

**STANDARD FOR MANUAL STATIONS FOR FIRE ALARM
SYSTEMS, INCLUDING ACCESSORIES**

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STANDARD FOR MANUAL STATIONS FOR FIRE ALARM SYSTEMS, INCLUDING ACCESSORIES

PREFACE

This is the Third Edition CAN/ULC-S528-14, Standard for Manual Stations for Fire Alarm Systems, Including Accessories.

This Edition of the Standard was formally approved by the ULC Standards Committee on Fire Alarm and Life Safety Equipment and Systems.

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

Appendix A, identified as Normative, indicates mandatory action or requirement. Appendix B, identified as Informative, is for guidance and informational purposes only.

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

This Third Edition National Standard of Canada is based on, and now supersedes, the Second Edition CAN/ULC-S528-05.

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

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

The initiation of the review of this Standard will commence within 5 years of the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

1 SCOPE

1.1 This Standard covers *manual stations* and their accessories for installation in ordinary locations, indoor and outdoor, for use in fire alarm systems.

1.2 A *manual station* having a pre-wound signalling mechanism and equipped with a tripping electromagnet to permit automatic actuation by separate detectors, and similar combination devices, will be judged with respect to compliance with the applicable requirements for both *manual stations* and electrically actuated transmitters.

1.3 This Standard does not cover municipal fire alarm boxes or electrically actuated transmitters.

1.4 This standard also covers *manual stations* used for ancillary service, such as *manual stations* for the electrical release of extinguishing systems.

2 REFERENCE PUBLICATIONS

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

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- ASTM B117-12, Standard Practice for Operating Salt Spray (Fog) Apparatus
- ANSI/ASTM B86-11, Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings
- ASTM E27-81, Standard Method of Spectrographic Analysis of Zinc and Zinc Alloys by the Solution-Residue Technique

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- CSA C22.2 No. 0.1-M1985 (R2008), General Requirements for Double-Insulated Equipment — General Instruction No. 1
- CSA C22.2 No. 0.15-01 (R2006), Adhesive Labels
- CAN/CSA C22.2 No.0.17-00 (R2009), Evaluation of Properties of Polymeric Materials
- CAN/CSA C22.2 No. 0.4-04 (R2009), Bonding of Electrical Equipment
- CAN/CSA C22.2 No. 5-09, Molded-Case Switches and Circuit Breaker Enclosures

- CSA C22.2 No. 8-M1986 (R2008), Electromagnetic Interference Filters (EMI)
- CAN/CSA C22.2 No. 18.1-04 (R2009), Nonmetallic Outlet Boxes
- CAN/CSA C22.2 No. 18.2-06, Tubing and Cable Fittings Conduit
- CAN/CSA C22.2 No. 18.3-04 (R2009), Tubing and Cable Fittings Conduit
- CSA C22.2 No. 21-95, Cord Sets and Power Supply Cords
- CSA C22.2 No. 24-93 (R2008), Temperature Indicating and Regulating Equipment
- CSA C22.2 No. 38-10, Thermoset-Insulated Wires and Cables
- CSA C22.2 No. 42-10, General Use Receptacles, Attachment Plugs and Similar Wiring Devices
- CSA C22.2 No. 43-08, Lampholders
- CSA C22.2 No. 49-, Flexible Cords and Cables
- CSA C22.2 No. 55-M1986 (R2008), Special Use Switches Wiring Products Forming Part of the Canadian Electrical Code Part II
- CAN/CSA C22.2 No. 65-03 (R2008), Wire Connectors
- CSA C22.2 No. 66.1-06 Low Voltage Transformers — Part 1: General Requirements
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- CSA C22.2 No. 111-10 (R2012), General-Use Snap Switches
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- CSA C22.2 No. 190-M1985 (R2009), Capacitors for Power Factor Correction
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- CSA C22.2 No. 4248.8-07, Fuseholders - Part 8: Class J
- CSA C22.2 No. 4248.9-07, Fuseholders - Part 9: Class – K
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- CSA C22.2 No. 4248.12-07, Fuseholders - Part 12: Class R
- CSA C22.2 No. 4248.15-07, Fuseholders - Part 15: Class T
- CAN/CSA C22.2 No. 60065-03 (R2007), Audio, Video, and Similar Electronic Equipment
- CAN/CSA C22.2 No. 61058-1-09, Switches for Appliances – Part 1: General Requirements
- CAN/CSA E60384-14-09, Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains

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- CAN/ULC-S524, Standard for Installation of Fire Alarm Systems
- CAN/ULC-S526, Standard for Visible Signal Devices for Fire Alarm Systems Including Accessories
- CAN/ULC-S527, Standard for Control Units for Fire Alarm Systems
- CAN/ULC-S710.2-11, Standard for Thermal Insulation – Bead-Applied One Component Polyurethane Air Sealant Foam, Part 2: Installation

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- ANSI/UL 94-13, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- ANSI/UL 746A-00 (R2011), Polymeric Materials - Short Term Property Evaluations
- ANSI/UL 746B-96 (R2011), Polymeric Materials - Long Term Property Evaluations
- ANSI/UL 746C-04 (R2012), Polymeric Materials - Use in Electrical Equipment Evaluations
- ANSI/UL 746D-98 (R2008), Polymeric Materials - Fabricated Parts
- ANSI/UL 796-10 (R2012), Printed-Wiring Boards
- UL 969-95 (R2008), Marking and Labeling Systems

3 GLOSSARY

NOTE: Terms used in this Standard that are in italic print are defined as follows:

3.1 *ADDRESSABLE MANUAL STATION* — A *manual station* that can be uniquely identified by a control unit and/or transponder to determine its presence and operating status and which may be commanded to change its operating parameters independently of other field devices that share a common circuit.

3.2 *MANUAL STATION* — A device designed to initiate a signal when operated manually.

4 GENERAL

4.1 COMPONENTS

4.1.1 Except as indicated in Clause 4.1.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Appendix A (Normative), Standards for Components, for a list of Standards that apply to components generally used in the products covered by this standard.

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

- A Involves a feature or characteristic not needed in the application of the component in the product covered by this Standard; or
- B Is superseded by a requirement in this Standard.

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

4.1.4 Specific components are recognized as being 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 for which they have been recognized.

4.2 CONTROL UNIT INTERFACE

4.2.1 A *manual station* incorporating circuitry for functional interfacing with a control unit for purposes such as supervision, point addressing, multiplexing, etc., shall be compatible with the control unit and shall also comply with the applicable functional requirements of CAN/ULC-S527, Control Units for Fire Alarm Systems.

4.2.2 An electrically energized *manual station* when used as an input *manual station* of a fire protective signalling system shall be energized from the system control unit in accordance with CAN/ULC-S527, Standard for Control Units for Fire Alarm Systems.

5 INSTALLATION WIRING DIAGRAM

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

5.1 Each *manual station* shall include installation instructions and drawings as specified in Clauses 5.2 through 5.5.

5.2 Installation drawings shall include the typical location, mounting, orientation and spacing of units.

5.3 Installation wiring drawings shall include the following items:

- A Typical wiring material type designation;
- B Typical wire gauge related to circuit voltage and power rating and circuit length;
- C Typical wiring method which shall be in accordance with CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, Section 32; and CAN/ULC-S524, Standard for Installation of Fire Alarm Systems;
- D Wire connections to the device, including equipment grounding by wire colour code and identified terminals, as applicable; and
- E Compatible interface equipment, such as control unit and end-of-line devices, or the applicable parameters of the interface equipment for voltage, power, and supervision compatibility specified.

5.4 Typical instructions shall include a statement to caution against changing factory applied finishes.

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5.5 The information required by Clauses 5.2 through 5.4 may be incorporated on the device if it is visible after installation. Alternatively it may be incorporated inside of the device if it is visible by opening the enclosure cover or by the removal of not more than two mounting screws.

6 CONSTRUCTION

6.1 GENERAL

6.1.1 A *manual station* shall be constructed for its intended installation and use and shall comply with the construction requirements contained in this Section, unless, where permitted by test, the construction is determined to be equivalent to these requirements.

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

6.1.3 The minimum size of a *manual station* shall be 77 cm².

6.1.4 The outer surface of the *manual station* used to initiate a fire alarm signal shall be permanently coloured red. Refer to Section 12, Ancillary Use Manual Stations.

6.1.5 If an additional alarm visual indicator is provided, it shall be positioned within the operating face or within the front face of the *manual station*. The visual indicator shall be:

- A Red;
- B Visible from a distance of 2 m directly in front of the *manual station*, in an ambient light intensity up to 500 lx; and
- C Identify the *manual station* which initiated an alarm until the alarm condition is reset.

6.1.6 Where other conditions of the *manual station* may be visually indicated, they shall be clearly distinguishable from the alarm indication, except when the *manual station* is switched into a service mode.

6.2 FRAME AND ENCLOSURE

6.2.1 A *manual station* shall be so formed and assembled that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without adversely affecting its performance, due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or development of other conditions which could impair operation of the device and increase the risk of fire or electrical shock. See Subsection 8.17, Mechanical Strength Tests for Enclosures.

6.2.2 Electrical parts of a *manual station* shall be so located or enclosed that suitable protection to a person against accidental contact with uninsulated hazardous live parts is provided.

6.2.3 Operating parts, such as contacts and similar parts, shall be adequately protected against mechanical damage and against fouling by dust or by other materials that might adversely affect their normal operation.

6.2.4 Provision shall be made for securely mounting the *manual station* in position. Bolts, screws, or other parts used for mounting shall be independent of those used for securing component parts of the assembly.

6.2.5 An opening for a winding shaft or similar part shall be no larger than is necessary (with sufficient clearance) for the proper operation of the *manual station*.

6.2.6 Except as noted in Clause 6.2.7, a back box provided for a *manual station* shall be of a thickness as specified in Subsection 6.3, Cast Metal Enclosures; or Subsection 6.4, Sheet Metal Enclosures.

6.2.7 A *manual station* need not be furnished with a back box if means for attachment to a standard outlet box are provided and, if while the *manual station* is mounted on such a back box, the spacings required in Subsection 6.12, Spacings, are provided.

6.2.8 There shall be adequate space 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 proper installation.

6.2.9 A *manual station* shall have provision for the connection of armoured cable or conduit either to its integral enclosure or to a back box to which it is intended to be attached.

6.2.10 The *manual station* shall have adequate protection against accidental operation.

6.2.11 A door provided to protect an actuating mechanism or similar part shall be held closed by a latch, catch, spring, or similar device. The method used shall not interfere with the normal operation of the *manual station* in accordance with the instructions marked upon it. A recess, bevelled surface, or the equivalent may be used to protect the actuating mechanism.

6.2.12 A *manual station* employing a part intended to be broken during its operation shall be equipped with a suitable breaking device or shall be designed so that injury to the operator shall not occur when operating the *manual station*.

NOTE: The breakable element is intended to give protection against unintentional operation and to be a deterrent against misuse. The visible displacement of the breakable element is accepted apparent breaking.

6.2.13 A door held closed by a break-glass type of latch and intended to be opened during operation of the *manual station* shall have a handle, tab, spring, or similar part to facilitate opening the door after the glass is broken.

6.2.14 The outside edges, corners, and projections of an enclosure which will be exposed after installation, or projecting operating controls, shall be smooth and rounded to a radius of 2 mm to minimize the possibility of a cut injury or injury by impact.

6.3 CAST METAL ENCLOSURES

6.3.1 The thickness of cast metal for an enclosure shall be as indicated in Table 1, except that cast metal of lesser thickness may be employed if, upon investigation (consideration being given to the shape, size and function of the enclosure), it is found to have adequate mechanical strength. See Subsection 8.17, Mechanical Strength Tests for Enclosures.

6.3.2 Die-cast metal for other than flush back boxes shall comply with one of the alloy specifications given in ANSI/ASTM B86, Standard Specification for Zinc and Zinc-Aluminum (ZA) Foundry and Die Castings.

6.3.3 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 employed, there shall be no fewer than three and one half nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

6.3.4 If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall be no fewer than five full threads in the metal and a smooth, well-rounded inlet hole for the conductors, which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing, eyelet, or grommet.

6.3.5 Die-cast metal for other than flush boxes is permitted when it complies with one of the alloy specifications given in ANSI/ASTM B86, Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings.

6.3.6 Compliance of a zinc-base alloy die casting with the requirement of Clause 6.3.5 is to be determined by ASTM E27, Standard Method of Spectrographic Analysis of Zinc and Zinc-Alloys by the Solution-Residue Technique.

6.4 SHEET-METAL ENCLOSURES

6.4.1 The thickness of sheet metal employed for the enclosure shall be not less than that indicated in Table 2 except that sheet metal of two sizes lesser thickness may be employed 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.

6.4.2 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 flat steel sheet having a minimum thickness of 1.35 mm.

6.4.3 A plate or plug closure for an unused conduit opening or other hole in the ultimate enclosure shall be not less than 0.69 mm thick if of steel, or 0.81 mm thick if of nonferrous metal, for a hole having a 35 mm maximum diameter.

6.4.4 A closure for a hole larger than 35 mm diameter shall have a thickness equal to that required for the enclosure of the *manual station* or a standard knockout seal shall be used. Such plates or plugs shall be mechanically secured.

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

6.4.6 A knockout shall be provided with a flat surrounding surface acceptable 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 under Subsection 6.12, Spacings.

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

6.5 NON-METALLIC ENCLOSURES

6.5.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength 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 2. See Subsection 8.17, Mechanical Strength Tests for Enclosures, and Subsection 8.18, Polymeric Materials Test.

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

- A The mechanical strength;
- B Resistance to impact;
- C Moisture absorptive properties;
- D Flammability and resistance to ignition from electrical sources;
- E Dielectric strength, insulation resistance, and resistance to arc tracking; and
- F Resistance to distortion and creeping at temperatures to which the material may be subjected under conditions of normal or abnormal usage.

NOTE: All these factors are considered with respect to ageing in accordance with Subsection 8.23, Elastomeric Materials.

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

6.6 ELECTRIC SHOCK

6.6.1 Any part that is exposed only during operator servicing shall not present the risk of electric shock. See Subsection 8.10, Electric Shock Current Test.

6.6.2 The insertion in any socket of any plug-in component used in the *manual station* shall not result in a risk of electric shock.

6.7 CORROSION PROTECTION

6.7.1 Metal parts, other than a bearing or similar part for which such protection is impracticable, shall be suitably protected against corrosion by enamelling, galvanizing, sherardizing, plating, or other equivalent means. Parts made of stainless steel do not require additional protection against corrosion.

6.7.2 The requirement of Clause 6.7.1 applies to all metal enclosures, 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 likelihood of binding due to corrosion.

6.7.3 The requirement in Clause 6.7.1 does not apply to minor parts such as washers, screws and bolts, if the failure of such unprotected parts would not be likely to result in a risk of fire, electric shock, or unintentional contact with moving parts that can cause injury to persons or prevent the intended operation of the *manual station*.

6.7.4 Metal shall not be used in combinations such as to cause galvanic action. Refer to Annex F of CSA C22.2 No 60065, Audio, Video, and Similar Electronic Equipment.

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

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

6.8 FIELD WIRING CONNECTION

6.8.1 General

6.8.1.1 A wiring terminal or lead shall be acceptable for the connection of conductors of at least the size required by CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations, corresponding to the electrical rating of the unit.

6.8.1.2 Wiring terminals shall be prevented from turning.

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

6.8.1.4 Dual terminals or dual leads, or equivalent means to achieve electrical supervision, shall be provided for each incoming and outgoing alarm-initiating-circuit connection.

6.8.1.5 A common dual terminal may be used for connection of both incoming and outgoing wires, provided that the construction of the terminal does not permit an uninsulated section of a single conductor to be looped around the terminal and serve as two separate connections, thereby precluding supervision of the connection in the event that the wire becomes dislodged from under the terminal.

6.8.1.6 A notched clamping plate under a single securing screw, in which separate conductors of an initiating circuit are intended to be inserted under each notch, is acceptable, but this arrangement shall be supplemented by additional marking in the wiring area or on the installation wiring diagram specifying the intended connections to the terminals.

6.8.2 Field Wiring Compartment

6.8.2.1 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 without damage to wire insulation or to internal components. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required.

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

6.8.2.3 The wiring terminals of a *manual station* intended for mounting in an outlet box shall be located or protected such that the wiring in the outlet box is not dislodged or forced against the terminals so as to adversely affect the conductor insulation when mounted as intended.

6.8.3 Terminals and Leads

6.8.3.1 Terminal parts by which connections are made shall ensure reliable connections even under hard usage. For 2.59 mm (No. 10 AWG) and smaller wires, the parts to which wiring connections are made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections may be provided if found to be equivalent.

6.8.3.2 If a wire-binding screw is employed at a wiring terminal, the screw shall be not smaller than No. 8, except that a No. 6 screw may be used for the connections of a 1.63 mm diameter (No. 14 AWG) or smaller conductor. A wire-binding screw shall thread into metal and shall be of nonferrous metal or plated steel.

6.8.3.3 Except as noted in Clause 6.8.3.4, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.27 mm in thickness for a No. 8 or larger screw, and not less than 0.76 mm in thickness for a No. 6 screw, and shall have no fewer than two full threads in the metal.

6.8.3.4 A 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 employed if they provide equivalent ruggedness of the terminal plate and thread security of the wire-binding screw.

6.8.3.5 Leads provided for field connections shall be stranded copper bunch tinned, not less than 150 mm long, provided with strain relief, and not smaller than 1.02 mm diameter (No. 18 AWG). Rubber or thermoplastic insulation shall be not less than 0.8 mm thick.

6.8.4 Ground Terminal and Lead

6.8.4.1 In a *manual station* intended for connection to a source of supply only by means of other than a metal-enclosed wiring system, such as non-metallic-sheathed cable:

- A An equipment ground terminal or lead shall be provided. The size shall be the same as the supply terminal or lead, but in no case smaller than 1.02 mm diameter (No. 18 AWG);
- B A marking shall be provided to indicate the system or systems with which it is intended to be used and;
- C The bonding 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.

6.8.4.2 The surface of an insulated lead intended solely for the connection of an equipment bonding conductor shall be green, with or without one or more yellow stripes. No other leads visible to the installer, other than grounding conductors, shall be so identified. The bonding means shall be used for no other purpose.

6.8.4.3 A field wiring terminal intended for connection of an equipment bonding conductor shall be plainly identified as per the requirements of CSA C22.2 No. 0.4, Bonding of Electrical Equipment, such as being marked G, GR, Ground, the internationally accepted ground symbol 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 *manual station*.

6.8.5 Strain Relief

6.8.5.1 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 the *manual station* to prevent any mechanical stress from being transmitted to terminals and internal connections.

6.8.5.2 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.

6.8.5.3 Each lead employed for field connections or an internal lead subjected to movement or handling during installation and servicing shall be capable of withstanding for 1 min, a pull of 45 N without any evidence of damage or of transmitting the stress to internal connections.

6.9 INTERNAL WIRING

6.9.1 General

6.9.1.1 The internal wiring of a *manual station* shall consist of suitably insulated conductors having adequate mechanical strength and current carrying capacity for the service and temperatures to which it may be subjected.

6.9.1.2 The wiring shall be routed away from moving parts and sharp projections, and shall be held in place with clamps, string ties, or the equivalent unless sufficiently rigid to retain its shaped form.

6.9.1.3 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.

6.9.1.4 The leads shall be secured or equivalently arranged to prevent abrasion of insulation and jamming between parts of the enclosure.

6.9.1.5 Stranded conductors clamped under wire-binding screws shall have the individual strands soldered together or equivalently arranged to ensure reliable connections.

6.9.2 Separation of Circuits

6.9.2.1 Internal wiring of circuits that operate at different potentials shall be reliably separated by barriers (see Subsection 6.9.5, Barriers), clamps, routing, or other equivalent means that ensure permanent separation sufficient for the conductors of the circuit having the highest voltage, unless all conductors are provided with insulation that is suitable for the highest potential involved.

6.9.3 Wireways

6.9.3.1 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, etc., that might abrade the conductor insulation.

6.9.3.2 Holes in sheet-metal walls through which insulated conductors pass shall be provided with smoothly rounded bushings or shall have smooth, well rounded surfaces upon which the wires may bear to prevent abrasion of the insulation.

6.9.4 Splices

6.9.4.1 All joints and connections shall be mechanically secure and shall provide adequate and reliable electrical contact without strain on connections and terminals.

6.9.4.2 A splice shall be provided with insulation equivalent to that on the wires being joined.

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

6.9.5 Barriers

6.9.5.1 Barriers used to provide separation between the wiring of different circuits shall be of metal or of suitable insulating material; of adequate mechanical strength if exposed or otherwise likely to be subject to mechanical injury; and reliably held in place.

6.9.5.2 A barrier of insulating material shall be not less than 0.71 mm in thickness and shall be of greater thickness if its deformation can be readily accomplished so as to defeat its purpose.