



UL 325

STANDARD FOR SAFETY

Door, Drapery, Gate, Louver, and Window
Operators and Systems

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UL Standard for Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems, UL 325
Sixth Edition, Dated October 14, 2013

Summary of Topics

The new edition dated October 14, 2013, were issued to incorporate the following new and revised requirements:

- **Revision to Remove Reference to the Terms "Primary" and "Secondary" when Describing Entrapment Protection Devices**
- **Addition of Requirements for Detachable Supply Cords**
- **Addition of Requirements for Light Sources Other than Incandescent Bulbs**
- **Clarification of Permanently Mounted Wireless Devices**
- **Reversal Requirements of B1 Protected Gate Operators**
- **Residential Garage Door Operator Test Set-Up For Reversal Tests**
- **Relocate External Entrapment Protection Requirement of Paragraph 34.1.6**
- **Gate Operators with Wireless External Entrapment Protection**
- **Revision of Pendulum Tolerance**
- **Addition of an Exception to Paragraphs 37.3.1 and 37.3.2 Regarding Elastomer Testing**
- **Correction of the Force Test Apparatus in Figure 47.2**
- **Revised Tolerances for the Puncture Probe**
- **Addition of Requirements for Electronic Instructions**
- **Residential Garage Door Operator and System Instructions Titles**
- **Clarification of the User Manual**
- **Clarification of the Instructional and Marking Requirements for Installations Less Than 8 Feet Above the Floor**
- **Revision of 58.8.4 to Align with ASTM F2200**

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 16, 2012.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
December 23, 2014	3.3, 3.15, 32.1.2, 32.1.3, 32.2.2.1, 32.2.2.3, 32.2.2.7, 32.2.2.8, 32.3.1, 32.3.6, 58.3.6, 58.3.7, 59.11 – 59.13; and Section 47
January 12, 2016	3.4, 3.11, 3.19, 25.11, 31.1.1, 31.1.2, 31.1.6, 31.1.7, 31.1.15, 31.2.1.1, 31.2.1.2, 58.1.6, 58.6.7, 61.5.1, and Table 31.1

OCTOBER 14, 2013

1



ANSI/UL 325-2013

UL 325

**Standard for Door, Drapery, Gate, Louver, and Window Operators and
Systems**

First Edition – April, 1973
Second Edition – April, 1979
Third Edition – April, 1986
Fourth Edition – May, 1995
Fifth Edition – June, 2002

Sixth Edition

October 14, 2013

This ANSI/UL Standard for Safety consists of the Sixth Edition.

The most recent designation of ANSI/UL 325 as an American National Standard (ANSI) occurred on October 14, 2013. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

The Department of Defense (DoD) has adopted UL 325 on January 21, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover electric operators for doors, draperies, gates, louvers, windows, exterior awnings and other opening and closing appliances rated 600 V or less to be employed in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover complete doors, gates, and other such assemblies that include electric opening and closing appliances.

1.3 These requirements also cover accessories, such as external entrapment protection devices, for use with appliances covered by this standard.

1.4 Doors and door operators intended for exit use as defined in the Life Safety Code, NFPA 101 and codes such as the BOCA National Building Code, the Standard Building Code, and the Uniform Building Code, are additionally subject to design requirements specific to such use.

1.5 These requirements do not address active fire alarm functionality, which is addressed in NFPA 80.

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 "appliance" or "operator" is used, it is understood that the requirement applies to all types of equipment within the scope of this Standard.

3 Glossary

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

- a) An inherently-limited Class 2 transformer;
- 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;
- 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.

3.2 COMBINATION RIGID ONE-PIECE OVERHEAD GARAGE DOOR OPERATOR SYSTEM – A door and operator combination where the door is constructed in one rigid piece.

3.3 COMBINATION SECTIONAL OVERHEAD GARAGE DOOR OPERATOR SYSTEM – A door and operator combination where the door and hardware are an integral part of an operator, the operator does not exert a driving force on the door in the closing direction, and may provide for inherent secondary entrapment protection for compliance with the requirements of this Standard.

3.3 effective December 23, 2014

3.4 COMMERCIAL/GENERAL ACCESS VEHICULAR GATE OPERATOR – CLASS II – A vehicular gate operator (or system) intended for use in a commercial location or building such as a multi-family housing unit (five or more single family units), hotel, garages, retail store, or other buildings accessible by or servicing the general public.

3.4 effective January 12, 2016

3.5 DOOR – A moving barrier such as a swinging, sliding, raising, lowering, rolling, or the like, barrier, that closes an opening for entrance and/or egress by persons or vehicles into or out of a building.

3.6 DRAPERY (or BLINDS, SHADES AND THE LIKE) OPERATOR (OR SYSTEM) – An operator (or system) for opening or closing of window drapery, blinds, shade, or other window coverings, other than louver or shutter operators and systems.

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

3.8 EXTERIOR AWNING – A plastic, canvas, or metal porch or shade supported by a frame and often retractable, placed over a storefront, doorway, window, or the side of a recreational vehicle.

3.9 EXTERNAL ENTRAPMENT PROTECTION DEVICE – A device, examples being an edge sensor, a photoelectric sensor, or similar entrapment protection device, which provides protection against entrapment when activated and is not incorporated as a permanent part of an operator.

3.10 GATE – A moving barrier such as a swinging, sliding, raising, lowering, rolling, or the like, barrier, that is a stand-alone passage barrier or is that portion of a wall or fence system that controls entrance and/or egress by persons or vehicles and completes the perimeter of a defined area.

3.11 INDUSTRIAL/LIMITED ACCESS VEHICULAR GATE OPERATOR – CLASS III – A vehicular gate operator (or system) intended for use in an industrial location or building such as a factory or loading dock area or other locations not accessible by or intended to service the general public.

3.11 effective January 12, 2016

3.12 INHERENT ENTRAPMENT PROTECTION SYSTEM – A system, examples being a motor current or speed sensing system, which provides protection against entrapment upon sensing an object and is incorporated as a permanent and integral part of an operator.

3.13 LIGHT DUTY (COMMERCIAL/INDUSTRIAL) VEHICULAR GATE OPERATOR (OR SYSTEM) – A commercial or industrial Class II, III, or IV vehicular gate operator (or system) intended and marked for limited or restricted duty.

3.14 LIGHT DUTY (COMMERCIAL/INDUSTRIAL) DOOR OPERATOR (OR SYSTEM) – A commercial/ industrial door operator (or system) intended and marked for limited or restricted duty. Doors used to secure store fronts and intended for pedestrian use, but usually operated only at the start and end of the business day are included. Doors used solely for pedestrian access and egress which open and close for each pedestrian or group of pedestrians are not covered by this definition.

3.15 LINE OF SIGHT – See National Electric Code, NFPA-70, Article 100, In Sight From (Within Sight From, Within Sight).

3.15 effective December 23, 2014

3.16 LOUVER OPERATOR (OR SYSTEM) – An operator (or system) intended to open and close louvers or shutters used for ventilation or as window coverings.

3.17 PEDESTRIAN DOOR OR GATE OPERATOR (OR SYSTEM) – A swinging, sliding, biparting, folding, or rotating door or gate operator (or system) that is used at pedestrian entrances or exits to buildings or other pedestrian traffic ways. They are not used for vehicular traffic.

3.18 RESIDENTIAL GARAGE-DOOR OPERATOR – A vehicular door operator serving a residential building of one to four single family units.

3.19 RESIDENTIAL VEHICULAR GATE OPERATOR – CLASS I – A vehicular gate operator (or system) intended for use in garages or parking areas associated with a residence of one-to four single families .

3.19 effective January 12, 2016

3.20 RESTRICTED ACCESS VEHICULAR GATE OPERATOR – CLASS IV – A vehicular gate operator (or system) intended for use in a guarded industrial location or building such as an airport security area or other restricted access locations not servicing the general public, in which unauthorized access is prevented via supervision by security personnel.

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

3.22 TWO SEQUENTIAL ACTIVATIONS – Two activations of an entrapment protection device that are not interrupted by an open or close limit device.

3.23 UNATTENDED OPERATION, RESIDENTIAL GARAGE DOOR OPERATOR – Operation without the user within the line-of-sight of the door.

3.24 VEHICULAR BARRIER (ARM) OPERATOR (OR SYSTEM) – An operator (or system) that controls a cantilever type device (or system), consisting of a mechanical arm or barrier that moves in a vertical arc, intended for vehicular traffic flow at entrances or exits to areas such as parking garages, lots or toll areas.

3.25 COMMERCIAL/INDUSTRIAL DOOR OPERATOR (OR SYSTEM) – A door operator (or system) intended for vehicular traffic and/or securing entrances or exits to commercial or industrial buildings areas. Some examples include multi-family housing units (three or more single-family units), hotels, garages, retail stores, or loading docks including, but not limited to, sliding, swing, bifold, accordion, sectional, and rolling door systems. Doors used to secure store fronts and intended for pedestrian use, but usually operated only at the start and end of the business day are included. Doors used solely for pedestrian access and egress which open and close for each pedestrian or group of pedestrians are not covered by this definition.

3.26 VEHICULAR HORIZONTAL SLIDE-GATE OPERATOR (OR SYSTEM) – A vehicular gate operator (or system) that controls a gate which slides in a horizontal direction that is intended for use for vehicular entrance or exit to a drive, parking lot, or the like.

3.27 **VEHICULAR SWING-GATE OPERATOR (OR SYSTEM)** – A vehicular gate operator (or system) that controls a gate which swings in an arc in a horizontal plane that is intended for use for vehicular entrance or exit to a drive, parking lot, or the like.

3.28 **VEHICULAR VERTICAL LIFT-GATE OPERATOR (OR SYSTEM)** – A vehicular gate operator (or system) that controls a gate which moves in the vertical direction and is intended for use at a vehicular entrance or exit to a drive, parking lot, or similar location.

3.29 **VEHICULAR VERTICAL PIVOT-GATE OPERATOR (OR SYSTEM)** – A vehicular gate operator (or system) that controls a gate that moves in an arc in a vertical plane that is intended for use for vehicular entrances or exits to a drive, parking lot, or the like.

3.30 **WINDOW OPERATOR (OR SYSTEM)** – An operator (or system) for opening casement, sliding, or other types of windows including skylights.

3.31 **WIRED CONTROL** – A control implemented in a form of fixed physical interconnections between the control, the associated devices, and an operator to perform predetermined functions in response to input signals.

3.32 **WIRELESS DEVICE** – A control implemented in means other than fixed physical interconnections (such as radio waves (RF) or infrared (IR) beams) between the control, the associated devices, and an operator to perform predetermined functions in response to input signals.

3.33 **WIRELESS CONTROL, PORTABLE** – A wireless control, as described in 3.32, that is portable in nature with an intended function only for manual activating the moving member by transmitting input to the operator.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 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.

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

4.4 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.

5 Units of Measurement

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

6 References

6.1 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

7 General

7.1 An appliance 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.

7.2 An appliance 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.

8 Frame and Enclosure

8.1 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.

8.2 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 appliance. 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.

8.3 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.

8.4 The effects of the following factors shall be determined for compliance of a nonmetallic enclosure or an enclosure of magnesium with 7.2:

- a) Mechanical strength,
- b) Resistance to impact,
- c) Moisture-absorption properties,
- d) Combustibility, and

- e) Resistance to distortion at temperatures to which the material is subjected under conditions of normal or abnormal use.

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

8.6 The requirement in 8.5 will necessitate the use of a barrier of noncombustible material:

- a) Under a motor unless:

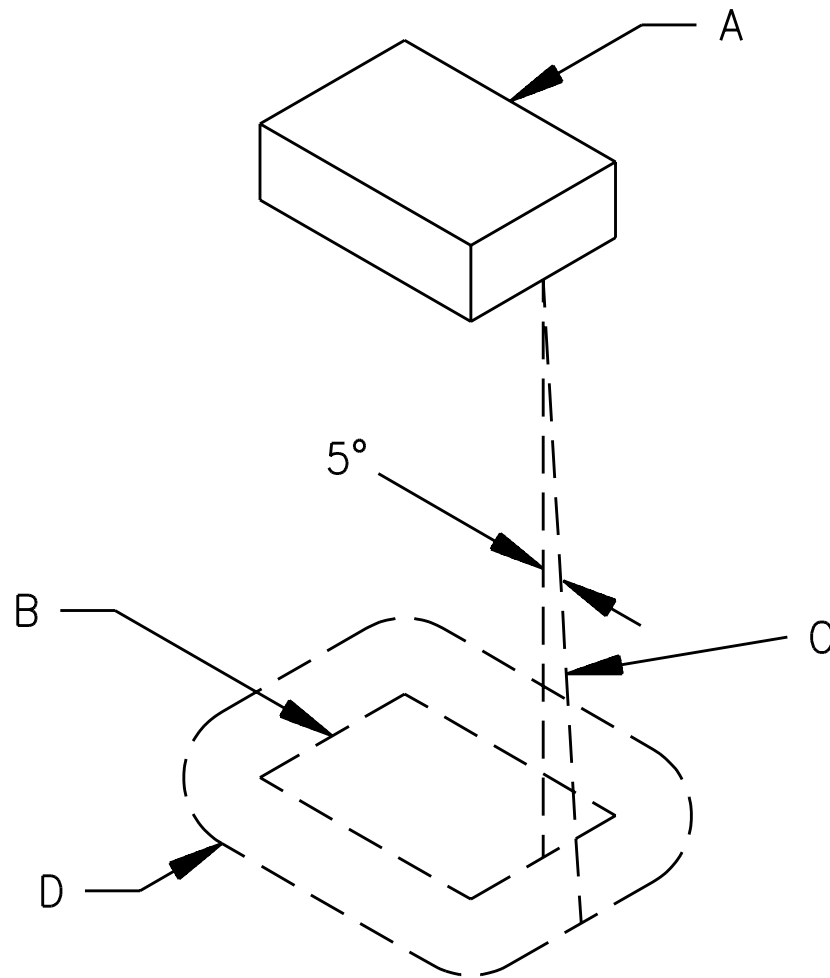
- 1) The structural parts of the motor or of the appliance provide the equivalent of such a barrier;
- 2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following 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 h of operation with the rotor of the motor locked.

- b) Under wiring, unless it is neoprene, cross-linked or thermoplastic-insulated.

8.7 The requirements in 8.5 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 appliance enclosure.

8.8 The barrier mentioned in 8.6 shall be horizontal, shall be located as illustrated in Figure 8.1, 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 8.1
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:

- a) tangent to the component,
- b) 5 degrees from the vertical, and
- c) 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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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.

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).			

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.

Figure 9.2
Probe for uninsulated live parts

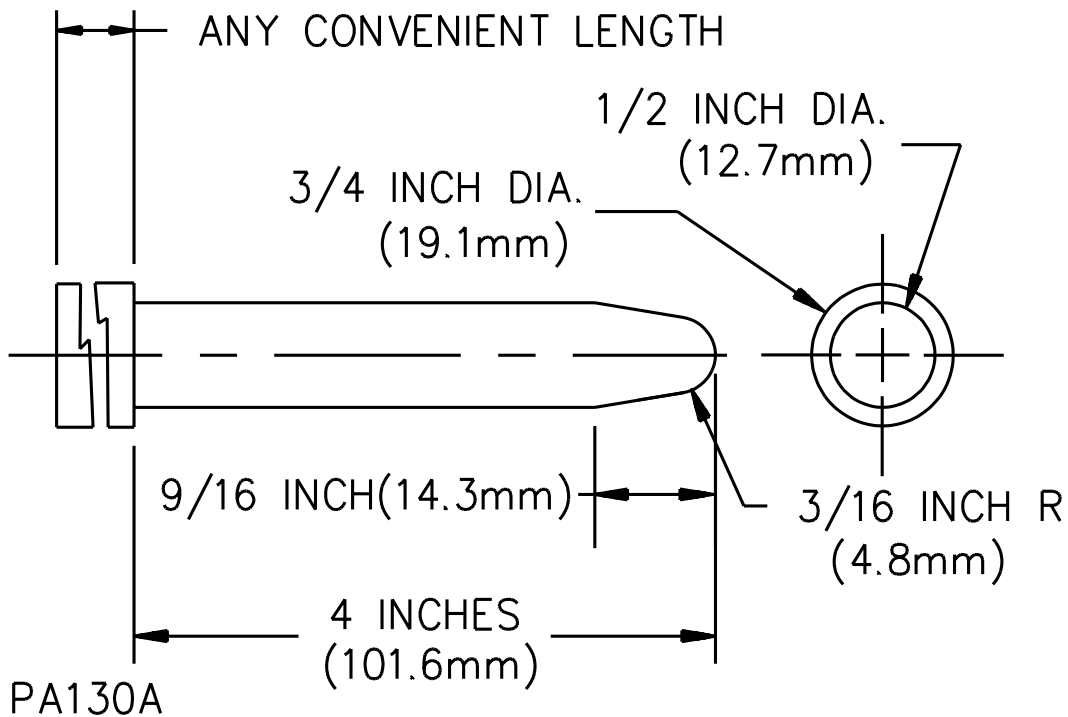
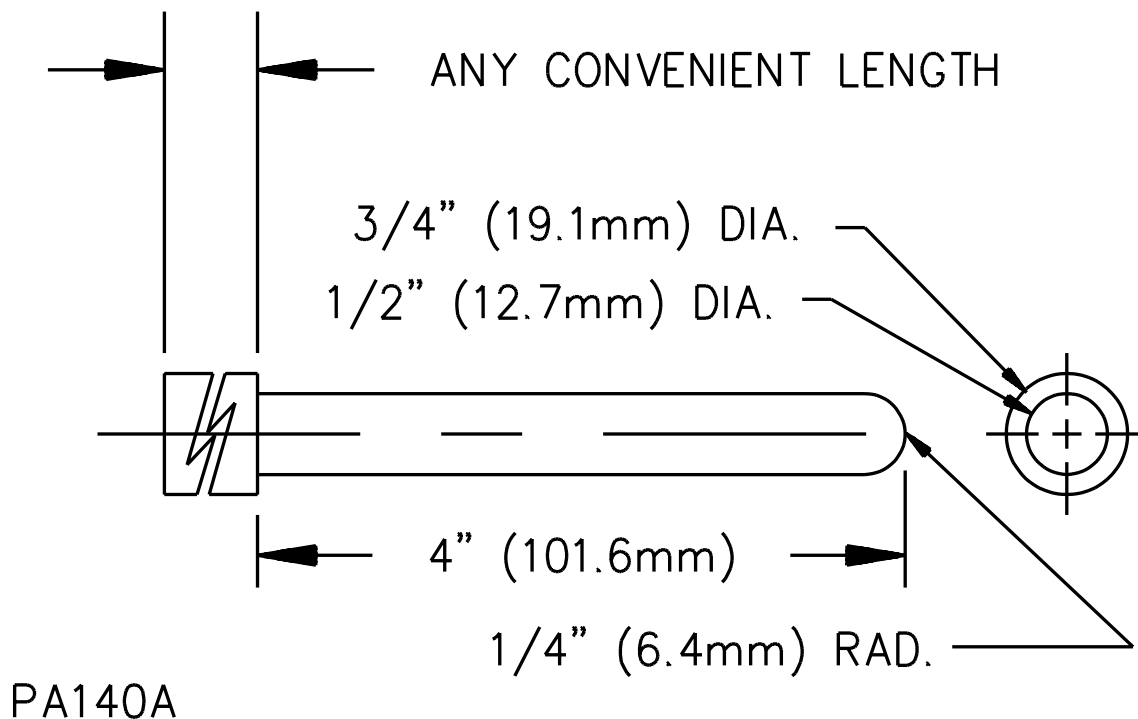


Figure 9.3
Probe for film-coated wire

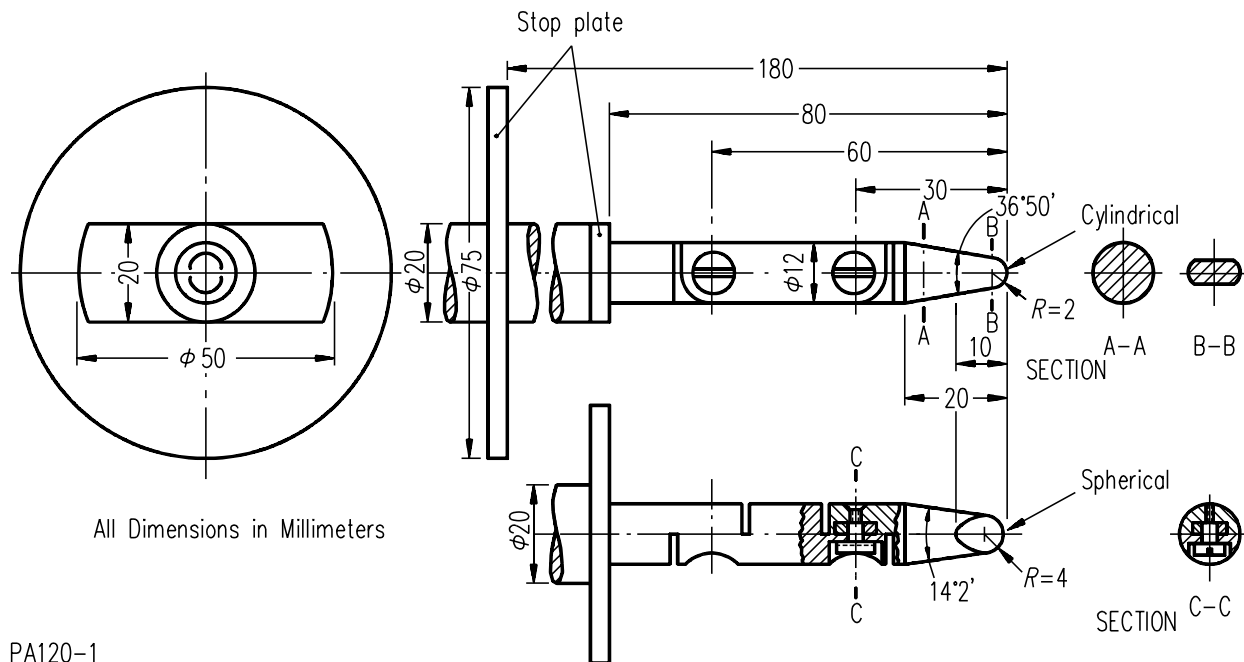


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Figure 9.4
International electrotechnical commission (IEC) articulate accessibility probe with stop plate
 Courtesy of IEC



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), or will be located higher than 8 ft (2.44 m) above the floor when the operator is installed as intended and is marked in accordance with 61.5.1. 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 appliance 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.

10 Mechanical Assembly

10.1 An appliance 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 an appliance 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 8.1 and 8.2 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 A nonmetallic enclosure is to be judged on the basis of the effect of exposure to ultraviolet light and water.

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, 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.
- 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 48. 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 48.
- 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 48, 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, 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. 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 48. 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.

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 or 11.10 or 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 An appliance shall have provision for permanent connection of a wiring system.

Exception: A residential garage door operator is not required to provide for permanent wiring when provided with instructions according to 58.4.3 and markings according to 61.3.4.

12.1.2 A drapery operator or a residential garage door operator as described in 12.4.1 may also be provided with a power-supply cord.

12.1.3 A residential or commercial pedestrian door operator as described in 12.5.1 may also be provided with a power-supply cord.

12.1.4 An exterior shutter operator and an exterior awning operator as described in 12.7.1 may also be provided with a power-supply cord.

12.1.5 Where supply cords are permitted by 12.1.2, 12.1.3 and 12.1.4, a detachable supply cord may be provided when:

- a) Complies with 12.3, 12.4, or 12.5 as applicable;
- b) The appliance inlet complies with the Standard for Attachment Plugs and Receptacles, UL 498;
- c) Installation instructions comply with 58.1.11; and

d) Markings required by this standard are not provided only on a cord tag.

12.1.6 Where an operator is provided with multiple sources of supply, such as a standby battery, the terminals of the appliance inlet, with the detachable supply cord removed shall not exceed 42.4 V_{peak}, 30 V_{rms}, or 60 V_{dc} with all other sources of supply connected.

12.2 Cord-connected operators

12.2.1 Strain relief

12.2.1.1 Strain relief shall be provided to prevent a mechanical stress on a flexible cord from being transmitted to terminals, splices, or internal wiring.

12.2.1.2 Means shall be provided to prevent the flexible cord from being pushed into the appliance through the cord-entry hole if such displacement may subject the cord to mechanical damage or exposure to a temperature higher than that for which the cord is rated, or may reduce spacings, such as to a metal strain-relief clamp, below the minimum acceptable values.

12.2.1.3 If a knot in a flexible cord serves as strain relief, a surface that the knot may contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the insulation on the conductors.

12.2.2 Bushings

12.2.2.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear. If Type SPT-2 or other cord lighter than Type SV is employed, the wall or barrier is of metal, and the construction is such that the cord may be subjected to strain or motion, an insulating bushing shall be provided. Ceramic materials and some molded compositions are generally acceptable for insulating bushing, but separate bushings of wood or of hot molded shellac-and-tar compositions are not acceptable.

12.3 Drapery operators

12.3.1 A cord-connected drapery operator shall be provided with a length of flexible cord and an attachment plug for connection to the supply circuit.

12.3.2 The flexible cord shall be of a type acceptable for the application. It shall be rated for use at a voltage not less than the rated voltage of the appliance, and shall have an ampacity not less than the current rating of the appliance.

12.3.3 The flexible supply cord shall be Type SPT-2 or heavier duty cord.

12.3.4 The length of the flexible cord shall not be less than 6 ft (1.83 m) nor more than 10 ft (3.05 m).

12.3.5 The attachment plug shall be rated for use at a current not less than the rated current and at a voltage equal to the rated voltage of the appliance.

12.3.6 The attachment plug shall be of the polarized type if the product is not provided with a grounding type attachment plug – see 24.1.

12.4 Residential garage door operators

12.4.1 With reference to 12.1.2, a residential garage door operator supplied with a flexible cord for connection to a supply circuit shall:

- a) Not be rated greater than 120 V;
- b) Not have a maximum appliance current draw greater than 15 A under a locked-rotor condition including the current draw of lamps and external devices; and
- c) Comply with the requirements in 12.4.2 – 12.4.6.

Exception: Compliance with 12.4.3 – 12.4.6 is not required when that portion of the product intended to be connected to the source of supply is not intended to be permanently attached to the building structure. Mounting to the building by keyhole slots is not permanently attached.

12.4.2 A flexible cord shall be Type SJT or heavier duty cord, not longer than 6 ft (1.83 m). The cord shall incorporate a grounding conductor and be terminated with a grounding type attachment plug.

12.4.3 The wiring compartment shall be so constructed and the cord so attached that permanent connection can be made to the power supply.

12.4.4 The cord shall enter the wiring compartment through a 7/8-in (22.2-mm) diameter hole that, after the cord and any bushing or fitting provided have been removed, provides an opening acceptable for attachment of a wiring system.

12.4.5 The power-supply cord shall be connected to the internal wiring by a device – terminal block, pressure cable connector, or the like – that will readily accommodate permanent wiring having a rated ampacity acceptable for the appliance.

12.4.6 The internal wiring terminals and leads for connection to the power supply shall be identified in accordance with 12.6.2.12, 12.6.2.13, 12.6.2.16, and 12.6.2.17.

12.5 Residential and commercial pedestrian door operators

12.5.1 A residential or commercial pedestrian door operator intended for indoor wall mounting only may be provided with flexible cord for connection to a supply circuit provided that the door operator:

- a) Complies with the requirements in 12.5.2 – 12.5.5, and
- b) Is provided with instructions in accordance with 58.2.4 and 58.2.5.

12.5.2 The flexible cord shall be Type AFS, S, SJ, SJO, SJT, SJTO, SO, ST, or STO, not longer than 18 in (0.46 m), and shall employ a grounding conductor and a grounding attachment plug.

12.5.3 The construction of the wiring compartment shall comply with the requirements in 12.4.3 and 12.4.4.

12.5.4 The internal power-supply cord connections shall comply with the requirements in 12.4.5.

12.5.5 The internal wiring terminals and leads shall comply with the requirements in 12.4.6.

12.6 Permanently connected appliances

12.6.1 Terminal compartments

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

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

12.6.1.3 The compartment mentioned in 12.6.1.2 shall be located so that during conduit connections thereto, internal wiring and electrical components will not be exposed to mechanical abuse or stress.

12.6.1.4 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.

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.

12.6.1.5 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.

12.6.2 Wiring terminals and leads

12.6.2.1 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 appliance.

12.6.2.2 If an appliance, other than a commercial or industrial appliance, 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 61.1.11.

12.6.2.3 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.

12.6.2.4 A wiring terminal shall be prevented from turning.

12.6.2.5 A wire-binding screw shall thread into metal.

12.6.2.6 A wire-binding screw at a wiring terminal shall not be smaller than No. 10.

Exception No. 1: A No. 8 screw may be used at a terminal intended only for the connection of a 14 AWG conductor.

Exception No. 2: A No. 6 screw may be used for the connection of a 16 or 18 AWG conductor.

12.6.2.7 A 14 AWG is the smallest conductor that may be used for branch-circuit wiring, and thus is the smallest conductor that is anticipated at a terminal for connection of a power-supply wire.

12.6.2.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050-in (1.27-mm) thick. There shall be no fewer than two full threads in the metal.

Exception: A plate not less than 0.030-in (0.076-mm) thick is acceptable if the tapped threads have equivalent mechanical strength.

12.6.2.9 A terminal plate may have the metal extruded at the tapped hole to provide the thickness necessary for two full threads or more, if the thickness of the unextruded metal is not less than the pitch of the thread.

12.6.2.10 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 12.6.2.1 and 12.6.2.6 under the head of the screw or the washer.

12.6.2.11 An appliance intended for connection to a grounded supply circuit and employing a lampholder of the Edison-screw-shell type, or either a single-pole switch or an overcurrent protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be the one connected to screw shells of lampholders and to which are connected no single-pole switches or single-pole controls other than automatic controls without a marked off position.

12.6.2.12 A terminal for connection of a grounded power-supply conductor shall be of or plated with metal substantially white in color and shall be readily distinguishable from the other terminals; or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on a wiring diagram adjacent to the terminals.

12.6.2.13 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector shall be marked in accordance with 61.2.5. The wire-binding screw or pressure wire connector shall be located so that it does not require removal during the normal servicing of the appliance.

12.6.2.14 A terminal used solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the application.

12.6.2.15 An appliance shall be provided with an equipment-grounding terminal or lead.

12.6.2.16 The surface of a lead intended for connection to a grounded power-supply conductor shall be white or grey, and shall be readily distinguishable from the other leads.

12.6.2.17 The surface of an insulated lead intended solely for connection to an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

12.6.2.18 The requirements in 12.6.2.16 and 12.6.2.17 relating to color coding for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

12.6.2.19 The free length of a lead inside an outlet box or wiring compartment shall be 6 in (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: A lead may be less than 6-in long if it is evident that the use of a longer lead might result in a risk of fire or electric shock.

12.6.2.20 A lead intended to be spliced in the field to a power-supply conductor shall not be smaller than 18 AWG and the insulation, if rubber or thermoplastic, shall not be less than 1/32-in (0.8-mm) thick.

12.6.2.21 A terminal or lead connected to a Class 2 power source and intended for connection of a Class 2 circuit to an external device shall be marked in accordance with 61.2.7.

12.7 Exterior shutter and exterior awning operators

12.7.1 With reference to 12.1.4, an exterior shutter and exterior awning operator having a flexible cord and an attachment plug for connection to a supply circuit shall:

- a) Not be rated greater than 120 V;
- b) Not have a maximum appliance current draw greater than 15 A under a locked-rotor condition, and
- c) Comply with the requirements in 12.7.2 – 12.7.6.

12.7.2 The power-supply cord may be 3 conductors (hot, neutral, and ground) or 4 conductors (direction 1, direction 2, neutral, and ground).

12.7.3 The flexible cord shall be Type SJTW or heavier duty cord not longer than 6.6 ft (2 m) for an exterior shutter operator and not longer than 26 ft (8 m) for an exterior awning motor. The cord shall incorporate a grounding conductor and be terminated with a grounding type attachment plug when a plug is provided.

12.7.4 The attachment plug, if provided, shall be rated for use at a current not less than the rated current of the operator and at a voltage equal to the rated voltage of the operator.

12.7.5 The power-supply cord may be permanently connected to the internal wiring of the operator with no removal possible. If permanent wiring to the wiring system is needed, the attachment plug, if provided, can be removed to expose the individual insulated conductors.

12.7.6 The power-supply cable may be removable from the head of operator by means of a device – molded connector or the like. If permanent wiring to the wiring system is needed, the attachment plug, if provided, can be removed to expose the individual insulated conductors.

13 Live Parts

13.1 Other than as noted in 13.2 and 14.4.2, a current-carrying part shall be of silver, copper, a copper alloy, or other material acceptable for the purpose. Unplated iron or steel shall not be used.

13.2 Plated iron or steel is an alternative for a current-carrying part:

- a) The temperature of which during normal operation is more than 100°C (212°F),
- b) Within a motor or associated governor, or
- c) In accordance with 4.1.

The foregoing restrictions do not apply to stainless steel and other corrosion-resistant alloys.

13.3 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable values.

13.4 Friction between surfaces is not acceptable as the sole means to prevent the turning of a live part, but a properly applied lock washer may be used for this purpose.

14 Internal Wiring

14.1 General

14.1.1 The wiring and connections between parts of an appliance shall be protected or enclosed.

Exception: A length of flexible cord may be employed for external connections if flexibility is essential. See 14.1.5 and 14.1.6. The design shall be such as to prevent damage to the cord resulting from contact with the door or building.

14.1.2 The internal wiring of an appliance shall consist of wires of a type or types that are acceptable for the application, when considered with respect to the temperatures and voltage to which the wiring is likely to be subjected, with respect to its exposure to oil or grease, and with respect to other conditions of service to which it is likely to be subjected.

14.1.3 Thermoplastic-insulated wire employed for internal wiring shall be standard building wire or appliance wiring material acceptable for the purpose.

Exception: The type of wiring insulation is not specified if the electrical source complies with 14.4.3 or the source and cable combination complies with Interconnection Cable Overload Test of Section 52.

14.1.4 Type AF or CF wire shall not be employed.

14.1.5 Internal wiring of an appliance is considered to be all the interconnecting wiring beyond the point where the power-supply cord of a cord-connected appliance enters the enclosure, or beyond the wiring terminals or leads for power-supply connection of a permanently connected appliance, some of such wiring may not be completely enclosed and some of it may be in the form of flexible cord. With reference to exposure of insulated wiring through an opening in the enclosure of an appliance, the protection of such wiring required in 14.1.1 is considered to exist if, when judged as though it were enameled wire, the wiring would be acceptable according to 9.2. Internal wiring not so protected may be acceptable if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

14.1.6 Type SJT, SJTO, ST, or STO cord – not longer than 12 in (305 mm) if it terminates in a conventional attachment plug – may be used to connect subassemblies of a residential door operator that is permanently connected to the power supply. See 14.1.1.

14.1.7 The internal wiring between components of an appliance shall consist of wires having insulation not less than 1/32-in (0.8-mm) thick.

Exception: The thickness of insulation on wiring in circuits supplied by a Class 2 transformer rated 30 V rms or less is not specified.

14.1.8 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method that is acceptable for the combination of metals involved at the connection point.

14.1.9 With reference to 14.1.8, a wire-binding screw or a pressure terminal connector used as a termination device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and the like.

14.1.10 A nominal 0.110-in, 0.125-in, 0.187-in, 0.205-in, or 0.250-in wide quick-connect terminal shall comply with the requirements for quick-connect terminals in the Standard for Electrical Quick Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rises. All tests are to be conducted in accordance with the requirements for quick-connect terminals in the Standard for Electrical Quick Connect Terminals, UL 310.

14.2 Protection of wiring

14.2.1 If the wiring of an appliance is located so that it may be in proximity to combustible material or may be subject to mechanical damage, it shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or otherwise acceptably protected.

14.2.2 Wires within an enclosure, compartment, raceway, or the like shall be located or protected so that no damage to conductor insulation can result from contact with any rough, sharp, or moving part.

14.2.3 A hole, through which insulated wires pass in a sheet-metal wall within the overall enclosure of an appliance shall be provided with a smooth, rounded bushing or shall have smooth rounded surfaces upon which the wires may bear to prevent abrasion of the insulation. A flexible cable used for external interconnection as mentioned in 14.1.1 shall be provided with bushings and strain relief in accordance with 12.2.1.1 – 12.2.2.1 and Strain-Relief Test, Section 51 unless the construction is such that the cord will be protected from stress or motion.

14.2.4 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the appliance.

14.3 Splices and connections

14.3.1 All splices and connections shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in a risk of fire, electric shock, or injury to persons.

14.3.2 A splice shall be provided with insulation equivalent to that of the wires involved if the spacing between the splice and other metal parts may not be permanently maintained.

14.3.3 Insulation consisting of two layers of friction tape, of two layers of acceptable thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape may be used on a splice if the voltage involved is less than 250 V. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat resistance, moisture-resistance characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable. An insulated splicing device is acceptable within the limits of its voltage and temperature ratings.

14.3.4 The means of connecting standard internal wiring to a wire-binding screw shall be such that loose strands of wire cannot contact other live parts not always of the same polarity as the wire or contact dead metal parts. This may be accomplished by the use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other reliable means.

14.4 Secondary circuits

14.4.1 Other than as noted in 14.4.2 and 14.4.4, secondary circuits are judged under the requirements for line-voltage circuits.

14.4.2 In a Class 2 circuit:

- a) Live parts are not required to be enclosed;
- b) The frame is useable as a current-carrying part;
- c) The spacing requirements of Table 23.2 do not apply; and
- d) The dielectric voltage-withstand test potential is as specified in 45.1(d).

14.4.3 A Class 2 transformer used as a supply for a Class 2 circuit shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

14.4.4 In a circuit that is supplied from an isolating transformer that does not comply with the requirements for a Class 2 transformer, has an open-circuit sinusoidal potential of 30 V (42.4 V peak) or less, and that includes:

- a) A reliable fixed impedance,
- b) A fuse, or

- c) A nonadjustable manually reset circuit protector that limits the power available to the levels for Class 2 transformers,

the portion of the circuit on the load side of the impedance, fuse, or protector is to be treated as though it were supplied from a Class 2 transformer. The secondary winding of the transformer; the impedance, the fuse, or the protector; and the wiring between the two are to be evaluated as though they are part of a line-voltage circuit. See 61.2.7.

Exception: The type of wiring insulation is not specified if the source and cable combination complies with Interconnection Cable Overload Test of Section 52.

14.4.5 A fuse or circuit protector used to limit the power as specified in 14.4.4 is to be rated or set at not more than 3.2 A for a circuit operating between 20 and 30 V rms sinusoidal and at not more than 5.0 A for a 0 – 20 V rms sinusoidal circuit. If an impedance is used to limit the current, its value is to limit the current under short-circuit conditions to not more than 8.0 A measured after 1 min.

14.4.6 The wiring in the secondary circuits mentioned in 14.4.2 and 14.4.4 shall be reliably routed away from the wiring and uninsulated live parts of other circuits or shall be provided with insulation that is rated for use at the highest of the voltages in the other circuits.

14.4.7 Wiring compartments or the equivalent for field-wiring terminals for secondary circuits shall be separated or segregated by barriers from wiring compartments for other terminals.

14.4.8 Cable supplied with the operator for connection of a Class 2 circuit to an external device shall be:

- a) Type CL2, CL2P, CL2R, or CL2X complying with the Standard for Power-Limited Circuit Cables, UL 13, or
- b) Other cable with equivalent or better electrical, mechanical, and flammability ratings.

15 Electrical Insulation

15.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, or other insulating material acceptable for the application.

15.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts if shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock. Thermoplastic materials are not considered to be acceptable for the sole support of uninsulated live parts, but may be employed if found to have equivalent mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric strength, and other properties acceptable for the application.

15.3 Small molded parts, such as brush caps, shall be constructed to have the necessary mechanical strength and rigidity to withstand the stress of actual service. Brush caps shall be secured or located to be protected from mechanical damage that might result during normal use.

16 Motors

16.1 A motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and shall be capable of handling the maximum normal load of the appliance as described in 44.2.1 – 44.10.1 without introducing a risk of fire, electric shock, or injury to persons.

16.2 A motor winding shall be such as to resist the absorption of moisture, and shall be formed and assembled in a workmanlike manner.

16.3 With reference to the requirements in 16.2, enameled wire is not required to be additionally treated to prevent absorption of moisture.

16.4 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly will be retained to the degree necessary to prevent accessible dead metal parts from becoming energized, and to prevent live parts from becoming accessible.

17 Overload Protection

17.1 A motor shall incorporate thermal or overload protection for running-overload (heating) and locked-rotor conditions complying with the requirements in 17.2.

Exception No. 1: A drapery operator incorporating a momentary contact switch – a switch that requires continuous pressure – is not required to have overload protection.

Exception No. 2: An integral horsepower or polyphase motor used on a commercial or industrial door operator is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

Exception No. 3: A motor supplied from a Class 2 circuit need not be provided with overload protection.

17.2 Motor-overload protection required for a product in accordance with 17.1 shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111.

Exception No. 1: When a product includes a control, such as a timer, that positively and reliably limits the length of time the product is able to operate, a shorter test duration for the Locked-Rotor Temperature, the Running Heating Temperature, and the Locked-Rotor Endurance tests meets the intent of the requirement. For this construction, the duration of these tests shall not be less than the time to which the control limits product operation.

Exception No. 2: When the time required to operate a manually reset protective device through 10 cycles of operation is longer than the time the product is intended to be operated during each use, less than 10 cycles of operation of the device for the Locked-Rotor Temperature Test meets the intent of the requirement. For this construction, the number of cycles shall be 4 cycles or the number of cycles required for maximum intended operating time of the product, whichever is longer.

Exception No. 3: A motor intended only for moving air and that has an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft is not required to have running overload protection.

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b) Impedance protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111, when the motor is tested as used in the product under locked-rotor conditions.

c) Other protection that is shown by test to be equivalent to the protection specified in item (a).

17.3 The functioning of a motor-protective device, whether such device is required or not, shall not result in a risk of fire, electric shock, or injury to persons.

17.4 An overload- or overcurrent-protective device shall not open the circuit during normal operation of the appliance, except as noted in 44.7.2 and 44.7.3.

17.5 An overcurrent or thermal protective device shall be of a type acceptable for the application.

17.6 A protective device, such as a fuse, the normal functioning of which requires renewal or replacement, shall be in a readily accessible location.

Exception No. 1: If the appliance, with the protective device shunted out of the circuit, complies with all applicable requirements in this standard, the protective device need not be readily accessible.

Exception No. 2: If the presence of the protective device would ordinarily be unknown to the user of the appliance because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like for the appliance, the protective device need not be readily accessible.

17.7 A protective device shall be wholly inaccessible from outside the appliance without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the appliance enclosure.

17.8 Unless the appliance is marked in accordance with 61.1.15, a fuseholder shall be designed and installed so that no uninsulated live part other than the screwshell or clips will be exposed to contact by a person removing or replacing a fuse. The screwshell of a plug-type fuseholder shall be connected toward the load.

Exception: The requirement relating to exposure of uninsulated live parts does not apply under the conditions described in Exception No. 2 to 17.6.

17.9 The door or cover of an enclosure shall be hinged or otherwise attached in an equivalent manner if it gives access to any overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device.

17.10 Means shall be provided for holding the door or cover over a fuseholder in a closed position, and the door or cover shall be tight-fitting.

18 Switches and Controls

18.1 A switch shall be located or protected so that it shall not be normally exposed to mechanical damage during use.

18.2 A switch shall be acceptable for the application, and shall have a current and voltage rating not less than that of the load that it controls when the appliance is operated normally.

18.3 A switch controlling one or more electric heating elements shall be arranged so that opening the switch will disconnect all the ungrounded conductors of the power-supply circuit.

18.4 A switch or other device that controls a contactor, a relay coil, or other electromagnetic device shall have voltage and volt-ampere ratings not less than the corresponding ratings of the load it controls.

18.5 The current rating of a switch that controls an inductive load, such as a transformer or an electric-discharge-lamp-ballast, shall not be less than twice the rated full-load current of the transformer or ballast unless the switch has been investigated and found to be acceptable for the application.

18.6 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be acceptable for use with tungsten-filament lamps.

18.7 A switch provided as part of an appliance intended to be connected to a power-supply circuit having a potential to ground of more than 150 V shall be acceptable for the maximum potential to ground of the circuit.

Exception: This requirement does not apply to an appliance marked in accordance with 61.1.6 or 61.1.7.

18.8 A commercial or industrial operator connected to a 2-wire, single-phase, or a 3-wire, 3-phase appliance with a rating in the range from 220 – 240 V is assumed to involve a potential to ground of more than 150 V.

18.9 A nominal 208 V, single or 3-phase appliance is considered to involve a potential to ground of less than 150 V.

18.10 An appliance control containing solid-state components that complies with the applicable requirements in the Standard for Solid-State Controls for Appliances, UL 244A, is acceptable for use in equipment covered by this standard. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

18.11 If a switch or circuit breaker is mounted such that movement of the operating handle, either linearly or rotationally, between the on and off positions results in one position being above the other position, then the upper position shall be the on position.

Exception: The requirement does not apply to a switching device having more than two on positions such as a double throw switch, or a switching device located in a low voltage circuit.

18.12 No switch or overcurrent-protective device of the single-pole type other than an automatic control without a marked off position shall be electrically connected to a terminal or lead intended for connection to the grounded conductor of the supply circuit.

18.13 If a three-button switch or control is provided with a commercial/industrial door operator (or system), one button shall be a stop button.

19 Heating Elements

19.1 A heating element shall be supported in a substantial and reliable manner, and shall be protected against mechanical damage and contact with outside objects.

20 Lampholders, Light Emitting Diodes (LED) Light Sources, and Lighting Ballasts

20.1 If an appliance is intended to be connected to the grounded conductor of the power-supply circuit, the screw shell of any Edison-base lampholder in the appliance shall be connected to that conductor.

20.2 A lampholder shall be designed or installed so that uninsulated live parts other than a lamp contact will not be exposed to contact by persons removing or replacing lamps in normal service.

20.3 A light emitting diode (LED) light source that serves as a source of illumination shall comply with the Standard for Light Emitting Diodes (LED) Light Sources for Use in Lighting Products, UL 8750. Individual light emitting diodes mounted on the printed wiring board of a control and intended for indicating purposes shall be evaluated with the control.

Exception: An LED light source and its driver supplied by a Class 2 circuit need not comply with this requirement.

20.4 Lighting ballasts shall comply with the Standard for Fluorescent-Lamp Ballasts, UL 935, or the Standard for High-Intensity-Discharge Lamp Ballasts, UL 1029.

21 Receptacles

21.1 An attachment-plug receptacle intended for use by the serviceman shall be of the grounding type.

21.2 The face of a receptacle shall:

- a) Be flush with or project beyond a nonconductive surrounding surface, or
- b) Project at least 0.015 in (0.31 mm) beyond a conductive surrounding surface.

21.3 An appliance having a general-use convenience receptacle rated 120 V, single phase, and 15 or 20 A shall be provided with a ground-fault circuit interrupter.

21.4 A general purpose receptacle rated for use on a nominal 120 V circuit shall be of a polarized type. The grounded supply conductor shall be connected to the terminal that is substantially white in color or otherwise marked to indicate that it is intended for connection to the grounded supply conductor.

22 Capacitors

22.1 The voltage rating of a capacitor, other than a motor capacitor, shall not be less than the maximum steady-state potential to which the capacitor is subjected during operation of the appliance.

22.2 A capacitor connected from one side of the line to the frame or enclosure of an appliance shall have a capacitance rating of not more than 0.10 μF .

23 Spacings

23.1 Other than noted in 14.4.2, 23.6, and 23.9, the spacing between field-wiring terminals of opposite polarity and the spacing between a field-wiring terminal and any other uninsulated metal part – dead or live – not of the same polarity, shall not be less than specified in Table 23.1.

Table 23.1
Spacings at field-wiring terminals

Potential involved, V	Minimum spacings, in (mm)			
	Between wiring terminals, through air, or over surface		Between terminals and other uninsulated terminals, metal parts not always through air, of the same polarity ^a	
			Over surface	Through air
250 or less	1/4	(6.4)	1/4	(6.4)
More than 250	1/2	(12.7) ^b	1/2	(12.7) ^b
^a Applies to the sum of the spacings involved where an isolated dead part is interposed.				
^b A spacing of not less than 3/8 in, through air and over surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integrated with a motor.				

23.2 Spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

23.3 Other than at field-wiring terminals and as noted in 14.4.2 and 23.6, the spacing between uninsulated live parts of opposite polarity, and between an uninsulated live part and dead metal part that is exposed to contact by persons or that may be grounded, shall not be less than the value specified in Table 23.2. If an uninsulated live part is not rigidly fixed in position, by means other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum acceptable spacing will be maintained.

Table 23.2
Spacings at other than field-wiring terminals

Potential involved, V	Minimum spacings, in (mm)							
	Motor diameter 7 in (178 mm) or less ^a				Motor diameter more than 7 in (178 mm) ^a			
	Over surface		Through air		Over surface		Through air	
0 – 125	3/32	(2.4) ^b	3/32	(2.4) ^b	1/4	(6.4) ^c	1/8	(3.2) ^c
125 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4) ^c	1/4	(6.4) ^c
251 – 600	1/2	(12.7) ^c	3/8	(9.5) ^c	1/2	(12.7) ^c	3/8	(9.5) ^c

^a This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and the like, used solely for motor mounting, cooling, assembly, or connection.

^b For a motor rated 1/3 horsepower (250 W output) or less, these spacings may not be less than 1/16 in.

^c Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 in over surface and through air is acceptable between film-coated wire rigidly supported and held in place on a coil and a dead metal part.

23.4 A wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire and a means of making the connection – a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or the like – factory-assembled to the wire, are provided as a part of the appliance.

23.5 In applying Table 23.1 to an appliance incorporating two or more motors of different sizes, the spacings in the appliance are judged on the basis of the size of the largest motor in the appliance.

23.6 The spacing requirements in 23.1 – 23.5 do not apply to the inherent spacings of a component of the appliance, such as a snap switch; such spacings are judged on the basis of the requirements for the component in question.

23.7 Where an isolated dead metal part is interposed between, or is in close proximity to:

- a) Live parts of opposite polarity,
- b) A live part and an exposed dead metal part, or
- c) A live part and a dead metal part that is to be grounded;

the spacing shall not be less than 3/64 in (1.2 mm) between the isolated dead metal part and any one of the other parts specified in (a) – (c) and the total spacing between the isolated dead metal part and the two other parts shall not be less than the value specified in Table 23.1 or Table 23.2, whichever is applicable.

23.8 In the application of 45.1 and Table 23.2 to a motor not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating current motor is to be used if the appliance is marked for use on alternating current only; otherwise, the table applying to direct-current motors is to be used.

23.9 At terminal screws and studs to which connection may be made in the field by means of wire connectors, eyelets, or the like, it is required that the spacings be not less than those specified in Table 23.2 when such connectors, eyelets, and the like are in such position that minimum spacings – opposite polarity and to dead metal – exist.

23.10 An insulating lining or barrier of vulcanized fiber or similar materials employed where spacings would otherwise be insufficient shall not be less than 1/32-in (0.8-mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 1/64-in (0.4-mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception No. 2: Insulating material having a thickness less than that specified may be used if, upon investigation, it is found to be acceptable for the application.

24 Grounding

24.1 Except for drapery operators, all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact by the user or serviceman and that are likely to become energized shall be reliably connected to:

- a) The equipment-grounding terminal or lead of a permanently installed appliance.
- b) The equipment-grounding conductor of the cord of a cord-connected machine.

24.2 The surface of insulation on a grounding conductor of a flexible cord shall be green or green with or without one or more yellow stripes. The grounding conductor shall be secured to the frame or enclosure of the appliance by means of a screw or other reliable means that is not unintentionally removable during any servicing operation involving the power-supply cord. A sheet-metal (spaced thread) screw shall not be used to secure a grounding conductor. Solder alone shall not be used for securing the grounding conductor. The grounding conductor shall be connected to the grounding blade or equivalent fixed contacting member of an attachment plug. For the purpose of this requirement, servicing includes repair of the appliance by a qualified serviceman.

24.3 The following are considered to constitute means for grounding:

- a) In an appliance intended to be permanently connected to a wiring system – the equipment-grounding terminal or lead.
- b) In a cord-connected appliance – an equipment-grounding conductor in the cord.

PROTECTION AGAINST RISK OF INJURY TO PERSONS

25 General

25.1 If an automatically-reset protective device is employed, automatic restarting of a motor shall not result in a risk of injury to persons.

25.2 An appliance is considered to comply with the requirement in 25.1 if some means is provided to prevent the motor from restarting when the protector closes.

25.3 Parts supported or actuated hydraulically shall not develop a risk of injury to persons due to pressure loss.

25.4 A part of a gate operator system or a door operator system supported or counterbalanced by a spring mechanism which is supplied with the operator system, such as a torsion or extension spring, shall not develop a risk of injury in the event the spring breaks. Similarly, the operator or system shall be equipped with a device capable of restraining the spring or any part of the spring in the event the spring breaks.

25.5 An enclosure, an opening, a frame, a guard, a knob, a handle, or the like shall not be sufficiently sharp to cause a risk of injury to persons in normal maintenance or use.

25.6 Software for use in an inherent secondary entrapment protection device shall comply with the Standard for Software in Programmable Components, UL 1998.

25.7 An electronic or solid-state circuit that performs a back-up, limiting, or other function intended to reduce the risk of fire, electric shock, or injury to persons, including entrapment protection circuits, shall comply with the requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, including environmental and stress tests appropriate to the intended usage of the end-product.

25.8 The following test parameters are to be used in the investigation of the circuit covered by 25.7, for compliance with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991:

- a) With regard to electrical supervision of critical components, an operator being inoperative with respect to closing movement of the door meets the criteria for trouble indication.
- b) A field strength of 3 V per meter is to be used for the Radiated EMI Test.
- c) The Composite Operational and Cycling Test is to be conducted for 14 days at temperature extremes of minus 35°C (minus 31°F) and 70°C (158°F).
- d) Exposure Class H5 is to be used for the Humidity Test.
- e) A vibration level of 5 g is to be used for the Vibration Test.
- f) When a Computational Investigation is conducted, λ_p shall not be greater than 6 failures/10⁶ hours for the entire system. For external secondary entrapment protection devices or systems that are sold separately, λ_p shall not be greater than 0 failures/10⁶ hours. For internal secondary entrapment protection devices whether or not they are sold separately, λ_p shall not be greater than 0 failures/10⁶ hours. The Operational Test is to be conducted for 14 days.

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Exception: An external secondary entrapment protection device or systems that is sold separately, and that has a λ_p greater than 0 failures/10⁶ hours meets the intent of the requirement when for the combination of the operator and the specified external secondary entrapment protection device or systems λ_p does not exceed 6 failures/10⁶ hours. See 61.3.5 – 61.3.7.

g) When the Demonstrated Method Test is conducted, the multiplier is to be based on the continuous usage level, and a minimum of 24 units for a minimum of 24 h per unit are to be tested.

h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (18°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing the opening and closing of the door or gate at a rate of one open-close operation per minute.

i) For the Electrical Fast Transient Burst Test, test level 3 is to be used for residential garage door operators and all other indoor use operators. For all other operators, test level 4 is to be used.

25.9 In the evaluation of entrapment protection circuits used in residential garage door operators, the critical condition flow chart shown in Figure 25.1 shall be used to:

- a) Conduct a failure-mode and effect analysis (FMEA),
- b) In investigating the performance during the Environmental Stress Tests, and
- c) During the Power Cycling Tests in accordance with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.