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SUBJECT 2593

OUTLINE OF INVESTIGATION

FOR

MOTOR DRIVEN TURNSTILE OPERATORS AND SYSTEMS

Issue Number: 3

APRIL 26, 2011

Summary of Topics

This Third Issue of the Outline of Investigation for Motor Driven Turnstile Operators and Systems is being issued to move the component standard requirements from Appendix A into the body of the standard, as well as includes specific component requirements that are being applied within the end product requirements. This Third Issue also includes miscellaneous editorial revisions related to moving the component requirements from Appendix A into the body of the standard.

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INTRODUCTION

1 Scope

1.1 These requirements cover electric turnstile operators and systems rated 250 V or less to be employed in ordinary locations in accordance with the National Electrical Code, NFPA 70 intended for permanent supply connection.

1.2 The rotating member of the turnstiles greater than 13 lb (6 kg) require further investigation.

1.3 These requirements do not cover doors, gates, and other such assemblies that include electric opening and closing equipment that are covered in the Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems, UL 325.

1.4 These requirements also cover accessories, such as external entrapment protection devices, for use with equipment covered by this Outline of Investigation.

1.5 Turnstiles intended for exit use as defined in the Life Safety Code, NFPA 101 and codes such as the International Building Code, are additionally subject to design requirements specific to such use.

1.6 These requirements do cover security or prevention from access.

2 Terminology

2.1 In the following text, a requirement that only applies to a specific type or types of equipment is identified by a specific reference in the requirement to the type or types of equipment covered by the requirement. In the absence of a specific reference, or if the term "operator" is used, it is understood that the requirement applies to all types of equipment within the scope of this Outline of Investigation.

3 Glossary

3.1 For the purpose of these requirements, the following definitions apply.

3.2 **AUTOMATIC ACTION** – That action of an automatic control in which the transmission and operation are produced by initiation which is not the result of actuation.

3.3 **AUXILIARY CONTROLS** – A nonessential control employed by a product that provides a functional utility but is not required in order for the product to comply with all applicable requirements of this Outline of Investigation.

3.4 **CLASS 2 CIRCUIT** – An isolated secondary circuit involving a potential of not more than 30 V (42.4 V peak) supplied by:

- a) A Class 2 circuit per 14.4.3;
- b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently-limited Class 2 transformer;
- c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;

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d) Any combination of (a), (b), and (c) above that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A line-connected circuit connected in series with an impedance as a means of limiting the voltage and current is not a Class 2 circuit.

3.5 ENTRAPMENT – The condition when an object is caught or held in a position that increases the risk of injury.

3.6 INHERENT ENTRAPMENT PROTECTION SYSTEM – An operator control which provides protection against entrapment upon sensing an object and is incorporated as a permanent and integral part of a system.

3.7 OPERATING CONTROL – A control where the operation of which starts or regulates the equipment during normal operation. A regulating control is an operating control.

3.8 MANUAL CONTROL – A control that requires direct human interaction to activate or rest the control.

3.9 PROTECTIVE CONTROL – A control where the operation of which is intended to prevent the risk of electric shock, fire, or injury under abnormal operation of the equipment and including entrapment during normal and abnormal operation. A limiting control is a protective control.

3.10 SYSTEM – In the context of these requirements, a system refers to a group of interacting devices intended to perform a common function.

3.11 TURNSTILE OPERATOR – A form of motor driven pedestrian gate which allows one person to pass at a time. It can also be made so as to enforce one-way traffic of people.

3.12 TURNSTILE SYSTEM – A turnstile operator provided with all parts that complete the assembly including the moving members.

3.13 TYPE 1.D ACTION – The actuation of a manual reset control of 3.8 designed so that disconnection can neither be prevented nor inhibited, by any reset mechanism and so that after disconnection, it is not possible to reclose the circuit even momentarily while the excess or fault condition persists.

3.14 TYPE 1.H ACTION – The actuation of a manual control of 3.8, that shall be so designed that the contacts cannot be prevented from opening and which may automatically reset to the closed position if the reset means is held in the reset position. The control shall not reset automatically at any temperature above -31°F (-35°C) with the reset mechanism in the normal position.

3.15 TYPE 2 ACTION – The actuation of an automatic control of 3.2, for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence are considered.

4 Units of Measurement

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

5 References

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

CONSTRUCTION

6 General

6.1 Equipment shall employ materials that are acceptable for the use and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 Equipment shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing its risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.3 A component of a product covered by this Standard shall:

- a) Comply with the requirements for that component as indicated elsewhere in this Standard;
- b) Be used in accordance with its rating established for the intended conditions of use;
- c) Be used within its established use limitations or conditions of acceptability;
- d) Additionally comply with the applicable requirements of this end product Standard; and
- e) Not contain mercury, unless used within a fluorescent, high intensity discharge, or neon lamp bulb.

Exception No. 1: A component of a product covered by this Standard is not required to comply with a specific component requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product;*
- b) Is superseded by a requirement in this Standard; or*
- c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.*

Exception No. 2: A component that complies with a component standard other than those cited elsewhere in this Standard is acceptable if:

- a) The component also complies with the applicable component standard indicated elsewhere in this Standard; or*
- b) The component standard:*

- 1) *Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, NFPA 70, where appropriate;*
- 2) *Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and*
- 3) *Any use limitations of the other component UL standard are identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.*

6.4 A component that is also intended to perform other functions, such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL standard that cover devices that provide those functions.

6.5 A component not anticipated by the requirements of this Standard, not specifically covered by the component standards cited in this Standard, and that involves a potential risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable standard, and shall comply with 6.3 (b) – (d).

6.6 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of this Standard.

7 Frame and Enclosure

7.1 For an unreinforced flat surface, cast metal shall not be less than 1/8-in (3.2-mm) thick, except that malleable iron may be not less than 3/32-in (2.4-mm) thick, and die-cast metal may be not less than 5/64-in (2.0-mm) thick. Corresponding thicknesses of not less than 3/32, 1/16, and 3/64 in (2.4, 1.6, and 1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or of a shape or size that provides mechanical strength equivalent to that required.

7.2 An enclosure of sheet metal shall be evaluated with respect to size, shape, thickness of metal, and acceptability for the application considering the intended use of the complete equipment. The use of sheet steel having a thickness of less than 0.026 in (0.66 mm) if uncoated or 0.029 in (0.74 mm) if galvanized or of nonferrous sheet metal having a thickness of less than 0.036 in (0.91 mm) is not acceptable.

Exception: Minimum thickness is not specified for an area that is relatively small or a surface that is curved or otherwise reinforced.

7.3 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 in (0.81 mm) if uncoated steel, not less than 0.034 in (0.86 mm) if galvanized steel and not less than 0.045 in (1.14 mm) if nonferrous.

7.4 The effects of the following factors shall be determined for compliance of a nonmetallic enclosure or an enclosure of magnesium that complies with 6.2, including enclosures of low-voltage circuits relied on for entrapment protection:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorption properties;
- d) Combustibility;
- e) Resistance to distortion at temperatures to which the material is subjected under conditions of normal or abnormal use; and
- f) Resistance to ultraviolet light, where applicable.

7.5 The enclosure of equipment shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the equipment is supported.

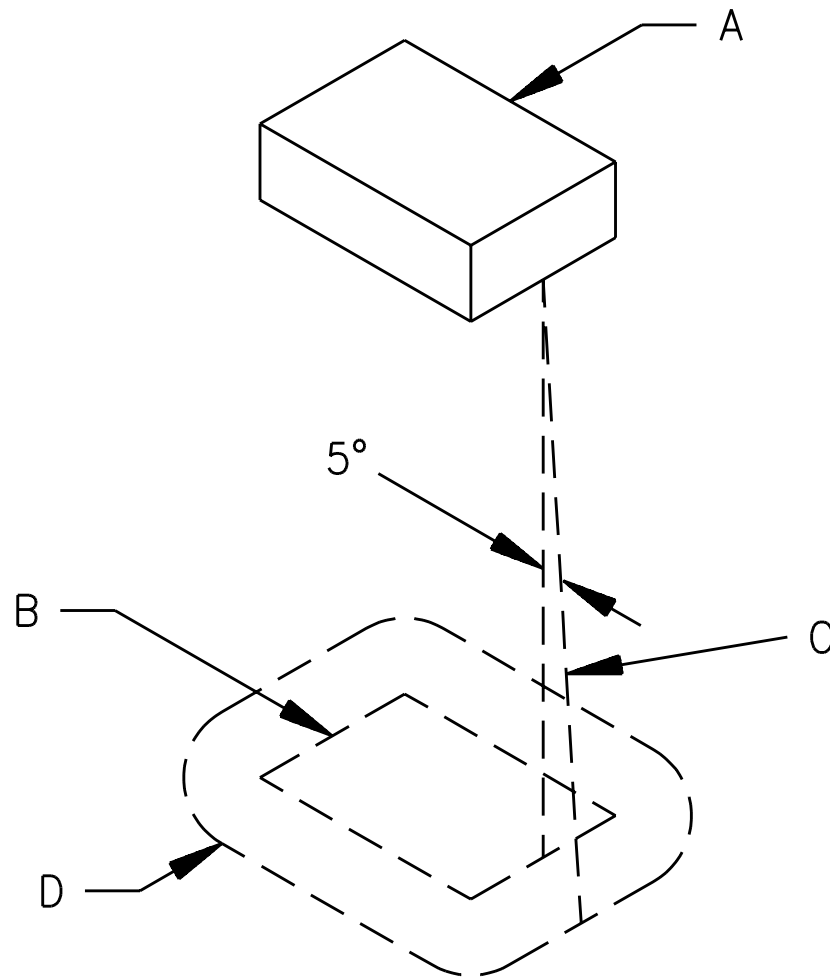
7.6 The requirement in 7.5, will necessitate the use of a barrier of noncombustible material:

- a) Under a motor unless:
 - 1) The structural parts of the motor or of the equipment provide the equivalent of such a barrier;
 - 2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the equipment when the motor is energized under each of the following fault conditions:
 - i) Open main winding;
 - ii) Open auxiliary winding;
 - iii) Starting switch short-circuited; and
 - iv) Capacitor of a permanent-split capacitor motor short-circuited – the short circuit is to be applied before the motor is energized, and the rotor is to be locked;
 - 3) The motor is provided with a thermal protector – a protective device that is sensitive to temperature and current – that will prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked; or
 - 4) The motor is provided with impedance protection that complies with the requirements in the Standard for Overheating Protection for Motors, UL 2111, and the temperature of the motor winding will not exceed 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.
- b) Under wiring, unless it is neoprene, cross-linked or thermoplastic-insulated.

7.7 The requirements in 7.5, will also necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that breakdown or malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the equipment enclosure.

7.8 The barrier mentioned in 7.6, shall be horizontal, shall be located as illustrated in Figure 7.1, and shall have an area in accordance with that illustration. Openings for drainage, ventilation, and the like may be employed in the barrier if such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 7.1
Location and extent of barrier



EB120A

A – Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always:

- 1) Tangent to the component;
- 2) 5 degrees from the vertical; and
- 3) Oriented so that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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7.9 Enclosure openings intended for conduit connection shall be suitable for conduit fittings in accordance with the Standard for Conduit, Tubing and Cable Fittings, UL 514B. Wet location applications shall be suitable for water-tight conduit fittings.

7.10 Gaskets and seals that comply with the Standard for Gaskets and Seals, UL 157, are considered to fulfill the requirements of 7.4, when serving to complete an enclosure or prevent water ingress.

7.11 Gaskets and seals exposed to outdoor conditions shall be suitable for ultraviolet exposure resistance.

8 Boxes and Raceways

8.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Wiring Methods and Materials, of the National Electrical Code, NFPA 70, and that comply with the relevant UL standard, such as the Standard for Metallic Outlet Boxes, UL 514A; the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers, UL 514C; and the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D, are considered to comply with the requirements of this Standard.

8.2 Nonmetallic enclosures supporting conduit connections shall comply with Connections for wiring systems and Polymeric enclosures – rigid metallic conduit connection test of the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50. Metallic enclosures supporting conduit connections shall comply with Connections for wiring systems, Metallic enclosure threaded opening test, and Metallic enclosure conduit hub test, of UL 50.

9 Accessibility of Uninsulated Live Parts and Film-Coated Wire

9.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either (a) or (b). See 14.4.2.

- a) For an opening that has a minor dimension (see 9.5) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 9.1.
- b) For an opening that has a minor dimension of 1 in or more, such a part or wire shall be spaced from the opening as specified in Table 9.1.

Exception: A motor need not comply with these requirements if the integral enclosure of the motor complies with the requirements in 9.2.

9.2 With respect to an integral enclosure of a motor as mentioned in the exception to 9.1:

- a) An opening that has a minor dimension (see 9.5) less than 3/4 in (19.1 mm) is acceptable if:
 - 1) Film-coated wire cannot be contacted by the probe illustrated in Figure 9.3;
 - 2) In a directly accessible motor (see 9.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 9.4; and
 - 3) In an indirectly accessible motor (see 9.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 9.2.

b) An opening that has a minor dimension of 3/4 in or more is acceptable if a part or wire is spaced from the opening as specified in Table 9.1.

9.3 The probes mentioned in 9.1 and 9.2, and illustrated in Figures 9.1, 9.2, 9.3, and 9.4, shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figures 9.1 and 9.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

9.4 The probes mentioned in 9.1 and 9.2, shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

9.5 With reference to the requirements in 9.1 and 9.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

9.6 With reference to the requirements in 9.2, an indirectly accessible motor is a motor that is accessible by the probe illustrated in Figure 9.1, only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed with or without using a tool under the conditions noted in 9.7 (a) and (b). A directly accessible motor is a motor that can be contacted by the probe illustrated in Figure 9.1, without opening or removing any part and will be located 8 ft (2.44 m) or less above the floor when the operator is installed as intended.

9.7 During the examination of a product to determine whether it complies with the requirements in 9.1 or 9.2, a part of the enclosure that may be opened or removed by the user (to attach an accessory, to make an operating adjustment, relamping, or for other reasons) is to be opened or removed if:

- a) The enclosure can be removed without tools; or
- b) The enclosure can only be removed using a tool, but it is necessary that the equipment be connected to the source of supply or instructions specify it be connected to the supply during user servicing operations.

9.8 With reference to the requirements in 9.1 and 9.2, insulated brush caps are not required to be additionally enclosed.

Table 9.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension ^a of opening,		Minimum distance from opening to part,	
in ^b	(mm)	in ^b	(mm)
3/4 ^c	(19.1)	4-1/2	(114)
1 ^c	(25.4)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
d		30	(762)

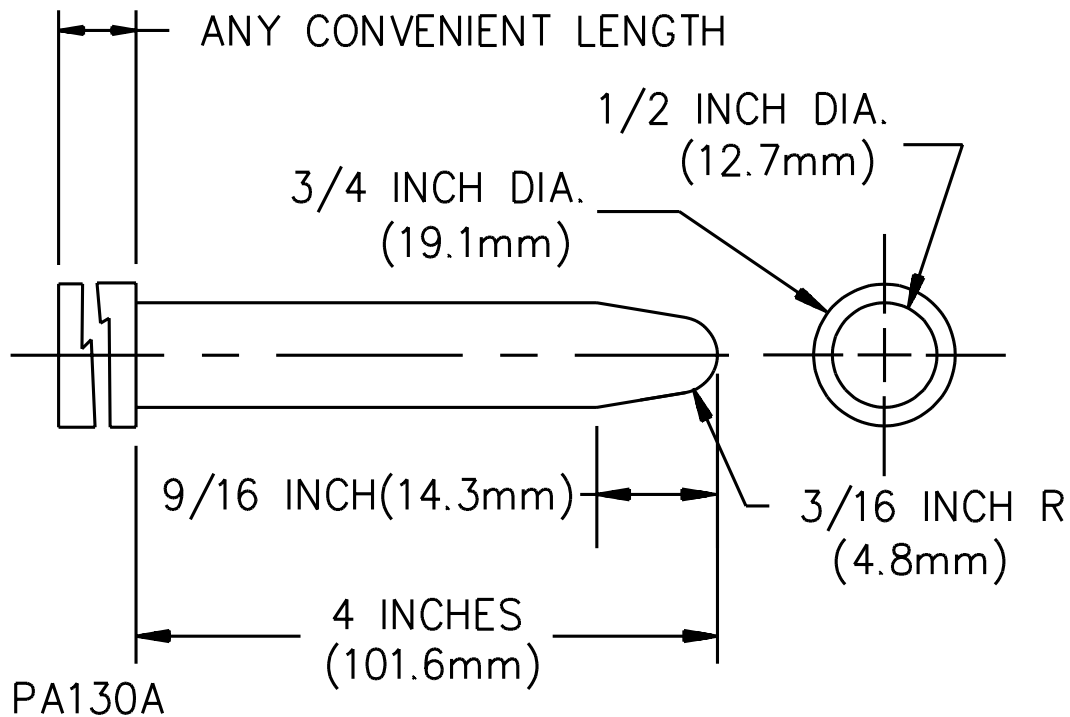
^a See 9.5.

^b Between 3/4 in and 2-1/8 in, interpolation is to be used to determine a value between values specified in the table.

^c Any dimension less than 1 in applied to a motor only.

^d More than 2-1/8 in, but not more than 6 in (152 mm).

Figure 9.2
Probe for uninsulated live parts



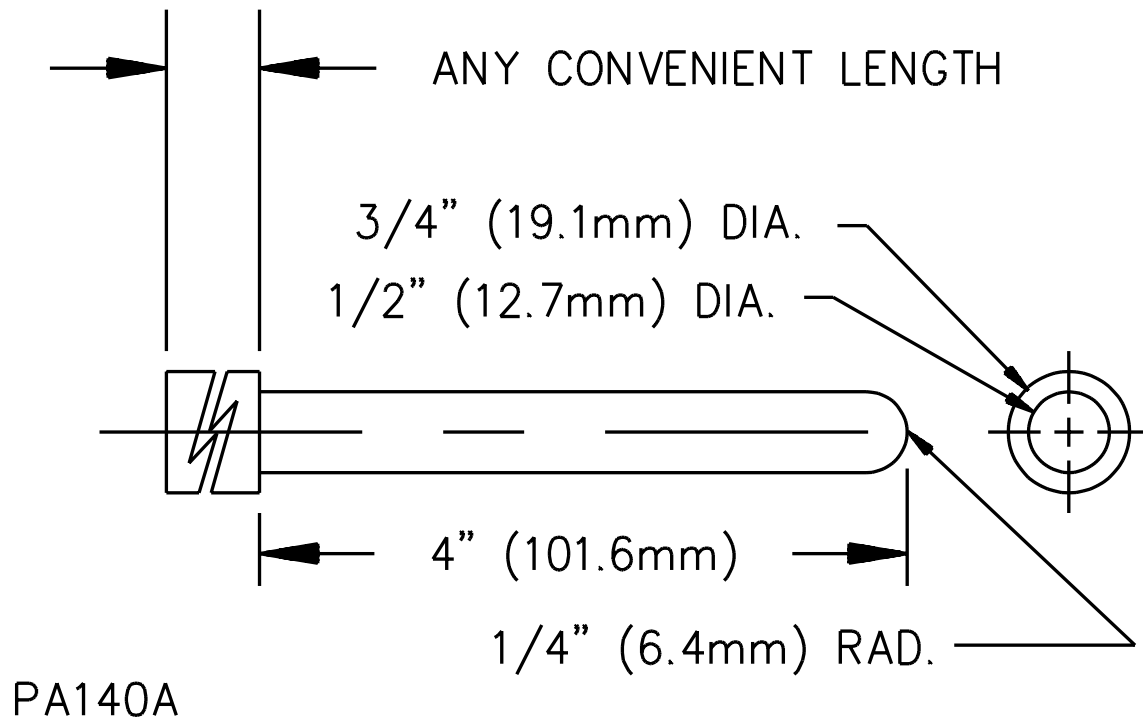
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Figure 9.3
Probe for film-coated wire

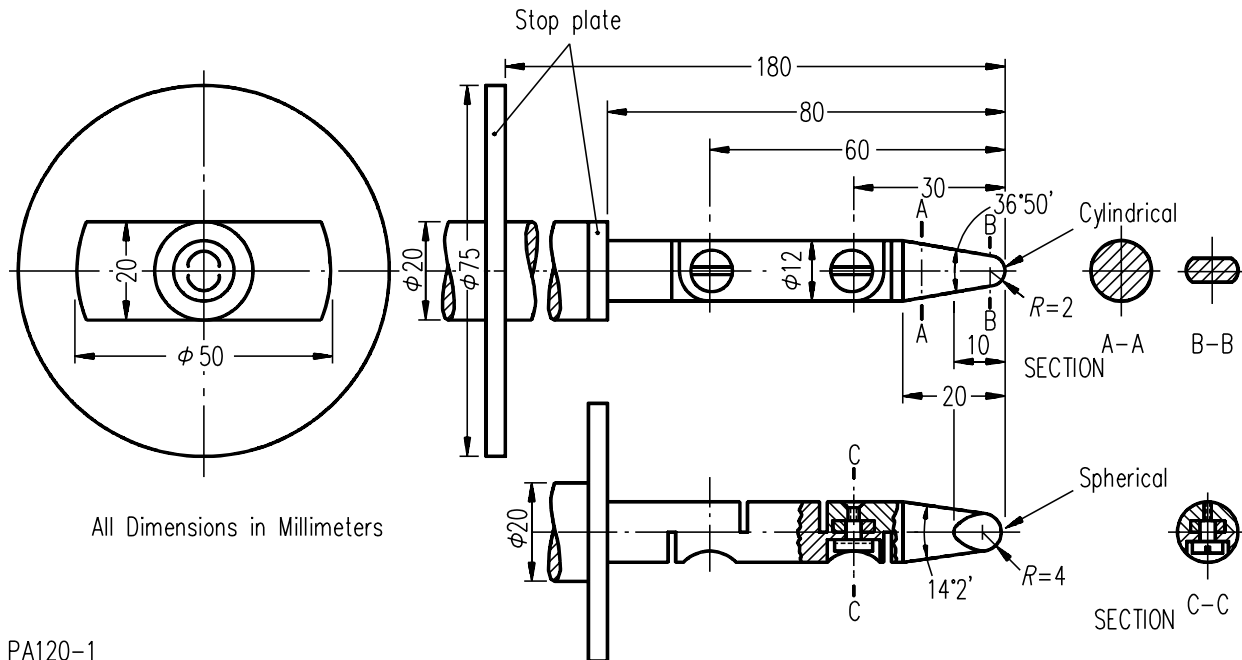


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Figure 9.4
International electrotechnical commission (IEC) articulate accessibility probe with stop plate
 Courtesy of IEC



10 Mechanical Assembly

10.1 Equipment shall be assembled so that it will not be adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise designed to prevent loosening.

10.2 A switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be mounted securely and, shall be prevented from shifting or turning.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

- a) The switch is of 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 normal operation of the switch.*
- b) Means for mounting the switch make it unlikely that operation of the switch will loosen it.*
- c) Spacings are not reduced below the minimum acceptable values if the switch rotates.*
- d) Normal operation of the switch is by mechanical means rather than direct contact by persons.*

Exception No. 2: 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 acceptable values.

10.3 Means for preventing the turning mentioned in 10.2, is to consist of more than friction between surfaces – for example, a properly applied lock washer, may be used to prevent the turning of a small stem-mounted switch or other device having a single-hole mounting means.

11 Protection Against Corrosion

11.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, if corrosion of such parts could result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: Surfaces of sheet steel and cast iron parts within an enclosure are not required to have protection against corrosion if the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors.

Exception No. 2: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

Exception No. 3: This requirement does not apply to the sheath of a heating element that is not an immersion-type element.

11.2 An enclosure of the equipment intended for outdoor installation shall be protected against corrosion as indicated in Table 11.1, and 11.7 – 11.12, or by other coating that has been shown by investigation to provide at least equivalent protection. See 7.1 and 7.2, for the required enclosure thickness.

Table 11.1
Protection against corrosion

Type of enclosure	0.053 in (1.4 mm) or thicker sheet steel, protection as specified in	Sheet steel thinner than 0.053 in (1.4 mm), protection as specified in
A. Outer enclosure protecting motors, wiring, or enclosed live parts	11.9	11.8
B. Outer enclosure that is the sole enclosure of live parts	11.8	11.8
C. Outer enclosure that does not enclose electrical parts	11.9	11.9
D. Interior enclosure protecting live parts other than motors and which is not provided with outer enclosure complying with item B	11.9	11.8

11.3 Metal shall not be used in combinations that are not galvanically compatible.

11.4 The requirements in 11.5 – 11.12, do not apply to a metal part, such as a decorative grille, that is not required to form a part of the enclosure.

11.5 Aluminum, brass, copper, or stainless steel may be used without additional protection against corrosion.

11.6 Unless otherwise specified in this end product Standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment, UL 746C. A nonmetallic enclosure intended for outdoor use is to be judged on the basis of the effect of exposure to ultraviolet light and water.

11.6.1 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

11.7 An enclosure of cast iron at least 1/8-in (3.2-mm) thick is considered to be protected by one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if such tests are considered necessary.

11.8 To comply with Table 11.1, referenced to this requirement, one of the following coatings shall be used:

- a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in Table I of ASTM Designation A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the test method of ASTM Designation A90/A90M-93.
- b) A zinc coating other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 in (0.015 mm) on each surface with a minimum thickness of 0.00054 in (0.014 mm). The thickness of the coating shall be established by the Metallic-Coating-Thickness Test, Section 44. An annealed coating shall also comply with 11.12.
- c) A zinc coating conforming with 11.9 (a) or (b), with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if such tests are considered necessary.
- d) A cadmium coating not less than 0.001-in (0.025-mm) thick on both surfaces. The thickness of coating shall be established by the Metallic-Coating-Thickness Test, Section 44.
- e) A cadmium coating not less than 0.00075-in (0.019-mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005-in (0.013-mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic-Coating-Thickness Test, Section 44, and the paint shall be as specified in (c).

11.9 To comply with Table 11.1, referenced to this requirement, one of the following coatings shall be used:

- a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in Table I of the Standard Specification for Sheet Steel, Zinc Coated (Galvanized) by Hot-Dip Process, General Requirements, ASTM Designation A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM Designation A90/A90M-93. An A60 (alloyed) coating shall also comply with 11.12;
- b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 in (0.010 mm) on each surface with a minimum thickness of 0.00034 in (0.008 mm). The thickness of the coating shall be established by the Metallic-Coating-Thickness Test, Section 44. An annealed coating shall also comply with 11.12;
- c) Two coats of an organic finish of the epoxy or alkyd resin type or other outdoor paint applied after forming on each surface. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests if such tests are considered necessary; or
- d) Any one of the means specified in 11.8.

11.10 With reference to 11.8 and 11.9, other finishes, including paints, metallic finishes, and combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping or other surface treatment – conforming with 11.8(a) or 11.9(a), as applicable, indicate they provide equivalent protection. Among the factors that are taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light and water.

11.11 If tests are required, the test specimens of a finish as described in 11.7, 11.10, 11.8(c) or 11.9(c), are to be consistent with the finish that is to be used in production with respect to the base metal, cleaning or pretreatment method, application method, number of coats, curing method, thickness, and the like.

11.12 A hot-dipped mill-galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing that is not otherwise required to be painted shall be painted in the bent or formed area if the shaping process damages the zinc coating, except that such an area on the inside surface of an enclosure that water does not enter during the rain test need not be painted. The zinc coating is considered to be damaged if flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification. Simple sheared or cut edges and punched holes are not considered to be formed.

12 Power-Supply Connections

12.1 General

12.1.1 The equipment shall have provision for permanent connection of a wiring system.

12.2 Supply Connections

12.2.1 Terminal compartments

12.2.1.1 A terminal compartment intended for connection of a supply raceway shall be attached to the equipment so as to be prevented from turning with respect thereto.

12.2.1.2 An outlet or terminal box in which connections to the power-supply circuit will be made shall be located so that, after the equipment has been installed as intended, such connections will be accessible for inspection.

12.2.1.3 The compartment mentioned in 12.2.1.2, shall be located so that during conduit connections thereto, internal wiring and electrical components will not be exposed to mechanical abuse or stress.

12.2.1.4 A conduit opening for connection of conduit to a terminal compartment shall accommodate conduit of the trade size determined in accordance with Table 12.1. Conduit openings of a nonmetallic enclosure shall comply with 8.2. The knockout dimensions shall comply with Table 12.2.

Table 12.1
Trade size of conduit

Wire size, AWG	Number of wires	Conduit trade size, in
14	2, 3, 4, 5, or 6	1/2
12	2, 3, or 4	1/2
12	5 or 6	3/4
10	2 or 3	1/2
10	4, 5, or 6	3/4
8	2, 3, or 4	3/4
8	5 or 6	1
6	2 or 3	3/4
6	4	1
6	5 or 6	1-1/4

NOTE – This table is based on the assumption that all conductors are of the same size and there are no more than six conductors in the conduit. Where more than six conductors are involved or where the conductors are not all the same size, the internal cross-sectional area of the smallest conduit for which a conduit opening is to be supplied shall be determined by multiplying the total cross-sectional area of the wires by 2.5. The cross-sectional area of the individual wires is to be based on Type THW wire.

Table 12.2
Knockout dimensions

Conduit trade size	Knockout diameter mm (inches)					
	Minimum		Nominal		Maximum	
	mm	(in)	mm	(in)	mm	(in)
1/2	21.82	(0.859)	22.23	(0.875)	23.01	(0.906)
3/4	27.79	(1.094)	28.17	(1.109)	28.98	(1.141)
1	34.52	(1.359)	34.93	(1.375)	35.71	(1.406)
1-1/4	43.66	(1.719)	44.04	(1.734)	44.86	(1.766)
1-1/2	49.73	(1.958)	50.39	(1.984)	51.21	(2.016)
2	61.80	(2.433)	62.71	(2.469)	63.50	(2.500)
2-1/2	74.12	(2.918)	75.41	(2.969)	76.20	(3.000)
3	90.50	(3.563)	91.29	(3.594)	93	(3.661)
3-1/2	103.20	(4.063)	104.78	(4.125)	106	(4.173)
4	115.90	(4.563)	117.88	(4.641)	119	(4.685)
5	142.88	(5.625)	145.26	(5.719)	147	(5.787)
6	170.18	(6.700)	173.05	(6.813)	175	(6.890)

12.2.1.5 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 in (0.81 mm) if uncoated steel, not less than 0.034 in (0.86 mm) if galvanized steel and not less than 0.045 in (1.14 mm) if nonferrous.

12.2.2 Wiring terminals and leads

12.2.2.1 Wiring terminals or leads employed shall be acceptable for the connection of conductors having an ampacity not less than the sum of 125 percent of the motor load and 100 percent of the other loads as marked on the equipment.

12.2.2.2 If equipment is constructed so that it may be adapted upon installation for either of two different supply voltages, it shall be provided with means by which the appropriate connections may be made during field installation, without the necessity of changing or disrupting internal wiring or connections other than at the point of field connection. See 54.1.11.

12.2.2.3 A wiring terminal shall be provided with a pressure terminal connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a wiring terminal intended for connection of a 10 AWG or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.