signaling box to prevent any mechanical stress from being transmitted to terminals and internal connections. Inward movement of leads provided with a ring-type strain relief or equivalent means shall neither damage internal connections or components nor result in reduction of electrical spacings.

6.6.2 Each lead used for field connections or an internal lead subjected to movement or handling during installation and servicing shall be capable of withstanding for one minute a pull of 10 pounds (4.45 N) without any evidence of damage or of transmitting the stress to internal connections.

7 Internal Wiring

7.1 General

7.1.1 Wiring shall have insulation rated for the potential involved and the temperatures to which it may be subjected. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string ties, or the 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 application of 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 If the use of a short length of insulated conductor (for example, a short coil lead) is not feasible, 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 (0.44 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, and the like, of polyvinyl chloride tubing having a wall thickness of 0.017 inch.

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

7.1.5 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or shall be equivalently arranged.

7.2 Wireways

7.2.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and similar parts, that can cause abrasion of the conductor insulation.

7.3 Splices

7.3.1 All splices and connections shall be mechanically secured and electrically bonded.

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

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

7.4 Barriers

7.4.1 A metal barrier shall have a thickness at least equal to that required by Table 3.2, based on 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 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 not be more than 1/16 inch (1.6 mm).

7.5 Bushings

7.5.1 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, which shall be secured in place, and have a smooth, rounded surface against which the wire may bear.

7.5.2 If the opening is in a phenolic composition or other equivalent nonconducting 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.

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

7.5.4 Fiber may be used where:

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

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

c) The bushing is formed and secured in place so that it will not be adversely affected by ordinary ambient conditions of humidity.

7.5.5 If a soft rubber bushing is used in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and similar parts.

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

8 Bonding for Grounding

8.1 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: Adhesive-attached metal-foil markings, screws, handles, and similar parts, which are located on the outside of enclosures or cabinets, and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized, are not required to be bonded.

Exception No. 2: Isolated metal parts, such as motor-controller magnet frames and armaturs, small assembly screws, and similar parts, which are positively separated from wiring and uninsulated live parts, are not required to be bonded.

Exception No. 3: Panels and covers which do not enclose uninsulated live parts are not required to be bonded if wiring is separated from the panel or cover so that it is not likely to become energized.

Exception No. 4: Panels and covers are not required to be bonded if they are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and secured in place.

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

8.3 A bonding conductor shall be of material intended for use as an electrical conductor. If of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall be not smaller than the maximum size wire used in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed so that it is protected from mechanical damage.

8.4 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.

8.5 A bolted or screwed connection that incorporates a star washer or serrations under the screwhead may be used for penetrating nonconductive coatings where required for compliance with 8.1.

8.6 Where the bonding means depends upon screw threads, the use of two or more screws or two full threads of a single screw engaging metal is in compliance with 8.1.

8.7 Metal-to-metal, hinge-bearing members for doors or covers may be used for bonding the door or cover for grounding, when a multiple bearing-pin type (piano-type) hinge is used.

8.8 The size of a copper or aluminum conductor used to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 8.1.

8.9 A conductor, such as a clamp or strap, used in place of a separate wire conductor may be used, when the minimum cross-sectional conducting area of the bonding means is not less than that of the wire specified in Table 8.1.

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

Table 8.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]	
	Copper, AWG	(mm²)
15	14	(2.1)
20	12	(3.3)
30	10	(5.3)
40	10	(5.3)
60	10	(5.3)
100	8	(8.4)
200	6	(13.3)

[a] Or equivalent cross-sectional area.

9 Components

9.1 Current-carrying parts

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

9.1.2 Bearings, hinges, and similar parts shall not be used for carrying current between interrelated fixed and moving parts.

9.2 Coil windings

9.2.1 The insulation of coil windings of relays, transformers, and similar parts, shall resist the absorption of moisture.

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

9.3 Insulating material

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

9.3.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated current-carrying parts of other than low-voltage circuits. Polymeric materials may be used for the sole support of uninsulated live parts if determined to have:

a) Mechanical strength and rigidity;

b) Dielectric voltage-withstand;

c) Resistance to heat, flame propagation, arcing, creep, and moisture; and

d) Other properties necessary for the application,

without displaying a loss of these properties beyond the minimum levels as a result of aging when tested as specified in the Polymeric Materials Tests, Section 28.

9.3.3 A flat sheet of insulating material, such as phenolic composition, intended for panel-mounting of parts, shall not be less than 3/8 inch (9.5 mm) thick, except that material less than 3/8 inch thick but not less than 1/8 inch (3.2 mm) thick may be used for a panel, if the panel is supported or reinforced to provide rigidity not less than that of a 3/8-inch sheet. Material less than 1/8 inch thick may be used for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

9.3.4 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 which are not staked, upset, sealed or equivalently prevented from loosening so as to prevent such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

9.3.5 A countersunk, sealed part shall be covered with a waterproof insulating compound that 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 not be less than 1/8 inch (3.2 mm).

9.4 Printed-wiring boards

9.4.1 The securing of components to the board shall be made in a positive manner. The spacings between circuits shall be as specified in Spacings, Section 10. 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.

9.5 Switches

9.5.1 A switch provided as part of a unit shall have a current voltage rating not less than that of the circuit it controls when the device is operated under any condition of intended service.

9.5.2 If a reset switch is provided, it shall be of a self-restoring type.

9.6 Lampholders and lamps

9.6.1 Lampholders and lamps shall be rated for the circuit in which they are used when the signaling box is operated under any condition of intended service.

9.6.2 A lampholder shall be installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps in intended service.

9.7 Protective devices

9.7.1 Fuseholders, fuses, and circuit breakers provided on a signaling box shall be rated for the application.

9.8 Mounting of components

9.8.1 All parts of a signaling box shall be mounted in position and prevented from loosening or turning if such motion may impair the performance of the unit, or may result in a risk of fire, electric shock, or injury to persons.

9.8.2 A switch, lampholder, attachment-plug receptacle, plug connector, or similar electrical component shall be mechanically secured and, except as noted in 9.8.3 and 9.8.4, shall be prevented from turning.

9.8.3 A switch need not be prevented from turning if all of the following conditions are met:

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

b) The means for mounting the switch makes it unlikely that the operation of the switch will loosen it.

c) The spacings are not reduced below the minimum required values if the switch rotates.

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

9.8.4 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum required values.

9.8.5 Uninsulated live parts shall be secured to the base or mounting surface so 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. The security of contact assemblies shall maintain the continued alignment of contacts.

9.8.6 Friction between surfaces shall not be used as a means to prevent shifting or turning of live parts, but a toothed lockwasher with spring take-up may be used.

9.8.7 Uninsulated live parts, such as field-wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required. 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) Some other equivalent method.

9.8.8 A flush plate for outlet-box mounting provided with a signaling box, or as an integral part thereof, shall be of ferrous metal at least 0.030 inch (0.76 mm) thick, of nonferrous metal at least 0.040 inch (1.02 mm) thick, or of nonconductive, noncombustible material at least 0.100 inch (2.54 mm) thick.

9.8.9 A yoke or strap or the mounting ears of a part intended to be mounted on a standard outlet box or similar back box shall be of metal at least 0.040 inch (1.02 mm) thick. Nonferrous metal shall be of thickness sufficient to provide mechanical strength and rigidity not less than that of steel 0.040 inch thick.

9.9 Operating components

9.9.1 Individual dust covers or dust-tight cabinets shall be provided to protect operating components and assemblies, such as switches, relays, and similar devices, against fouling by dust or by other material that can impair their operation.

9.9.2 An operating mechanism shall be assembled so that its operation is not impaired by any condition of intended operation.

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

9.9.4 Gears and coded signaling wheels shall have smooth engaging surfaces. Cams, wheels, and similar parts shall be mechanically fastened to prevent independent turning or loosening.

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

9.9.6 Manually operated parts shall withstand the stress to which they are subject in operation.

9.9.7 An electromagnetic device shall provide intended electrical and mechanical performance under all conditions of anticipated operation.

9.9.8 A gear-train driving spring shall be anchored at each end. The spring-winding means either shall have a positive stop to limit the winding or shall withstand the maximum force likely to be applied without impairing the operation of the mechanisms.

9.10 Capacitors

9.10.1 A capacitor shall use such materials and shall be constructed so that it will not constitute a risk of fire. Its operation shall not be impaired by the temperatures to which it may be subjected under the most severe conditions of anticipated use (see the Temperature Test, Section 20). A paper capacitor shall be impregnated or enclosed to exclude moisture.

10 Spacings

10.1 An electrically-actuated transmitter shall maintain spacings between uninsulated live parts and dead-metal parts and between uninsulated current-carrying parts of opposite polarity. The spacings shall not be less than those specified in Table 10.1.

10.2 Spacings measured ″To walls of enclosure″ as specified in Table 10.1 are applicable between an uninsulated live part and:

a) A wall or cover of a metal enclosure;

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

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

These spacing requirements are not applicable to an individual enclosure of a component part within an outer enclosure.

Table 10.1
Minimum spacings

Point of application	Minimum spacings				
	Voltage range, volts	Through air, inch[a]	(mm)	Over surface, inch[a]	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	(6.4)	1/4	(6.4)
Sheet metal enclosures	0 – 300	1/2	(12.7)	1/2	(12.7)
Installation wiring terminals (general application):					
With barriers – see 10.3	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	3/8	(9.5)	3/8	(9.5)
Installation wiring terminals (special application):					
Do not apply to solder-type terminals	0 – 30	1/8	(3.2)	1/8	(3.2)
	31 – 150	3/16	(4.8)	3/16	(4.8)
	151 – 300	1/4	(6.4)	1/4	(6.4)
Rigidly clamped assemblies:[b]					
100 volt-amperes maximum	0 – 30	1/32[c]	(0.8)	1/32[c]	(0.8)
Over 100 volt-amperes	0 – 30	3/64	(1.2)	3/64	(1.2)
	31 – 150	1/16	(1.6)	1/16	(1.6)
	151 – 300	3/32	(2.4)	3/32	(2.4)
Other parts	0 – 30	1/16	(1.6)	1/8	(3.2)
	31 – 150	1/8	(3.2)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)

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

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

[c] Spacings less than those indicated, but not less than 1/64 inch (0.4 mm), may be used 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).

10.3 A barrier or liner of insulating material used where spacing would otherwise be insufficient shall be of impregnated fiber, phenolic composition, or equivalent material and shall not be less than 0.028 inch (0.71 mm) thick. A barrier or liner used in conjunction with not less than one-half the ″Through air″ spacing specified in Table 10.1 may be less than 0.028 inch thick but shall not be less than 0.013 inch (0.33 mm) thick and shall be located so that it will not be impaired by operation of the unit.

10.4 Insulating material having a thickness less than that specified in 10.3 may be used if it has equivalent mechanical and electrical properties.

10.5 Film-coated wire is considered to be a bare current-carrying part in determining compliance of a device with the spacing requirements, but film-coating may be used as turn-to-turn insulation in coils.

11 Servicing Protection

11.1 Uninsulated live parts or moving parts that can cause injury to persons shall be located, guarded, or enclosed to prevent contact by persons during anticipated servicing, such as lamp, fuse or rod replacement, control adjustment, and maintenance.

11.2 If the linear distance from a component requiring servicing to any uninsulated high-voltage current-carrying part is less than 6 inches (152 mm), protection by insulating tape, barriers, or equivalent shall be provided.

11.3 In lieu of the minimum 6-inch (152-mm) requirement, an interlock shall be provided on the cover to de-energize all live parts in the enclosure, or the cover front shall be provided with the word ″CAUTION″ and the following or equivalent permanent and prominent marking: ″De-energize Unit Prior To Servicing.″

12 Outdoor-Use Signaling Boxes

12.1 A signaling box intended for outdoor use shall comply with the following construction requirements in addition to the preceding construction requirements in this standard.

12.2 The enclosure shall be provided with external means for mounting, except that internal means for mounting may be used if constructed to prevent water from entering the enclosure.

12.3 Holes for conduit shall be threaded unless they are located wholly below the lowest terminal lug or other live part within the enclosure. If knockouts or unthreaded holes are provided, there shall be provision for drainage of the enclosure.

12.4 An enclosure of sheet steel less than 0.120 inch (3.05 mm) thick [0.125 inch (3.17 mm) if zinc-coated] shall be either:

a) Galvanized by the hot-dipped process after forming and assembly;

b) Made from hot-dipped sheets; or

c) Provided with a coating that imparts corrosion protection equivalent to that of zinc applied by the hot-dip process (see the Corrosion Tests, Section 22).

12.5 A gasket shall be of durable material that resists moisture and shall be cemented, pinned, or otherwise secured to one of the contacting surfaces.

12.6 The elements of a rectifier shall be impregnated or sealed to exclude moisture.

PERFORMANCE

13 General

13.1 Three representative samples of signaling boxes in commercial form are to be subjected to the applicable tests specified in Sections 14 – 29.

13.2 A signaling box that must be mounted in a specific position if it is to function as intended is to be tested in that position.

13.3 Unless specified otherwise, the test voltage for each test of a signaling box is to be as shown in Table 13.1 at rated frequency.

Table 13.1
Test voltages

Rated voltage, nameplate	Test voltage
110 – 120	120
220 – 240	240
Other	Marked rating

13.4 The installation wiring terminals of each sample are to be connected, in accordance with the installation wiring diagram, to the corresponding terminals of a system control unit with which the signaling box is intended to be used. However, other equipment may be substituted for the system control unit if this substitution results in the same performance of the box and provides indication of all intended signaling functions of the box.

13.5 Each sample is to be mounted on its back box in the intended manner.

14 Normal Operation Test

14.1 General

14.1.1 A signaling box shall operate as intended for all of the signaling functions for which it was constructed when actuated as intended and in accordance with any instructions marked upon it.

14.1.2 A device provided for maintenance testing of the mechanism or contacts of a signaling box shall operate as intended. It shall not be possible to leave the testing means in any condition that will prevent subsequent intended operation of the box without the condition being evident.

14.1.3 When a signaling box intended to transmit more than one type of signal is operated,

a) The different signal-initiating means shall not interfere with each other;

b) A false fire alarm signal shall not be transmitted during operation of other signals; and

c) Any other signal shall not be mistaken for a fire alarm signal.

14.1.4 A combined fire alarm and manual signaling box for a fire alarm system shall comply with the applicable requirements specified for a box intended to be used separately for the same services.

14.1.5 A signaling box having a glass panel, disc, rod, or similar part that must be broken to operate it for a signal or for access to its actuating means shall satisfactorily complete five part-breaking operations using the means provided with the box, without jamming of the mechanism or other interference by broken particles. It shall be practicable to remove and replace the broken parts. The maximum allowable force to actuate a box requiring a pushing or pulling action shall not exceed 15 pounds (67 N) applied in the direction of intended operation. The minimum force to actuate a box requiring a striking action shall be 1 foot-pound (1.36 J) applied in the direction of intended operation.

14.1.6 A signaling box shall complete five operations as intended for each designated signaling function. A person unfamiliar with the functioning of mechanical parts of a box shall successfully operate it for a fire alarm signal by following the directions with which it is marked.

14.1.7 The switching contacts of a signaling box shall operate in the intended manner while connected in series with an incandescent lamp load of approximately 25 – 50 milliamperes and a 6-volt, direct-current source.

14.2 Coded signaling boxes

14.2.1 A coded signaling box mechanism shall operate at any intended speed adjustment and for each complete set of the maximum intended number of signal rounds without transmitting confusing signal impulses.

14.2.2 A coded signaling box having a pre-wound mechanism is to be prepared for normal signaling operation by connecting it to related devices and circuits as specified in 13.3 – 13.5, and when any operating part that requires winding, setting, or other action to obtain normal signaling operation has been conditioned as intended.

14.2.3 A coded signaling box having a pre-wound mechanism shall be capable of transmitting not less than five complete sets of three or more alarm-signal rounds when fully wound or shall either indicate when it has been restored to normal after an alarm signal by transmitting a rewind signal or indicate when it is run down by visible means at the box or by the operation of signaling contacts intended to produce a trouble signal.

14.2.4 A coded signal mechanism that requires manual rewinding to restore it to the normal signaling condition shall be constructed to prevent partial rewinding. The winding feature shall not be impaired when the force required for full winding is exerted.

14.2.5 Operation of a coded signaling box to indicate a watchman's visit to a signaling station shall cause the transmission of a distinctive supervisory signal by which the box may be identified.

14.2.6 The starting lever of a coded signaling box shall be constructed so that, after the lever has been pulled and released, it will not be possible to interfere with or confuse the signals being transmitted by the box by further manipulation of the lever.

14.2.7 A coded signaling box shall transmit not less than three rounds of its signal when operated in accordance with the instructions marked upon it. If the actuating lever is not moved to its maximum distance of travel so that less than the maximum number of rounds of signal are transmitted, there shall be no transmission of partial rounds but only complete coded signals of one or more rounds.

14.2.8 A non-interfering circuit feature of a coded signaling box shall be effective only during operation of the box for a fire alarm signal.

14.2.9 A non-interfering shunt or equivalent type of coded signaling box shall operate as intended without loss of signals from the box that is electrically nearest to the beginning of the initiating device or signaling line circuit when two or more boxes connected to the same circuit are operated at or about the same time.

14.2.10 The loss of any part of a signal round or loss of all of the remaining rounds of signal being transmitted by a box that was operated prior to the operation of the box electrically nearest to the beginning of the signaling line circuit is not considered to be interference.

14.2.11 A non-interfering, electromagnet-type of coded signaling box shall operate as intended without interference or loss of signals when two or more boxes connected to the same circuit are operated so as to start singularly, simultaneously, or consecutively.

14.2.12 As used in 14.2.11, interference is considered to be the loss or confusion of any portion of a box signal due to the operation of another box connected to the same circuit. The loss of all signals from any box that is operated while another box is operating is not considered to be interference.

14.2.13 A successive signaling type of coded signaling box shall operate as intended without loss of signals from each box operated when the starting levers of two or more boxes connected to the same circuit are operated at or about the same time.

14.2.14 Successive-signaling operation is considered to be the transmission of the complete number of alarm-signal rounds of the first box operated, without interference or confusion of signals caused by the action of any other box connected to the same circuit and operated while the first box is operated, followed by transmission of the complete number of signal rounds from each of the other boxes operated until all of the operated boxes have completed their signals.

14.3 Non-coded signaling boxes

14.3.1 The contacts of a non-coded signaling box shall remain in the operated condition until the mechanism has been restored to its nonalarm condition.

14.3.2 The contact-actuating means of a non-coded signaling box shall not be restored in such a way that it appears to be reset for subsequent operation without the contacts being adjusted so that they will perform as intended when the box is again operated.

14.3.3 Operation of a non-coded signaling box to indicate a watchman's visit to a signaling station shall cause the transmission of a distinctive watchman's supervisory signal by which the box may be identified. See 14.1.3.

14.4 Watchman's suppressed-signaling tour devices

14.4.1 The watchman's key or similar device and the tour-station devices with which it is to be used shall operate as intended as a suppressed-signal combination under all conditions of anticipated operation.

14.4.2 The watchman's key or similar device shall be constructed so that it must be operated at each tour-station device (of any combination intended to be used) in a fixed order of succession in order to transmit signals indicating the start and finish of each tour. It shall be necessary to operate the watchman's key or similar device in each tour-station device in turn in order to obtain signals indicating a complete tour.

14.4.3 Each time a signal-transmitting, tour-station device is operated by the watchman's key or similar device, it shall transmit a signal that will identify the device operated. If the device is intended to transmit signals that indicate the start and finish of a tour, the start and finish signals shall be different.

14.4.4 A watchman's suppressed-signaling tour devices include fixed tour stations and a portable key or similar device to be carried by a watchman and operated at each station. The fixed tour stations include a tour-start and -finish type and an intermediate type. A tour-start and -finish type is one that transmits a distinctive signal at the beginning and end of each tour. Except as indicated in the following sentence, an intermediate type is one that either:

a) Requires mechanical operation in a fixed order of succession and does not transmit a signal or

b) Transmits a signal only when it has not been operated within a prescribed time interval.

A station that transmits a signal each time it is operated may also be used as an intermediate station.

14.4.5 It shall be impractical to operate a signal-transmitting, tour-station device for signals without using the watchman's key or similar device in the intended manner.

14.4.6 The watchman's key or similar device and the tour-station devices shall be constructed so that their intended method of operation cannot be defeated by tampering without leaving evidence of the tampering and to prevent the successful manipulation of mechanical and electrical parts and the use of substitute parts to avoid the intended method of operation.

14.4.7 A watchman's suppressed-signaling tour device that depends solely upon electrical circuit performance for the signal-suppressing feature of operation shall be capable of operating in conjunction with the system control unit with which it is intended to be used and that has been investigated and determined to have the necessary properties for obtaining the performance equal to that indicated in 14.4.1 – 14.4.6.

15 Circuit Emergency Operation

15.1 A signaling box intended to provide signaling during circuit-fault conditions shall transmit signals as intended when a single break or a single, ground-fault condition of the initiating device or signaling line circuit is created on either side of the box connections to the circuit.

15.2 Compliance with the requirement in 15.1 is to be determined by starting with the normal supervisory condition and then introducing the type of fault with which the signaling box is to be operated. The related system-control unit or equivalent unit is to be adjusted as intended for either the normal supervisory condition or the fault condition as required for the test operation indicated in 15.1 prior to operating the signaling box.

15.3 Each fault condition is to be applied separately, the signaling box operated, the result noted, the fault removed, and the combination then restored to the normal monitoring condition prior to establishing the next fault. The operation of the signaling contacts of the box is to be checked with each kind of fault applied to the outgoing and incoming portions of the signaling line circuit in turn.

16 Overcurrent and Undercurrent Operation Test

16.1 The electromagnets of a signaling box shall withstand without damage a continuous current equal to 110 percent of the rated normal operating current during the normal supervisory condition of the circuit and shall operate as intended during the normal signaling condition at the increased current. They shall also operate as intended at 85 percent of the rated normal operating current.

17 Overload and Endurance Test

17.1 General

17.1.1 Except as indicated in 17.1.2, the current-interrupting contacts and the operating mechanism of a signaling box shall perform as intended when subjected to the overload and endurance conditions specified in 17.1.3 – 17.1.5. There shall not be electrical or mechanical malfunction of the box assembly, nor burning, pitting, or welding of contacts.

17.1.2 The overload and endurance tests may be waived if the signaling box uses a single-pole switching device having an ampere rating of not less than twice the ampere rating of the box.

17.1.3 A coded signaling box is to be operated for 500 cycles of operation by manually operating the actuating means (starting lever, key, tripping arm, or similar device) so that the box mechanism produces the maximum number of signal impulses obtainable for each operation of the box. The test current is to be 150 percent of the rated current, except as indicated in 17.1.4 for 50 cycles and is to be rated current during the following 450 cycles.

17.1.4 A watchman's signaling box is to be operated for 5000 cycles of operation by manually operating the watchman's key or other intended actuating means so that the box mechanism produces the maximum number of signal impulses obtainable for each operation of the box. The test current is to be 150 percent of the rated current for 50 cycles and is to be the rated current during the following 4950 cycles.

17.1.5 A combined fire alarm and watchman's signaling box is first to be tested for 500 cycles of fire alarm signal operation under the conditions indicated in 17.1.3, and then for 4500 cycles of operation under the conditions indicated in 17.1.4.

17.1.6 The contacts of a coded signaling box that control only electromagnets used for noninterfering signals or for successive signals are to be subjected to:

a) 50 cycles of operation with the overload resulting from operation at 115 percent of the rated current and

b) 450 cycles at rated current.

17.1.7 A non-coded signaling box is to be operated manually for 500 cycles of operation of each different set of switching contacts at the rate of 6 cycles per minute. Each cycle is to consist of making and breaking 150 percent of the rated current and at rated voltage.

17.1.8 The signaling box is to be tested either with the load (inductive or noninductive) that the contacts are intended to control or with an equivalent load (see 17.1.10 and 17.1.11). Also:

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

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

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

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

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

17.1.9 For alternating-current signaling circuits, an equivalent inductive test load is to have a power factor of 0.6 or less.

17.1.10 For direct-current signaling circuits, an equivalent inductive test load is to have the direct-current resistance needed to obtain the test current and the inductance (calibrated) needed to obtain a power factor of 0.6 when the load is connected to a 60-hertz rms potential equal to the rated direct-current test voltage. When the inductive load has both the required direct-current resistance and the required inductance, the current measured with the load connected to an alternating-current circuit will be equal to 0.6 times the current measured with the load connected to a direct-current circuit when the voltage of each circuit is the same.

17.1.11 The load is to be applied so as to obtain a potential difference of 240 volts between contacts that could be used in that manner.

17.1.12 A signaling box intended for use on circuits having one conductor grounded is to be tested with the enclosure connected through a 3-ampere cartridge fuse to the grounded conductor. If the box is intended for use on other types of circuits, the enclosure is to be connected through a similar fuse to the live pole least likely to strike ground.

17.2 Watchman's suppressed-signaling tour devices

17.2.1 The watchman's key or similar device and each different type of tour-station device shall withstand 6000 cycles of operation without being adversely affected. There shall not be malfunction of electrical and mechanical parts, undue wear of parts, or impaired operation of the key and station devices.

17.2.2 Each test cycle is to include operation of the key or similar device in:

a) A tour-starting, signal-transmitting station;

b) The first intermediate station;

c) Either all other intermediate stations or in a testing device that will position the key in the same manner as that obtained by operating it in the other stations; and

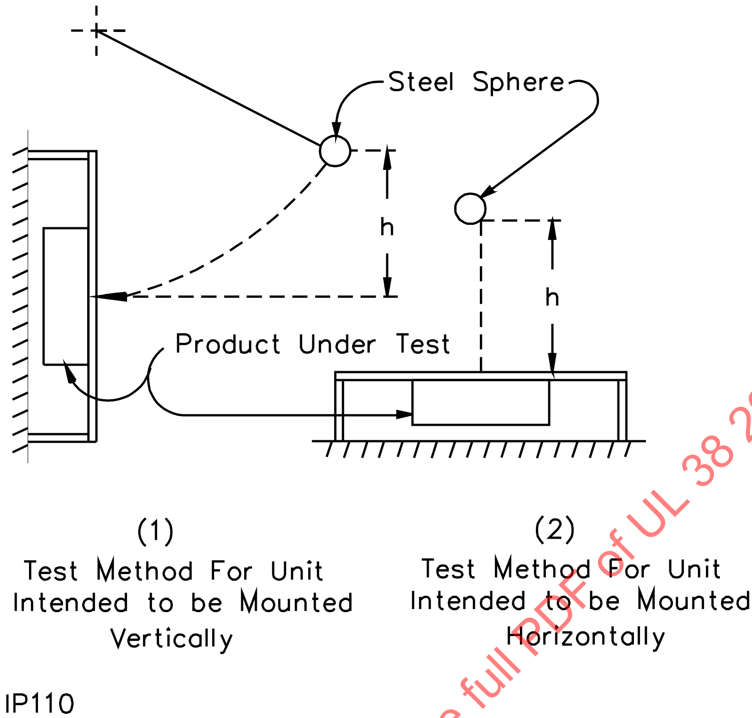
d) A tour-finishing, signal-transmitting station.

18 Jarring Test

18.1 A signaling box shall withstand jarring resulting from impact and vibration, such as might be experienced in service, without causing signaling operation of any part and without impairing its subsequent operation.

18.2 The effects of jarring are to be determined by supporting the box in the position of intended use at the center of a 6 by 4 foot (1.8 by 1.2 m), 3/4-inch (19.1-mm) thick plywood board secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board. This impact is to be applied by means of a 1.18 pound (0.54 kg), 2-inch (51-mm) diameter steel sphere swung through a pendulum arc from a height (h) of 2.54 feet (775 mm) to apply 3 foot-pounds of energy. The signaling contacts are to be connected in series with an indicating lamp across a power source as a means of indicating false operation. See Figure 18.1.

Figure 18.1
Jarring test



19 Drop Test

19.1 The watchman's key or similar portable device shall function as intended after it is dropped five times from a height of 3 feet (915 mm) onto a hardwood surface so as to strike in as many different positions as is practicable.

20 Temperature Test

20.1 The materials used in the construction of a signaling box shall not be adversely affected by the temperatures attained under any condition of intended operation.

20.2 A material is considered to be adversely affected if it is subjected to a temperature rise greater than that indicated in Table 20.1.

20.3 The classes of material used for electrical insulation referred to in items 7 and 8 of Table 20.1 include:

a) Class A (Class 105) – Impregnated cotton, paper, and similar organic materials when impregnated, and enamel as applied to coil windings; and

b) Class B (Class 130) – Inorganic materials, such as mica and impregnated asbestos.

20.4 All values for temperature rises apply to equipment intended for use where prevailing ambient temperatures are not higher than 25°C (77°F). If equipment is intended specifically for use with a prevailing ambient temperature higher than 25°C, the test of the equipment is to be made at the higher ambient temperature, and the allowable temperature rises specified in the table are to be reduced by the amount of the difference between the higher ambient temperature and 25°C.

20.5 Temperature measurements on equipment intended for recessed mounting are to be made with the unit installed in an enclosure made of nominal 1-inch (19.1-mm) wooden boards having clearances of 2 inches (50 mm) on the top, sides, and rear, and having the front extended to be flush with the signaling-box cover.

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

20.7 Except at coils, temperatures are to be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). The preferred method of measuring the temperature of a coil is the thermocouple method, but a temperature measurement by either the thermocouple or change-in-resistance method may be performed. However, the thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is used.

20.8 Thermocouples are to be of 24 – 30 AWG (0.21 – 0.06 mm^2) iron and constantan wires. A potentiometer-type indicating instrument is to be used whenever referee temperature measurements by thermocouples are required.

20.9 The thermocouple wire is to comply with the requirements for thermocouples as listed in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

Table 20.1
Maximum temperature rises

Device or material	°C	(°F)
1. Any point on rectifiers:		
a) Copper oxide	30	54
b) Germanium	50	90
c) Magnesium-copper sulfide	95	171
d) Selenium	50	90
e) Silicon	75	135
2. Rubber or thermoplastic insulation	35[a]	63[a]
3. Varnished cloth insulation	60	108
4. Fuses	65	117
5. Surfaces adjacent to or upon which the unit may be mounted in service	65	117
6. Wood or other combustible material	65	117
7. Fiber used as electrical insulation	65	117
8. Phenolic composition used as electrical insulation	125	225
9. Capacitors	40	72
10. Solid-state devices (transistors, silicon-controlled rectifiers, integrated circuits):	see b	
a) Wirewound resistor	150[c]	302[c]
b) Carbon resistor	d	d
c) Sealing compound	15°C (27°F) less than the melting point[c]	

Table 20.1 Continued on Next Page

Table 20.1 Continued

Device or material	°C	(°F)

[a] This limitation does not apply to an insulated conductor or a material that has been investigated and accepted for a higher temperature.

[b] The temperature of a solid-state device 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 any other condition of operation of the complete unit that produces the maximum temperature dissipation of its components. For reference purposes, 0°C (32°F) shall 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 condition of operation. Both solid-state components and integrated circuits may be operated up to the maximum ratings, under any one of the following conditions:

1. All components comply with the requirements of MIL-STD-883E.
2. 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.
3. Each assembled production unit is subjected to a burn-in test for 24 hours while connected to a source of rated nameplate voltage and frequency in an ambient of at least 49°C (120°F) followed by operational tests.

[c] These are limiting temperatures, not maximum temperature rises.

[d] The maximum temperature on a carbon resistor shall not be greater than 50°C (122°F) during the normal supervisory condition and not greater than 75°C (167°F) during alarm condition.

20.10 The temperature of a copper coil winding is to be determined by the change-in-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:

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

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.

20.11 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.

20.12 A signaling box is to be connected to a supply circuit of rated voltage and frequency (see 13.3) and operated under representative service conditions that are likely to produce the highest temperature. The test is to be terminated when constant temperatures are attained.

20.13 Following the test, the signaling box is to be subjected to the Dielectric Voltage-Withstand Test, Section 24.

21 Electric Shock Current Test

21.1 If the open circuit potential between any part that is exposed only during operator servicing and either:

a) Earth ground or

b) Any other exposed accessible part

exceeds 42.4 volts peak, the part shall comply with the requirements in 21.2 – 21.4, as applicable.

21.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 21.1 when the resistor is connected between any part that is exposed only during operator servicing and either:

a) Earth ground or

b) Any other exposed accessible part.

Table 21.1
Maximum current during operator servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1,000	11.0
2,000	14.1
3,000	17.3
4,000	19.6
5,000	22.0
6,000	25.1
7,000 or more	27.5

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

21.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 21.2 shall not exceed:

a) The value determined by the following equation:

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

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time and

I is the peak current in milliamperes; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum transient current duration are shown in Table 21.2.

Table 21.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
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	12

Table 21.2 Continued on Next Page

Table 21.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
700.0	10
809.0	8.3

21.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

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

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

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge (E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or similar part).

Typical calculated values of maximum capacitance are shown in Table 21.3.

21.5 With reference to the requirements in 21.2 and 21.3, the current is to be measured while the resistor is connected between ground and:

a) Each accessible part individually and

b) 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.

21.6 With reference to the requirements in 21.5, 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 to be considered to be able to contact parts simultaneously, if the parts are within a 4 by 8 inch (102 by 203 mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously, if the parts are not more than 6 feet (1.8 m) apart.

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

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

21.9 Current measurements are to be made with any operating control, or adjustable control that is subject to user operation:

a) In all operating positions and

b) Either with or without a separable connector or similar component in place.

These measurements are to be made with controls placed in the position that causes maximum current flow.

Table 21.3
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	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00