



# UL 79

## STANDARD FOR SAFETY

Power-Operated Pumps for Petroleum  
Dispensing Products

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UL Standard for Safety for Power-Operated Pumps for Petroleum Dispensing Products, UL 79

Tenth Edition, Dated April 29, 2016

### **Summary of Topics**

***This revision of ANSI/UL 79 dated March 19, 2021 includes the Endurance Test; [45.2](#)***

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated January 15, 2021.

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## **UL 79**

### **Standard for Power-Operated Pumps for Petroleum Dispensing Products**

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

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover products described in [1.2](#). Requirements for the installation and use of these products are included in the Flammable and Combustible Liquids Code, NFPA 30; the Automotive and Marine Service Station Code, NFPA 30A; and the National Electrical Code, NFPA 70.

1.2 These requirements cover electrically-, hydraulically-, or pneumatically-driven power-operated pumps for use with petroleum products in the following applications:

- a) Self-contained flammable liquid dispensing devices and submerged pumps used in storage tanks that provide the petroleum product to remote control flammable liquid dispensing devices. They are intended for operation at discharge pressures of 50 pounds per square inch (psig) (345 kPa), or the marked maximum discharge pressure rating, when less, with the ambient and liquid temperature within the range of minus 20°F (minus 29°C) – 125°F (52°C).
- b) Flammable liquid dispensing systems to transfer the petroleum product from a tank or container to a vehicle or another container. They are intended for operation at the marked maximum discharge pressure, or less, with the ambient and liquid temperature within the range of minus 20°F (minus 29°C) – 125°F (52°C).
- c) Vapor recovery applications for flammable liquid dispensing devices. They are intended to operate under a vacuum at the inlet and a maximum discharge pressure of 50 psig (345 kPa), or marked discharge pressure, whichever is less.

1.3 These requirements do not cover:

- a) Oil burner pumps, which are evaluated under the Standard for Pumps for Oil-Burning Appliances, UL 343.
- b) Pumps for engine-powered automotive equipment.
- c) Pumps for marine use which are evaluated under the Standard for Mechanically and Electrically Operated Fuel Pumps for Marine Use, UL 1130.
- d) Pumps for use in chemical, petrochemical, or petroleum processing plants; utility power plants; petroleum production facilities; pipeline pump stations; pipeline or marine terminals; or bulk plant distribution and related facilities.
- e) Pumps used in mobile applications, such as on tank trucks, portable tanks, or portable containers mounted on vehicles.
- f) Pumps rated more than 600 volts.
- g) Pump assemblies also provided with a flammable liquid meter or electrically-operated shutoff valve, which are evaluated in accordance with the Standard for Power-Operated Dispensing Devices for Petroleum Products, UL 87.

1.4 The pump assembly is not prohibited from being constructed such that it provides for the installation and use of a flammable liquid hose and hose nozzle valve.

1.5 "Petroleum Products," as used herein, means gasoline, gasoline/alcohol blends up to 15% Ethanol or 15% Methanol, diesel fuel, fuel oil, lubricating oil, and the vapors of these fuels. Other petroleum products are not prohibited from being used in the pump when the materials comply with the requirements

in Materials, Section 5, when the pump is evaluated using the additional liquids, and the additional petroleum products are marked on the pump as indicated in 74.1(f).

## 2 General

### 2.1 Components

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

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

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

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

2.1.5 Electrical components, including motors and wiring, when incorporated by a manufacturer in an assembly with a pump, and including the means provided in the pump assembly for electrical connections, shall comply with the requirements for equipment for use in hazardous locations, Class I, Group D, National Electrical Code, NFPA 70, Articles 500 and 501.

### 2.2 Units of measurement

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

### 2.3 Undated references

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

## 3 Glossary

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

3.2 HAZARDOUS LOCATIONS – Locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixture.

3.3 INTRINSICALLY SAFE CIRCUIT – A circuit incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. Abnormal conditions include unintentional damage to any part of the equipment or wiring, insulation or other malfunction of electrical components, application of overvoltage, adjustment and maintenance operations, and other similar conditions.

3.4 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

3.5 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.2 volts supplied by:

- a) A battery;
  - b) A Class 2 transformer; or
  - c) A combination of a transformer and a fixed impedance that, as a unit, complies with the performance requirements for Class 2 transformers in accordance 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.
- A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current is not a low-voltage circuit.

3.6 RAINPROOF ENCLOSURE – An enclosure that prevents the entrance of a beating rain to the extent that there is no wetting of electrical parts and no water enters a compartment housing field installed wiring.

## CONSTRUCTION

### 4 Assembly

4.1 The construction of a pump shall be such that parts can be assembled in the intended manner after being dismantled to the extent needed for replacement of parts or for other maintenance or servicing.

4.2 When a pump requires the use of special pipe flanges, gaskets, bolts, or other special fittings or parts for making connections, such parts shall be furnished as part of the pump assembly.

4.3 A product shall be formed and assembled so that it has the strength and rigidity required to resist the abuses to which it is subjected without resulting in the risk of fire, electric shock, or injury to persons due to total or partial collapse with:

- a) Resulting reduction of spacings;
- b) Loosening or displacement of parts; or
- c) Other defects.

4.4 A pump-motor assembly to be shipped from the manufacturer disassembled shall be provided with the marking described in [74.9](#).

### 5 Materials

5.1 A metal part to be used for bodies or closures shall be inherently resistant to the action of the liquid to be handled. Other parts in contact with the liquid to be handled shall be resistant to the action of such liquid when malfunction of the part results in:

- a) Leakage;
- b) Malfunction of equipment connected to the outlet of the pump; or
- c) A risk of injury to persons.

5.2 With reference to the requirement in [5.1](#), an elastomeric part used in contact with liquid or vapor shall have the following properties when tested as specified in the Standard for Gaskets and Seals, UL 157:

- a) Those properties relating to minimum tensile strength and elongation after oven aging, as specified in UL 157. The service temperature used to determine the conditioning time and temperature for oven aging is to be 140°F (60°C), unless the product is designated for use at a higher temperature, or the temperature of the component measured during the temperature test is higher.
- b) Low temperature rating of minus 20°F (minus 29°C).
- c) Volume change and extraction as specified in the requirements for UL 157, for end-use applications of gasoline, gasoline/alcohol blends up to 15% Ethanol, gasoline/alcohol blends up to 15% Methanol, diesel fuel, fuel oil, and lubricating oil. Other end-use applications, when marked on the pump, shall use the fluids marked for exposure.

*Exception No. 1: Polytetrafluoroethylene (PTFE) is considered to comply with the requirements of this paragraph.*

*Exception No. 2: When an elastomeric part does not comply with the requirements described in (a) – (c), the pump assembly shall be evaluated in accordance with [5.5](#).*

*Exception No. 3: Testing with methanol is only required when the product is specifically rated for methanol blend use.*

5.3 An elastomeric part forming a part that is depended on for protection of electrical components from rain or submersion in water shall have the following physical properties when tested as specified in the Standard for Gaskets and Seals, UL 157:

- a) Those properties relating to minimum tensile strength and elongation after oven aging, as specified in UL 157. The service temperature used to determine the conditioning time and temperature for oven aging is to be 140°F (60°C), unless the product is designated for use at a higher temperature, or the temperature of the component measured during the temperature test is higher.
- b) Low temperature rating of minus 20°F (minus 29°C).

5.4 The Standard for Gaskets and Seals, UL 157, provides for the testing of either finished elastomeric parts, or sheet or slab material. Sheet or slab material is to be tested when the elastomeric parts are O-rings having a diameter of less than 1 inch (25.4 mm). The material tested is to be the same as that used in the product, regardless of whether finished elastomeric parts, or sheet or slab material is tested.

5.5 When the limits for tensile strength and elongation, volume change or extraction, aging, or low temperature are exceeded, the gasket material may be retested in the complete pump assembly after conditioning as outlined below.

5.6 When the limits for tensile strength, elongation, volume change or extraction are exceeded, the complete assembly constructed with the gasket installed as intended shall be filled with the appropriate test fluid for 70 hours at room temperature, and then shall comply with the requirements for the Leakage Test, Section [43](#) and the Hydrostatic Strength Test, Section [49](#).

5.7 Where the oven aging results are not in accordance with [5.2\(c\)](#), the complete assembly with the gasket installed as intended, shall be placed in an air oven for the same duration and at the same temperature used when testing the gasket material, and then shall comply with the Leakage Test, Section [18](#), and the Hydrostatic Strength Test, Section [49](#), while at the test temperature.

5.8 Where the low temperature results are not in accordance with 5.2(d), the complete assembly with the gasket installed as intended, shall be placed in a cold chamber for 24 hours at the same temperature used when testing the gasket material, and then shall comply with the Leakage Test, Section 18, and the Hydrostatic Strength Test, Section 21, while at the test temperature.

5.9 A plastic part of a pump that comes in contact with fluid or vapor and whose malfunction of the parts results in the hazards specified in 5.1 shall comply with the requirements of the Dimensional Stability Test, Section 51.

5.10 Except as indicated in 5.11, liquid-confining parts, which under conditions of deterioration would result in external leakage of the fluid being confined, other than a valve disc or soft seat, a seal ring, a diaphragm, or a gasket, shall have a melting point (solidus temperature) of not less than 950°F (510°C) and a tensile strength of not less than 10,000 psi (69 MPa) at 400°F (204°C).

5.11 A brazing material used for joining liquid-confining parts of a pump shall have a melting point (solidus temperature) exceeding 1000°F (538°C).

5.12 Sand castings used in the construction of liquid-confining parts, failure of which will allow external leakage, shall be free from porosity leakage and shall have a design thickness of not less than that specified in Table 5.1.

**Table 5.1**  
**Minimum thickness of liquid-confining sand-castings**

Material	Minimum wall thickness,	
	inch	(mm)
Cast iron	3/16	4.8
Malleable iron, ductile iron, or cast steel	1/8	3.2
Brass or bronze	3/32	2.4
Aluminum	5/32	4.0

5.13 When warping of a casting can affect the tightness of liquid-confining joints, or the necessary fit of parts, the casting shall be stress-relieved to reduce the possibility of warping.

5.14 When atmospheric corrosion of a part will interfere with the intended function of a pump or permit external leakage, the part shall be of corrosion-resistant material or be provided with a corrosion-resistant protective coating.

5.15 A coating as specified in 5.14 need not be provided on ferrous materials used for fluid-confining parts having the following thicknesses:

- a) Castings having a wall thickness of not less than 1/4 inch (6.4 mm);
- b) Standard pipe and fittings conforming to ANSI/ASME B36.10M, Schedule 40; and
- c) Fabricated sheet steel parts having a minimum wall thickness of 0.093 inch (2.36 mm).

5.16 A protective coating as specified in 5.14 shall provide resistance against corrosion to a degree not less than that provided by the protective coatings indicated in 5.17.

5.17 Cadmium plating shall have a thickness of not less than 0.0003 inch (0.008 mm) and zinc plating shall have a thickness of not less than 0.0005 inch (0.013 mm). However, on parts where threads

constitute the major portion of the area, the thickness of the cadmium or the zinc plating shall be not less than 0.00015 inch (0.0038 mm) as determined by the Metallic Coating Thickness Test, Section [56](#).

5.18 A protective coating indicated in [5.16](#) or other coatings in contact with liquid shall be resistant to the action of the liquid, as indicated in the Coating Liquid Resistance Test, Section [57](#).

5.19 A pressure confining part made of drawn brass or machined from brass rod, and consisting of 15% or more zinc content, shall withstand, without cracking, the Moist Ammonia-Air Stress Cracking Test, Section [54](#).

5.20 The reliability of a nonmetallic, pneumatic pressure confining part shall be determined for each application. Among the factors to be taken into consideration with the reliability of a nonmetallic material are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Resistance to distortion and creeping at temperature and pressures to which the material is subjected under conditions of intended use; and
- d) Dimensional stability.

Compliance with this requirement is determined by the tests of Sections [51](#), [68](#), [69](#), and [70](#).

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

5.22 The requirement in [5.21](#) also applies to an adhesive used to secure a conductive part, including a nameplate, which when loosened or dislodged is capable of:

- a) Energizing an accessible dead metal part,;
- b) Making a live part accessible;
- c) Reducing spacings below the minimum values specified in [Table 31.2](#); or
- d) Short-circuiting live parts.

## 6 Bodies, Covers, and Heads

6.1 A pump body assembly shall withstand the deformation, leakage, and hydrostatic strength test requirements specified in [42.1](#), [43.1](#), and [49.1](#). These requirements do not apply to body sections of submersible type pumps intended to be immersed in the liquid.

6.2 Plugs and other parts, other than cap screws and bolts threaded into noncorrosion-resistant ferrous parts of the pump, shall be of corrosion-resistant metal or provided with a protective coating when they are required to be removed for adjustment, repair, or other care of the pump.

6.3 A plug, cap, or other part threaded into or on the pump body shall engage with at least four full threads.

6.4 A bolt or a screw hole shall not extend through the outer walls of a pump body into a liquid-handling section.



## 7 Drive-Shaft Seals

7.1 A stuffing box or a seal shall comply with the requirements specified in the Endurance Test, Section [45](#).

7.2 An adjustable stuffing box, when guarded or not accessible, or when clearly visible to the operator, shall be provided with a spring-loaded follower gland or the equivalent.

7.3 An automatic spring take-up for a gland shall employ a spring made of corrosion resistant material or coated to retard corrosion.

7.4 The physical characteristics of a take-up spring shall be such that it advances the gland through not less than one-half its possible travel from its initial setting with the spring compressed.

7.5 The stuffing-box recess shall be such that packing material does not come into contact with screw threads.

## 8 Diaphragms

8.1 A metal part coming in contact with a diaphragm shall have no sharp edges, burrs, projections, and surfaces that are capable of chafing or abrading the diaphragm.

8.2 A pump, in which a flexible diaphragm, bellows, or similar construction constitutes the only fluid seal, shall be constructed such that the atmospheric side of the diaphragm or bellows is enclosed in a casing construction to reduce external leakage in the event of a diaphragm or bellows rupture, or shall have provisions for connection of a vent pipe or tubing intended to be routed to the outdoors or other location determined to be equivalent. See [74.8](#).

## 9 Springs

9.1 A spring shall be guided and arranged to reduce binding, buckling, or other interference with its free movement. When required, ends of a spring shall be closed and squared.

## 10 Floats

10.1 A float constructed to actuate a mechanism shall have a buoyancy not less than 50 percent greater than that required to operate the mechanism. See the Float Buoyancy Test, Section [50](#).

10.2 A hollow float shall withstand an external crushing pressure of not less than 35 psig (240 kPa). See the Float Test, Section [49](#).

10.3 A cork float shall be provided with a coating that is resistant to the action of the liquid with which it is in contact.

10.4 A float shall be secured to its corresponding lever, rod, or other part of the mechanism by a method that prevents the float from becoming detached under its intended conditions of operation.

10.5 A float constructed of nonmetallic materials shall comply with the requirements of the

- a) Float Buoyancy Test, Section [50](#);
- b) Dimensional Stability Test, Section [51](#); and
- c) Weight Change Test, Section [52](#).

## 11 Air Separators

11.1 Air separators that are provided as an integral part of a pump assembly shall be provided with floats that comply with the requirements of Floats, Section [10](#).

11.2 The valve mechanism operated by the float shall be subjected to the endurance test described in [46.1](#). When the valve mechanism closes a vent to atmosphere, it shall also be subjected to the leakage test described in [43.6](#).

## 12 Strainers

12.1 A strainer integral with or provided as part of a pump assembly shall comply with the requirements in [12.2](#) – [12.5](#) and with the applicable requirements in the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331.

12.2 A strainer shall enable the removal of foreign matter (sediment or dirt) without depositing the foreign matter in the outlet side of the strainer when the screen or filter element is removed for cleaning.

12.3 A strainer shall be installed and located so that removal and replacement of the strainer element is accomplished without breaking liquid lines or disturbing any part of the pump assembly. The location shall provide for the collection and removal of any spillage.

12.4 A drain opening shall be closed by a pipe plug made of corrosion resistant material or a steel pipe plug coated to resist corrosion, not smaller than 1/4 inch pipe size (ANSI B36.10M). A pet cock or valve shall not be provided for drainage purposes.

12.5 The force necessary to open a strainer shall not permanently distort the assembly or piping to which the strainer is attached.

## 13 Outlet Pressure Regulation

13.1 A pump assembly for use with or in petroleum product dispensing devices shall incorporate means for the prevention of or the relief of pressures developed by the pump in excess of the maximum discharge pressure of 50 psig (345 kPa) or the marked maximum discharge pressure rating, whichever is less. A pump assembly for use with or in petroleum product dispensing systems shall incorporate means for the prevention of or the relief of pressures developed by the pump in excess of the maximum discharge pressure. See Blocked Outlet Test, Section [47](#).

13.2 To comply with the requirements in [13.1](#), a pump assembly is not prohibited from being equipped with:

- a) A bypass valve connected between the discharge and suction ports;
- b) A relief valve arranged to be connected between the discharge side and the supply tank through a separate return line. When the relief valve is not provided as part of the pump, it shall be marked as indicated in [74.6](#);
- c) A means to effect an automatic reduction in volumetric capacity upon an increase in pressure at the outlet; or
- d) An energy input incapable, because of power or speed, of developing a discharge pressure in excess of the maximum discharge pressure.

13.3 After the valve or other means for pressure regulation has been adjusted in accordance with the requirements in [13.1](#), it shall:

- a) Be capable of being sealed to discourage tampering;
- b) Be located within the pump body and require tools for access; or
- c) Be constructed so that the maximum adjustment obtainable does not result in a pressure in excess of the maximum discharge pressure under maximum output conditions.

## 14 Pressure Relief

14.1 A pump for use with or in petroleum product dispensing devices shall incorporate means for the relief of pressures developed by thermal expansion of the fluid in excess of the maximum discharge pressure of 50 psig (345 kPa). A pump assembly for use with or in petroleum product dispensing systems shall incorporate means for the relief of pressures developed by thermal expansion in excess of the marked maximum discharge pressure. Thermal expansion pressure shall anticipate a temperature rise of 50°F (27.8°C) in an ambient temperature of 75°F (24°C). See the Pressure Relief Test, Section [48](#).

14.2 To comply with the requirements in [14.1](#), a pump assembly is not prohibited from being equipped with:

- a) A bypass valve connected between the discharge and suction ports and
- b) A relief valve arranged to be connected between the discharge side and the supply tank through a separate return line. When the relief valve is not provided as part of the pump, it shall be marked as indicated in [74.6](#).

14.3 After the valve or other means for pressure relief has been adjusted in accordance with the requirements in [14.1](#), it shall be:

- a) Capable of being sealed to discourage tampering;
- b) Located within the pump body and require the use of tools for access; or
- c) Constructed so that the maximum adjustment obtainable does not result in a pressure in excess of the maximum discharge pressure.

## 15 Mounting and Base

15.1 A pump shall be provided with supporting and mounting means independent of liquid-handling pipe connections. A mounting arrangement shall permit anchoring of the pump by bolts or cap screws.

15.2 When a base is furnished as part of a pump assembly, it shall be arranged to permit attachment and alignment of mounted parts and for anchoring to a mounting surface by cap screws or bolts.

## 16 Guards

16.1 A gear, belt, pulley, or other rotating part shall be enclosed in a metal guard or the pump assembly shall be furnished with an enclosure.

## 17 Piping and Fittings

17.1 Pipe threads shall be in accordance with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1.

*Exception: Pumps intended for use in installations where pipe fittings incorporate other than NPT type threads shall be permitted to be provided with pipe threads complying with a national pipe thread standard compatible with those fittings. The pipe thread type shall be identified in accordance with [74.1\(j\)](#).*

17.2 Flanges of flange-type pumps shall comply with the appropriate American National Standard for pipe flanges and flanged fittings covering the material from which they are made, or such flanges and flanged fittings shall comply with all of the tests in Sections [41](#), [42](#), [43](#), [49](#) and [54](#) as complete assemblies forming part of the pump.

17.3 An opening threaded for attachment to pipe shall be constructed so that a pipe threaded two threads beyond standard construction (for the size in question) is capable of being threaded into the opening without distorting any part of the fitting.

17.4 A male thread for attachment to pipe fittings shall have no shoulder within the distance specified in [Table 17.1](#), from the beginning of the thread, including any chamfer, nor shall any shoulder prevent an additional turn being made within this distance as determined by assembling the part into a fitting within a tolerance of plus or minus one thread.

**Table 17.1**  
**Minimum shoulder distance from beginning of thread**

Pipe size, ANSI B36.10M, nominal inches	Shoulder distance,	
	inches	(mm)
1/8	3/8	9.5
1/4, 3/8	9/16	14.3
1/2, 3/4	3/4	19.1
1	15/16	23.8
1-1/4	31/32	24.6
1-1/2	1	25.4
2	1-1/32	26.2
1-1/2	1-33/64	38.5
3	1-37/64	40.1

17.5 A threaded pipe connection shall be made with litharge and glycerine cement, shellac, shellac and inert powder filler, or a gasoline-resistant pipe-joint sealing compound.

17.6 Pipe shall be standard full-weight (ASTM Schedule 40) wrought iron or steel, or iron-pipe size brass or copper pipe. Malleable-iron, steel, brass, or copper fittings shall be used. A union, when used, shall be of the ground-joint type or a part that has been determined to be equivalent.

17.7 Tubing is not prohibited from being used where it is protected by its location in the pump assembly or by its intended installation location.

17.8 Tube fittings intended for the tubing utilized shall be used. Brass or copper in combination with aluminum shall not be used unless coated with chromium or a metallic coating that has been determined to be equivalent to preclude electrolytic action. A coating shall not be less than 0.0002 inch (0.005 mm) thick.

17.9 Seamless drawn aluminum or copper tubing that is capable of handling liquid and steel tubing of the seamless, brazed, or welded type shall have a wall thickness not less than that specified in [Table 17.2](#).

**Table 17.2**  
**Wall thickness for aluminum copper and steel tubing**

Outside diameter,		Minimum wall thickness			
		Aluminum and copper,		Steel,	
inch	(mm)	inch <sup>a</sup>	(mm) <sup>a</sup>	inch <sup>a</sup>	(mm) <sup>a</sup>
1/8	3.17	0.0265	0.67	0.028	0.71
1/4	6.35	0.0265	0.67	0.028	0.71
5/16	7.94	0.0265	0.67	0.028	0.71
3/8	9.53	0.0265	0.67	0.028	0.71
1/2	12.7	0.0315	0.80	0.028	0.71

<sup>a</sup> Nominal wall thickness of tubing is required to be greater than the thickness indicated to maintain the minimum wall thickness.

17.10 Steel tubing of the wall thickness specified in [Table 17.2](#) shall be protected with a corrosion-resistant coating that has been determined to be equivalent to that provided by hot-dip galvanizing.

## 18 Hose Nozzle Valve, Hose, and Coupling

18.1 If a hose nozzle valve is provided, the hose nozzle valve shall be in accordance with the Standard for Hose Nozzle Valves, UL 2586.

18.1A When the pump manufacturer specifies a hose nozzle valve and/or hose assembly intended for the pump, the function of the locking mechanism and control application, Section [37](#) and [38](#) respectively, is to be verified on a representative sample of the pump with that hose nozzle valve and/or hose assembly intended for the pump. Alternate combinations of nozzles and hoses shall be verified by the end user and when instructions as shown in [72.4](#) are included. Alternately, the marking shown in [74.4](#) can be used to cover the combinations when each combination is verified by the testing agency.

Note – It is permissible to use a combination of the instructions and marking to cover the combinations of hose nozzle valves and/or valve and hose combinations.

Note – The hose may not form part of the control application or locking mechanism and in such cases shall not need to be described in the instructions or marking.

18.2 When a hose assembly, consisting of hose and couplings, is supplied with the pump assembly, it shall have nonferrous couplings attached and comply with the Standard for Hose and Hose Assemblies for Dispensing Flammable Liquids, UL 330.

## 19 Conduit Seals

19.1 A factory-installed conduit seal incorporated as part of the product shall comply with the requirements of the Leakage Test, Section [43](#); the Leakage of Wire Seal Test, Section [44](#); and the Hydrostatic Strength Test, Section [49](#).

19.2 When a conduit seal is incorporated with the product, the wires or conductors shall be securely held and tightly sealed where they pass into the enclosure. When a sealing compound or cement is used it shall:

- Provide a tight fit;
- Neither soften nor crack under service conditions;
- Be resistant to the solvent action of the liquids and vapors to which it is capable of being exposed – see the Tests on Sealing Compounds, Section [55](#);

- d) Be resistant to moisture and aging; and
- e) Have a depth equal to the inside diameter of the conduit or 5/8 inch (15.9 mm), whichever is greater.

The sealing compound used in a conduit seal shall not flow or creep at the operating temperature of the device. Sealing compounds that soften with the application of heat shall have a softening point of not less than 200°F (93.3°C) when used adjacent to motors having Class A (Class 105) insulation and not less than 236°F (113.3°C) when used adjacent to motors having Class B (Class 130) insulation. The softening point is to be determined in accordance with the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

19.3 When a nipple is used to retain the sealing compound for lead wires, the depth of the seal shall not be less than the internal diameter of the nipple or 5/8 inch (15.9 mm), whichever is greater. Depending on the compound, the size of the lead wires, and the construction of the sealing well, a greater depth of sealing compound shall be used as required to form a tight seal. Means shall be provided in the nipple to anchor the sealing compound.

## 20 Electrical Equipment

20.1 Electrical conduit to be immersed in the liquid to be handled shall be of the rigid, seamless, metallic type or other material that has been determined to be equivalent.

20.2 Electrical equipment and wiring shall be arranged so that the liquid does not drip or drain on them during the intended care and usage of the pump assembly.

20.3 Wiring shall be in threaded rigid metal conduit, threaded steel intermediate metal conduit, or Type MI cable with termination fittings that comply with the requirements for Class I, Group D equipment for use in hazardous locations specified in the National Electrical Code, NFPA 70. All boxes, fittings, and joints shall be threaded for connection to conduit or cable terminations in compliance with the requirements in Class I, Group D equipment for use in hazardous locations. At least five full threads shall engage in each threaded joint.

*Exception: The housing is not prohibited from being considered the electrical enclosure for intrinsically safe circuit wiring.*

20.4 One end of a wireway between two parts that are factory-attached to an assembly is not prohibited from being secured to one of the parts by means of straight threads and, where necessary for security, with a locknut when the other end of the wireway is secured to the other part by tapered threads.

20.5 A compartment enclosing a switch or other part that is capable of producing arcs shall be sealed from any adjacent compartment in which field connections are to be made.

20.6 The ends of all conduit lengths, including nipples, shall be chamfered after threading to remove burrs or sharp edges.

20.7 For a vapor-tight fit, the sheath of shielded or multiconductor cables shall be split to enable the seal materials to be poured around the individual conductors.

*Exception: Shielded or multiconductor cables that are evaluated in accordance with the Leakage of Wire Seal Test, Section [44](#), for the cable are not required to be split.*

20.8 A terminal box threaded to conduit enclosing wiring sealed against the entry of water, petroleum products, or vapor shall not be subject to turning or require removal to accommodate replacement or

extraction of parts for maintenance, servicing, or to facilitate the connection of field-installed piping or conduit.

20.9 Upper ends of conduit subject to immersion or to entry of water, liquids, or vapors shall be sealed in the area between the conduit inside diameter and the enclosed wiring. Sealing shall be by means of litharge and glycerine, or with a nonmetallic material which has been successfully evaluated for use in this application. See Tests on Sealing Compounds, Section 55.

20.10 Threaded joints for conduit shall provide for five full-thread engagement. Threads subject to turning during installation or use shall be coated with litharge and glycerine. Threads not subject to turning during installation or use and subject to immersion in petroleum products shall be coated with litharge and glycerine or a gasoline-resistant pipe-joint sealing compound. Threaded joints in a coupling used to join lengths of conduit immersed in petroleum products shall be prevented from turning by leak-tight welding or brazing at the conduit and outside surfaces of couplings or by coating all threads with litharge and glycerine.

20.11 Wiring for motor or other leads subject to accidental immersion in petroleum products shall be of gasoline-resistant wiring material conforming with the construction, performance, and marking requirements in the Standard for Thermoset-Insulated Wires and Cables, UL 44, or the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

20.12 Grounding of motors and other electrical components and wiring shall be provided in accordance with the provisions of the National Electrical Code, NFPA 70.

20.13 An outlet box or enclosure shall have no unplugged openings other than those to which conduit is always connected when the pump assembly is installed.

20.14 A pump assembly intended for use with a dispensing device that is to be connected to the branch circuit shall not be constructed in such a manner that is required that the outlet box of the product be moved in order to care for the device.

20.15 The size of a junction box in which field installed conductors are to be connected by splicing shall not be less than that specified in Table 20.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for pump motor circuits shall not be smaller than 14 AWG (2.1 mm<sup>2</sup>). A field-furnished conductor for a reset motor, signaling, or other circuit rated less than 5 amperes shall not be smaller than 18 AWG (0.8 mm<sup>2</sup>) when the wire size is marked on the installation wiring diagram.

20.16 The size of a junction box in which field installed conductors are to be connected to factory installed terminal strips shall be determined by Table 20.1 as the summation of the volumes required for each field furnished conductor plus the volume utilized by the factory installed wiring and terminal block.

**Table 20.1**  
**Size of junction boxes**

Size of conductor, AWG (mm <sup>2</sup> )		Free space within box for each conductor			
		Box with hubs, cubic inches (cm <sup>3</sup> )		Box without hubs, cubic inches (cm <sup>3</sup> )	
16 or smaller	1.3 or less	1.3	21.3	1.5	24.6
14	2.1	1.8	29.5	2.0	32.8
12	3.3	2.0	32.8	2.25	36.9
10	5.3	2.2	36.1	2.5	41.0
8	8.4	2.7	44.2	3.0	49.2



20.17 When it is required that supply connections be made directly to a motor, the terminal compartment on the motor shall comply with the requirements for terminal compartments in either the Standard for Electric Motors, UL 1004 or the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

## 21 Supply Connections

21.1 A permanently-connected product shall have provision for connection to a wiring system in accordance with the National Electrical Code, NFPA 70.

21.2 A terminal box or compartment in which power-supply connections to a permanently-connected product are to be made shall be located in such a manner that the connections are readily accessible for inspection after the product is installed as intended.

21.3 A terminal box or compartment intended for connection of a supply raceway shall be attached to the product so as to be prevented from turning.

21.4 A permanently-connected product shall be provided with wiring terminals for the connection of conductors having an ampacity:

- a) Not less than 125 percent of the full load motor-current rating of horsepower rated motors;
- b) Not less than 100 percent of the ampere ratings of all other loads; or
- c) Both (a) and (b); or

the product shall be provided with leads for such connection. See [21.8](#).

21.5 A field-wiring terminal is a terminal to which a wire is 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 similar parts – to the terminal, are provided as a part of the product.

21.6 Wiring terminals for the supply conductors – See Grounding, Section [27](#), for termination of the grounding conductor – shall be provided with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw.

*Exception No. 1: A soldering lug is not prohibited from being used.*

*Exception No. 2: A wire binding screw is not prohibited from being employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm<sup>2</sup>) or smaller conductor when upturned lugs or parts that have been determined to be equivalent are provided to hold the wire in place.*

21.7 A wiring terminal shall be prevented from turning.

21.8 A lead inside an outlet box or wiring compartment shall not be smaller than 18 AWG (0.82 mm<sup>2</sup>), and rated for the maximum operating voltage of the pump assembly. The free length of the lead shall be 6 inches (150 mm) or more when the lead is intended for field connection to an external circuit.

*Exception No. 1: A lead that is less than 6 inches long complies with the intent of this requirement when it is evident that the use of a longer lead is capable of resulting in a risk of fire or electric shock.*

*Exception No. 2: Factory wiring terminating at a terminal strip shall also be minimum 18 AWG (0.82 mm<sup>2</sup>) unless arranged or guarded to protect from damage during field wiring.*



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

*Exception No. 1: A No. 8 screw is not prohibited from being used at a terminal when it is intended only for the connection of a 14 AWG (2.1 mm<sup>2</sup>) conductor.*

*Exception No. 2: A No. 6 screw is not prohibited from being used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm<sup>2</sup>) conductor. See [21.13](#).*

21.10 The smallest conductor that is specified in the National Electrical Code, NFPA 70, for use in branch-circuit wiring is 14 AWG (2.1 mm<sup>2</sup>). Therefore, the smallest conductor that is anticipated at a terminal for connection of a power-supply wire is 14 AWG.

21.11 A wire-binding screw shall thread into metal.

21.12 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick and shall not have less than two full threads in the metal.

*Exception No. 1: A terminal plate less than 0.050 inch thick but not less than 0.030 inch (0.76 mm) thick is not prohibited from being used when the tapped threads result in a secure connection in which the threads do not strip upon the application of a 20 pound-inch (2.26 N·m) tightening torque.*

*Exception No. 2: A terminal plate formed from stock not less than 0.050 inch thick is not prohibited from having the metal extruded at the tapped hole to provide two full threads.*

21.13 A terminal plate shall incorporate upturned lugs or a cupped washer, and shall be capable of retaining a supply connector of the size specified in [21.4](#) under the head of the screw or washer.

21.14 A permanently-connected product rated 125 volts or less, or 125/250 volts (3-wire) or less, and employing a single-pole switch or overcurrent-protective device other than an automatic control without a marked "off" position shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The terminal or lead to be connected to the grounded supply conductor shall be the one to which no switch or overcurrent-protective device of the single-pole type, other than an automatic control without a marked "off" position, is connected.

21.15 A terminal intended for the connection of a grounded supply conductor (neutral) shall be of or plated with metal that is substantially white in color and shall be readily distinguishable from the other terminals; or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

21.16 Conductors intended for field connection to a grounded supply conductor shall be identified (finished a white or gray color) or the intended wiring connections shall be clearly indicated in some other manner, such as on an attached wiring diagram. All other current-carrying conductors shall be finished in colors other than white, gray, or green with or without one or more yellow stripes.

21.17 Conductors intended for field connection to a 120-volt branch circuit protective device shall be provided and arranged such that an individual grounded supply conductor is provided for each ungrounded supply conductor.

21.18 Supply leads that are subject to handling during installation or routine maintenance of the product shall be capable of withstanding a pulling force as described in the Conductor Secureness Test, Section [65](#).

*Exception: This requirement does not apply to leads that are integral with components such as motors where the leads have been subjected to this test during the investigation of the component.*

## 22 Current-Carrying Parts

22.1 A current-carrying part shall be made of silver, copper, a copper alloy, or other similar metal.

22.2 Iron or steel shall not be used as a current-carrying part.

*Exception No. 1: Iron or steel provided with a corrosion-resistant coating is not prohibited from being used for a current-carrying part:*

- a) *When it complies with the requirements of [2.1.1](#) or*
- b) *Within a motor or associated governor.*

*Exception No. 2: The requirement does not apply to stainless steel.*

## 23 Insulating Material

23.1 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current Arc Resistance (HAI), and Comparative Tracking Index (CTI) values indicated in [Table 23.1](#). A material is in direct support of an uninsulated live part when it is in direct physical contact with the uninsulated live part, or when it serves to physically support or maintain the relative position of the uninsulated live part.

*Exception: A generic material provided in the thickness indicated in [Table 23.2](#) complies with [23.1](#) without additional evaluation.*

**Table 23.1**  
**Minimum material characteristics for the direct support of uninsulated live parts**

Flame class	RTI Electrical	Maximum performance level category (PLC)		
		HWI <sup>b,c</sup>	HAI <sup>d,e</sup>	CTI <sup>f,g,h</sup>
HB	a	2	1	3
V-2, VTM-2	a	2	2	3
V-1, VTM-1	a	3	2	3
V-0, VTM-0	a	4	3	3
<b>Relative Thermal Index (RTI)</b> <sup>a</sup> The electrical Relative Thermal Index (RTI) value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used. The RTI shall not be exceeded during the Temperature Test, Section <a href="#">60</a> .				
<b>Hot Wire Ignition (HWI)</b> <sup>b</sup> The Hot Wire Ignition (HWI) value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a HWI value, the material is evaluated as in footnote c.				
<sup>c</sup> A material without an HWI Performance Level Category (PLC) value or with a HWI PLC value greater (worse) than the value required by <a href="#">Table 23.1</a> shall be subjected to the end-product Abnormal Overload Test or the Glow Wire End-Product Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.				

**Table 23.1 Continued on Next Page**

Table 23.1 Continued

Flame class	RTI Electrical	Maximum performance level category (PLC)		
		HWI <sup>b,c</sup>	HAI <sup>d,e</sup>	CTI <sup>f,g,h</sup>
<b>High Current Arc Resistance to Ignition (HAI)</b> <sup>d</sup> The HAI value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a HAI value, the material is evaluated as in footnote e. <sup>e</sup> A material without an HAI PLC value or with an HAI PLC value greater (worse) than the value required by <a href="#">Table 23.1</a> shall be subjected to the end-product Arc Resistance Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.				
<b>Comparative Tracking Index (CTI)</b> <sup>f</sup> The Comparative Tracking Index (CTI) PLC value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a CTI value, the material is evaluated as having the same CTI value found for the greater thickness. The CTI value applies to insulating materials used in pollution degree 3 environments for voltages of 600 V or less. For equipment where pollution degree 1 or 2 is maintained, an insulating material shall have a CTI PLC of 4 or less. For equipment rated 601 – 1500 volts, see footnote h. <sup>g</sup> A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by <a href="#">Table 23.1</a> shall have a proof tracking index of 175 when used in pollution degree 3 environment or a proof tracking index of 100 when used in pollution degree 1 or 2 environment as determined by the end-product Proof Tracking Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. <sup>h</sup> For equipment rated 601 – 1500 volts, the insulating material shall not track beyond one inch in less than 60 minutes using the time to track method of the Inclined Plane Tracking Test specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. The voltage for the Inclined Plane Tracking Test shall not be less than the rated voltage of the equipment.				

**Table 23.2**  
**Generic materials for direct support of uninsulated live parts**

Generic material	Thickness,		RTI, °C
	inch	(mm)	
Diallyl phthalate	0.028	0.71	105
Epoxy	0.028	0.71	105
Melamine	0.028	0.71	130
Melamine-phenolic	0.028	0.71	130
Phenolic	0.028	0.71	150
Unfilled nylon	0.028	0.71	105
Unfilled polycarbonate	0.028	0.71	105
Urea formaldehyde	0.028	0.71	100
Ceramic, porcelain, and slate		No limit	No limit
Beryllium oxide		No limit	No limit
NOTE – Each material shall be used within its minimum thickness and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test, Section <a href="#">60</a> .			

23.2 Vulcanized fiber is capable of being used for insulating bushings, washers, separators, and barriers. However, vulcanized fiber shall not be used as the sole support for uninsulated live parts where shrinkage, current leakage, or warping results in a risk of fire or electric shock.

23.3 Insulating material, including barriers between parts of opposite polarity and material that is capable of being subjected to the influence of the arc formed by the operating of a switch, shall be investigated for use in this application.

23.4 A printed-wiring board for which loosening of the bond between the conductor and base material results in contact between uninsulated primary circuit parts shall comply with the applicable requirements in the Standard for Printed-Wiring Boards, UL 796.

## 24 Internal Wiring

### 24.1 Mechanical protection

24.1.1 Wiring and connections between parts of a product shall be protected or enclosed.

24.1.2 Wires within an enclosure, a compartment, a raceway, or a similar device shall be routed or otherwise protected so that damage to conductor insulation does not result from contact with any rough, sharp, or moving part.

24.1.3 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces to prevent abrasion of the insulation.

24.1.4 Insulated wires are not prohibited from being bunched and passed through a single opening in a metal wall within the enclosure of a product.

### 24.2 Types of wire

24.2.1 Except for intrinsically safe circuits rated not more than 30 volts AC (42.4 volts peak), internal wiring shall consist of wires of a type or types that are rated for the application when evaluated with respect to the temperature, ampacity, and voltage to which the wiring is subjected and with respect to exposure to oil, grease, or other conditions of service to which it is subjected.

24.2.2 Thermoplastic-insulated wire employed for internal wiring shall be standard building wire or appliance wiring material that has been evaluated for the purpose.

24.2.3 Gasoline-resistant wire is not prohibited from being exposed to gasoline vapor (not liquid gasoline) at temperatures within the limits of the temperature rating of the wire type.

24.2.4 A conductor having solid neoprene insulation or other material that has been determined to have equivalent resistance to gasoline vapor is not prohibited from being used for internal wiring and as leads for components, such as motors, ballasts, solenoid valves, or similar items, when it has a temperature rating consistent with its use.

24.2.5 Regarding the requirements specified in [24.2.4](#), appliance wiring material having 90°C (194°F) solid neoprene insulation is not prohibited from being used for internal wiring not exposed to liquid gasoline when the insulation is at least 3/64 inch (1.2 mm) thick for 12 and 14 AWG (3.3 and 2.1 mm<sup>2</sup>) sizes and at least 1/32 inch (0.82 mm) thick for 16 and 18 AWG (1.3 and 0.82 mm<sup>2</sup>) sizes. A braid covering is not required to be provided. Wire having 1/32 inch thick insulation shall not be used in discharge devices rated in excess of 300 volts.

24.2.6 When wiring is not routed near heat-producing components such as resistors, coils ballasts, or similar items, the wire size shall be as specified in [Table 24.1](#). Wiring is applicable to both component leads and other wiring.

*Exception No. 1: Leads furnished with a Class I, Group D motor are not required to comply with the requirements of [Table 24.1](#).*

*Exception No. 2: Wiring is not prohibited from being:*

- a) *Routed near heat-producing components or*
- b) *Smaller than the sizes specified in [Table 24.1](#).*

*Exception: when it complies with the requirements of the Temperature Test, Section [60](#).*

**Table 24.1**  
**Wire size for circuit requirements**

Wire size		Circuits not employing motors, amperes	Circuits for motors, amperes
AWG	(mm <sup>2</sup> )		
18	0.82	6	4.8
16	1.3	8	6.5
14	2.1	15	12.0
12	3.3	20	16.0

## 24.3 Splices and connections

24.3.1 Splices in wiring shall be located only in junction boxes or areas that have been determined to be equivalent.

24.3.2 Each splice and connection shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be mechanically secured before being soldered when breaking or loosening of the connection is capable of resulting in a risk of fire or electric shock.

24.3.3 The requirement in [24.3.2](#) necessitates the use of a lock washer or other means that has been determined to be equivalent to reduce the possibility of a wire-binding screw or a nut being loosened.

24.3.4 A splice shall be provided with insulation that has been determined to be equivalent to that of the wires involved when permanence of spacing between the splice and other metal parts is not maintained.

24.3.5 Insulated or uninsulated aluminum conductors used as internal wiring, such as for internal connection between current-carrying parts or as motor windings, shall be terminated by a method that has been determined to be appropriate for the combination of metals involved at the point of connection.

24.3.6 With reference to the requirements in [24.3.5](#), a wire-binding screw or a pressure wire connector used as a terminating device shall be rated for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and similar conditions.

24.3.7 Insulation consisting of:

- a) Two layers of friction tape;
- b) Two layers of thermoplastic tape; or
- c) One layer of friction tape on top of one layer of rubber tape

is not prohibited on a splice when the voltage involved is less than 250 volts. In determining when splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing complies with the intent of this

requirement, consideration shall be given to such factors as its dielectric properties, heat- and moisture-resistant characteristics, and similar features. Thermoplastic tape is not to be wrapped over a sharp edge.

24.3.8 When stranded internal wire is connected to a wire-binding screw, loose strands of wire shall be positively prevented from contacting an uninsulated live part that is not always of the same polarity as the wire and from contacting a dead metal part. This shall be accomplished:

- a) By use of a pressure terminal connector, soldering lug, or crimped eyelet;
- b) By soldering all strands of the wire together; or
- c) By other means that have been determined to be equivalent.

24.3.9 A nominal 0.110 inch (2.8 mm), 0.125 inch (3.2 mm), 0.187 inch (4.75 mm), 0.205 inch (5.2 mm), or 0.250 inch (6.35 mm) wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes shall be investigated with respect to:

- a) Crimp pullout;
- b) Engagement-disengagement forces of the connector and tab; and
- c) Temperature rises.

All tests shall be conducted in accordance with UL 310.

## 25 Separation of Circuits

25.1 Conductors of circuits operating at different potentials shall be reliably separated from each other unless they are each provided with insulation rated for the highest potential involved.

25.2 An insulated conductor shall be reliably retained so that it is not capable of contacting an uninsulated live part of a circuit operating at a different potential.

25.3 In a compartment that is intended for the field installation of conductors and that contains provision for connection of Class 2 or Class 3 circuit conductors and Class 1 (power or lighting) circuit conductors, as defined in the National Electrical Code, NFPA 70, a barrier shall be provided to separate the conductors of the different circuits, or the arrangement of the compartment shall be such that a minimum spacing of 1/4 inch (6.4 mm) is permanently maintained between the conductors of the different circuits, including the conductors to be field installed.

## 26 Capacitors

26.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container that protects the plates against mechanical damage and that prevents the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall be of metal providing strength and protection not less than that of 0.020 inch (0.51 mm) thick uncoated steel. Sheet metal having a thickness less than 0.026 inch (0.66 mm) shall not be used.

*Exception: The individual container of a capacitor that is made of sheet metal less than 0.020 inch thick or of material other than metal is not prohibited from being used when the capacitor is mounted in an enclosure that houses other parts of the product and when such housing is evaluated for the enclosure of live parts.*

26.2 When a capacitor that is not a part of a capacitor motor or a capacitor-start motor is connected in a product that is intended to be automatically or remotely controlled so that malfunction or breakdown of the capacitor is capable of resulting in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the product to reduce the possibility of such a condition occurring.

26.3 A capacitor connected from one side of the line to the enclosure of a product shall have a capacitance rating of not more than 0.10 microfarad. See [60.1.1](#).

26.4 When a product employs a combination consisting of a rectifier and an electrolytic capacitor, a risk of fire, electric shock, or injury to persons shall not occur when either the rectifier or the capacitor is short-circuited.

26.5 Under both normal and abnormal conditions of use, a capacitor employing a liquid dielectric medium more flammable than askarel shall not expel the dielectric medium when tested in accordance with the applicable performance requirements in this standard.

26.6 When a product is constructed to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit, such a capacitor or unit shall be supplied with the product. See [74.11](#).

## 27 Grounding

### 27.1 General

27.1.1 A product shall have provision for grounding. This requirement also applies to pneumatically-powered pump assemblies.

27.1.2 Means shall be provided so that connection to a field-installed equipment grounding conductor is capable of being made in the same junction box used for field-installed conductors.

27.1.3 Grounding means shall be in accordance with [27.1.4](#) – [27.1.7](#). All exposed dead-metal parts and all dead-metal parts within the enclosure that are exposed to contact during any user servicing operation and are capable of becoming energized shall be reliably connected to the means for grounding.

27.1.4 The equipment grounding terminal or lead at the point at which the power-supply wiring system is connected shall be used for grounding.

27.1.5 When a product is provided with means for separate connection to more than one power supply, each such connection shall be provided with a means for grounding.

27.1.6 A terminal intended solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the application. A connection device that depends on solder alone shall not be provided for connecting the equipment-grounding conductor. A push-in, screwless connector or quick-connect or similar friction fit connector shall not be used for the grounding terminal intended for the connection of field supply connections.

27.1.7 A wire-binding screw or pressure wire connector intended for the connection of an equipment grounding conductor shall be located so that it is not capable of being removed during servicing of the product.

27.1.8 With reference to the requirement in [27.1.3](#), the following dead-metal parts are not capable of becoming energized:

- a) A small metal part, such as an adhesive-attached foil marking, a screw, a handle, and a similar item, that is:



1) On the exterior of the enclosure and separated from all electrical components by grounding metal or

2) Electrically isolated from all electrical components;

b) A panel, cover, or other metal part that is isolated from all electrical components by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material not less than 1/32 inch (0.80 mm) thick and securely mounted in place;

*Exception: A barrier or liner made from other materials or that is less than 1/32 inch thick is not prohibited from being used when it complies with the requirements for internal parts in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.*

c) A panel, cover, or other metal part that does not enclose uninsulated live parts and is electrically isolated from other electrical components; and

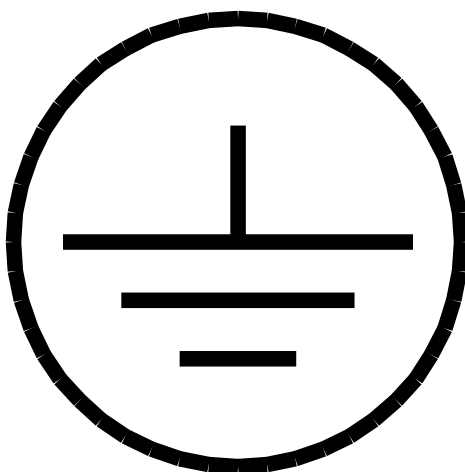
d) Metal parts such as cores and assembly screws of a relay or a solenoid that are positively separated from wiring and uninsulated live parts.

## 27.2 Grounding identification

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

27.2.2 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, or slotted, or both. A pressure wire connector intended for connection of an equipment-grounding conductor shall be plainly identified, such as by being marked "G," "GR," "Ground," "Grounding," or by a similar designation, or by a marking on a wiring diagram provided on the product. The grounding symbol illustrated in [Figure 27.1](#) used as an identifying means complies with the intent of this requirement; however, when used alone, the symbol shall be defined in the installation instructions provided with the product.

**Figure 27.1**  
**Grounding symbol**





## 28 Motors

### 28.1 Construction

28.1.1 A motor intended for use in a Division 1 classified area shall comply with the requirements in the Standard for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations, UL 674. Motors for use in Division 2 Hazardous (Classified) Locations shall comply with the Outline of Investigation for Electric Motors and Generators for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2 and Zone 22 Hazardous (Classified) Locations, UL 1836. Motors for use in unclassified areas shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

28.1.2 A motor shall be successfully evaluated for the application and shall be capable of handling the maximum normal load of the product as described in [60.2.1](#) without creating a risk of fire, electric shock, or injury to persons.

28.1.3 A motor winding shall resist the absorption of moisture.

28.1.4 With reference to the requirement in [28.1.3](#), film-coated wire is not required to be additionally treated to prevent absorption of moisture. However, fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to prevent moisture absorption.

28.1.5 Motors for electrically-operated pump assemblies intended to be used outdoors shall comply with the requirements of the Rain Test, Section [63](#). Pump assemblies complying with the Rain Test shall be marked in accordance with [74.7](#).

### 28.2 Overload protection

28.2.1 A motor for use in an unclassified area shall be provided with overload protection consisting of one of the following:

- a) Thermal protection complying with the applicable requirements in either the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Thermally Protected Motors, UL 1004-3.

*Exception No. 1: For a product that includes a control as mentioned in [28.2.3](#), the duration of the temperature test and the endurance test described in UL 2111 or UL 1004-3, both under locked-rotor conditions, is not prohibited from being less than that specified; however, it shall not be less than the period of operation of the product intended by the manufacturer.*

*Exception No. 2: When the time required to operate a manually-reset protective device through 10 cycles of operation is longer than the time that the product is intended to be operated during each use, the number of operations of the device for the temperature test under locked-rotor conditions is not prohibited from being less than 10 cycles; however, it shall not be less than four cycles.*

- b) Impedance protection complying with the applicable requirements in either the Standard for Overheating Protection for Motors, UL 2111 or Standard for Impedance Protected Motors, UL 1004-2, 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 mentioned in (a).

28.2.2 The control specified in Exception No. 1 to [28.2.1\(a\)](#) is a control that positively and reliably limits the length of time the product can be operated – for example, a timer.

28.2.3 For a multispeed motor, the requirement in [28.2.1](#) applies to all speeds at which the motor is intended to operate.

28.2.4 When a requirement in this standard refers to the horsepower rating of a motor, and the motor is not rated in horsepower, the appropriate table of the National Electrical Code, NFPA 70, that gives the relationships between horsepower and full-load currents for motors shall be used. For a universal motor, Table 430-148 of the NEC – the table applying to a single-phase, AC motor – shall be used when the product is marked for use only on alternating current; otherwise, Table 430-147 of the NEC – the table applying to DC motors – shall be used.

28.2.5 The functioning of a motor-protective device provided as part of a product shall not result in a risk of fire or injury to persons.

28.2.6 Overload devices employed for running-overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system, and in each ungrounded conductor of a 3-phase supply system.

28.2.7 Fuses employed for motor running-overload protection shall be located in each ungrounded conductor; and in the case of a 3-phase, 3-wire, AC motor, the fuses shall be located in each of the three phases.

### 28.3 Brushes and brush holders

28.3.1 A brush cap shall be recessed, enclosed, or otherwise protected from mechanical damage that occurs during the intended use of the product.

28.3.2 A brush cap that is accessible to the user without the removal of a guard or enclosure shall be provided with a positive means that prevents its disengagement from the brush-holder assembly. The use of screw threads on the brush cap as the only means of securing the brush cap to the brush-holder assembly is not a positive means.

28.3.3 A brush-holder assembly shall be constructed so that when a brush is worn out – that is, no longer capable of performing its function – the brush, spring, and other parts of the assembly are retained to the degree required to reduce the risk of:

- a) Accessible dead metal parts becoming energized and
- b) Live parts becoming accessible.

## 29 Overload- or Thermal-Protective Devices

29.1 An overload- or thermal-protective device shall have a current and voltage rating not less than the load that it controls.

29.2 When the current rating of a product is more than 40 amperes, and there are subdivided circuits within the product feeding two or more power-consuming components – motors or motor-control circuits – connected in parallel with each other across any pair of main-supply terminals or leads, overcurrent protection shall be provided as a part of the product for the conductors of each terminal circuit.

*Exception: Additional overcurrent protection is not required as a part of the product for the conductors of the following subdivided circuits:*

- a) *For each separate motor circuit supplied by insulated conductors having an ampacity at least one-third that of the protective device in the branch circuit to which the product shall be connected.*

*b) For each separate motor-control circuit supplied by insulated conductors having an ampacity at least one-fifth that of the protective device in the branch circuit to which the product shall be connected*

29.3 A protective device such as a fuse, the functioning of which requires renewal or replacement, shall be in a readily accessible location. A protective device shall be wholly inaccessible from outside the product 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 are not prohibited from projecting outside the enclosure.*

29.4 A fuseholder shall be constructed and installed so that no uninsulated live part, other than the screw shell or clips, are exposed to contact by persons removing or replacing fuses. The screw shell of a plug-type fuseholder shall be connected toward the load.

### 30 Switches and Controls

30.1 A switch or other control device shall have a current and voltage rating not less than that of the load that it controls.

30.2 With reference to the requirement in [30.1](#), the current rating of a switch that controls an inductive load other than a motor, such as a transformer, shall not be less than twice the rated full-load current of the transformer, unless the switch has been investigated and found capable of handling the load.

30.3 A line-connected, manually-operated single-pole switch or an overcurrent (overload) protective device of the single-pole type, other than an automatic control without a marked "off" position, shall be connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

30.4 A switch or other control shall be guarded or located so that it is not capable of being damaged during the intended use of the product.

30.5 Variable speed motor drives shall be evaluated in accordance with the requirements of the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1.

30.6 Variable-speed motor drives that use electronics that are intended to limit the maximum output pressure of the pump assembly shall be evaluated in accordance with the requirements of the Standard for Limit Controls, UL 353.

30.7 A failure in the electronics of the motor drive described in [30.6](#) during its intended operation is not prohibited when there is no loss of protective function of limiting the maximum output pressure of the pump.

30.8 A blocked outlet of a pump which does not usually experience such a condition shall be considered a fault condition when the product is evaluated in accordance with [30.6](#).

### 31 Spacings

31.1 All uninsulated live parts connected to circuits of different voltage ratings shall be spaced from each other as though they were parts of opposite polarity in accordance with the requirements in [31.3](#) and [31.4](#), and shall be evaluated on the basis of the highest voltage involved.

31.2 The spacing between uninsulated live parts of opposite polarity, and between such parts and dead metal that are capable of being grounded in service is not specified for parts located in low-voltage circuits.

31.3 The spacing between a field-wiring terminal and any other uninsulated live or dead metal part not of the same polarity shall not be less than the applicable value specified in [Table 31.1](#). See [21.5](#) and [31.7](#).

**Table 31.1**  
**Spacings at field-wiring terminals**

Potential involved, volts	Minimum spacings, inch (mm)					
	Between wiring terminals, through air or over surface		Between terminals and other uninsulated metal parts not always of the same polarity <sup>a</sup>			
			Over surface		Through air	
250 or less	1/4	6.4	1/4	6.4	1/4	6.4
More than 250	1/2 <sup>b</sup>	12.7 <sup>b</sup>	1/2 <sup>b</sup>	12.7 <sup>b</sup>	3/8	9.5

<sup>a</sup> Applies to the sum of the spacings involved where an isolated dead part is interposed.

<sup>b</sup> A spacing of not less than 3/8 inch, through air and over surface, is capable of being used at wiring terminals in a wiring compartment or terminal box that is integral with a motor.

31.4 Other than at wiring terminals, the spacing between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead metal part that is exposed to contact by persons or that is capable of being grounded shall not be less than the value specified in [Table 31.2](#).

*Exception: Spacings are not prohibited from being as specified in [31.10](#).*

**Table 31.2**  
**Spacings at other than field-wiring terminals**

Potential involved, volts	Diameter of motor used in product							
	7 inches (178 mm) or less <sup>a</sup>				More than 7 inches (178 mm) <sup>a</sup>			
	Over surface,		Through air,		Over surface,		Through air,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 125	3/32 <sup>b</sup>	2.4 <sup>b</sup>	3/32	2.4	1/4 <sup>c</sup>	6.4 <sup>c</sup>	1/8 <sup>c</sup>	3.2 <sup>c</sup>
126 – 250	3/32	2.4	3/32	2.4	1/4 <sup>c</sup>	6.4 <sup>c</sup>	1/4 <sup>c</sup>	6.4 <sup>c</sup>
251 – 600	1/2 <sup>c</sup>	12.7 <sup>c</sup>	3/8 <sup>c</sup>	9.5 <sup>c</sup>	1/2 <sup>c</sup>	12.7 <sup>c</sup>	3/8 <sup>c</sup>	9.5 <sup>c</sup>

<sup>a</sup> This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and similar items, used solely for motor mounting, cooling, assembly, or connection.

<sup>b</sup> For a motor rated 1/3 horsepower (250 watt output) or less, these spacings shall not be less than 1/16 inch (1.6 mm).

<sup>c</sup> Film-coated wire is determined to be an uninsulated live part. However, a spacing of not less than 3/32 inch over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part complies with the intent of this requirement.

31.5 When an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or when a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing is maintained.

31.6 In a product incorporating two or more motors of different sizes, the spacings in the product shall be evaluated on the basis of the size of the largest motor in the product. See [31.8](#).

31.7 The spacing requirements in [31.3](#) – [31.6](#) do not apply to the inherent spacings of a component of a product, such as a snap switch; such spacings shall be evaluated on the basis of the requirements for the component.

31.8 The spacings in a motor shall comply with the spacing requirements in the Standard for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations, UL 674, Outline of Investigation for Electric Motors and Generators for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2 and Zone 22 Hazardous (Classified) Locations, UL 1836, or the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, as applicable.

31.9 At terminal screws and studs to which connections are made in the field by means of wire connectors, eyelets, or similar parts, as described in [21.5](#), spacings shall not be less than those specified in [Table 31.2](#) when such connectors, eyelets, or similar parts are in such position that minimum spacings – opposite polarity and to dead metal – exist.

31.10 When 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 capable of being grounded,

the spacing shall not be less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the other parts mentioned in (a) – (c) when the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in [Table 31.2](#).

31.11 An insulating lining or barrier of vulcanized fiber or similar materials employed where spacing would otherwise not comply with the requirements of [Table 31.2](#) shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it is not adversely affected by arcing, except that vulcanized fiber not less than 1/64 inch (0.4 mm) thick complies with the intent of this requirement when used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

*Exception: Thinner insulating material complies with the intent of this requirement when it complies with the requirements for internal barriers in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.*

## 32 General

32.1 When the operation and maintenance of a product involves the risk of injury to persons, protection shall be provided to reduce the risk.

32.2 When evaluating a product with respect to the requirement in [32.1](#), consideration shall be given to reasonably foreseeable misuse of the product.

32.3 The adequacy of a guard, a release, an interlock, and a similar part, and whether such a device is required, shall be determined from an investigation of the complete product, its operating characteristics, and the risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any one component, but not more than one component at a time, unless one breakdown contributes to another malfunction. When the investigation shows the breakdown or malfunction of a particular component is capable of resulting in a risk of injury to persons, that component is to be investigated for its reliability.

32.4 Specific constructions, tests, markings, guards, and similar features are detailed for some common constructions. Specific features and products not covered herein shall be given consideration. See Cautionary Markings, Section [75](#).

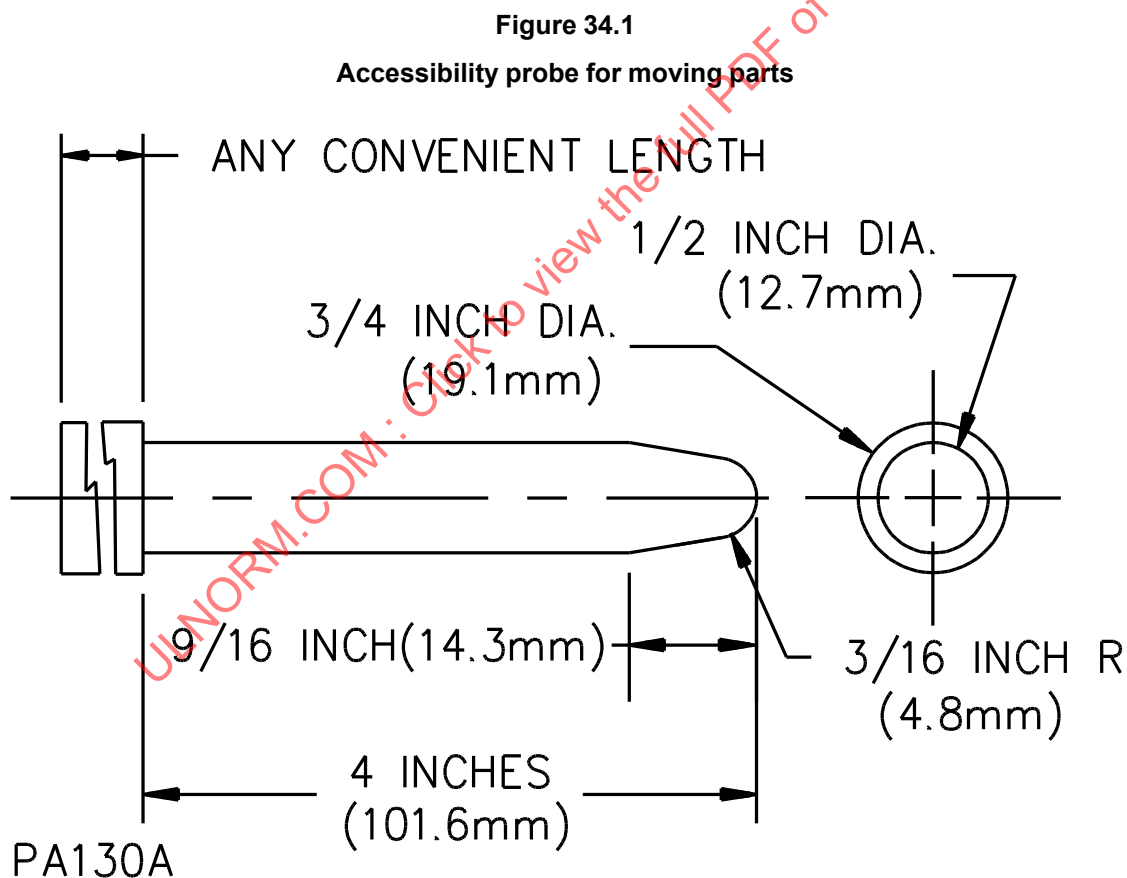
### 33 Sharp Edges

33.1 An enclosure, a frame, a guard, a handle, or a similar part shall not be of such sharpness to constitute a risk of injury to persons during the intended maintenance and use of the product.

### 34 Enclosures and Guards

34.1 A moving part that is capable of causing a risk of injury to persons shall be enclosed, guarded, located, or otherwise arranged to reduce the risk of unintentional contact, and such a part shall not be contacted by the probe illustrated in [Figure 34.1](#).

*Exception: A part or portion of a part that is exposed to contact in order to perform a specific work function is not required to be enclosed; however, when required, guarding shall be provided. See [34.3](#).*



34.2 A moving part that is capable of resulting in a risk of injury to persons shall be evaluated with respect to:

- a) The degree of exposure required to perform the intended function;
- b) The sharpness of the moving part;

- c) The risk of unintentional contact;
- d) The speed of the moving part; and
- e) The risk that a part of the body becomes endangered, or that clothing becomes entangled, by the moving part.

These factors are to be evaluated with respect to both the intended operation of the product and its reasonably foreseeable misuse.

34.3 Some guards are required to be of the self-restoring type. Other features of guards that shall be evaluated include:

- a) The amount of effort required to remove the guard without the use of tools;
- b) The amount of effort required to remove the guard for servicing;
- c) Strength and rigidity;
- d) Completeness; and
- e) The creation of additional risk of injury to persons such as pinch points, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and similar functions.

34.4 An enclosure or guard located over a rotating part shall retain a part that, because of breakage or other reasons, is capable of loosening or separating from a rotating part. The enclosure or guard shall also retain a foreign object that is capable of being struck and propelled by the rotating part.

34.5 When complete guarding of a moving part that obviously causes injury to persons defeats the utility of a product:

- a) A control shall be provided and
- b) A marking shall be provided in accordance with [75.7](#).

34.6 During the examination of a product to determine whether it complies with the requirements in [34.1](#), a part of the enclosure that is capable of being removed without the use of a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

*Exception: A part is not required to be opened or removed when it is marked in accordance with [75.6](#).*

## 35 Materials

35.1 The material of a part, such as an enclosure, a frame, a guard, or similar item, the breakage or deterioration of which is capable of resulting in a risk of injury to persons, shall have such properties as to meet the demand of expected loading conditions.

35.2 The requirement in [35.1](#) applies to those portions of a part that is adjacent to a moving part that has been determined to involve a risk of injury to persons.

## 36 Surface Temperatures

36.1 During the Temperature Test described in Section [60](#), the temperature of a surface that is capable of being contacted by the user shall not be more than the maximum value specified in [Table 36.1](#).



*Exception: The temperature of a pump surface and associated fittings and a motor frame that exceeds the applicable limit specified in [Table 36.1](#) complies with the intent of the requirement when the product is marked in accordance with [75.5](#).*

**Table 36.1**  
**Maximum surface temperatures**

Location	Composition of surface <sup>a</sup>			
	Metallic,		Nonmetallic,	
	°C	(°F)	°C	(°F)
A handle or knob that is grasped for lifting, carrying, or holding	50	122	60	140
A handle or knob that is contacted but does not involve lifting, carrying, or holding, and other surfaces subject to contact in operation and user maintenance	60	140	85	185
A surface subject to casual contact	70	158	95	203
<sup>a</sup> A handle, knob, or similar part made of a material other than metal, that is plated or clad with metal that is less than or equal to 0.005 inch (0.13 mm) thick is determined to be a nonmetallic part.				

36.2 All values for temperatures specified in [Table 36.1](#) are based on a 25° C (77° F) ambient temperature. Tests that are conducted at any ambient temperature within the range of 20 – 30°C (68 – 86° F) comply with the intent of this requirement.

### 37 Locking Mechanism

37.1 When a pump assembly has provision for storing a hose-nozzle valve, it shall be provided with effective means for locking both the motor switch and each hose-nozzle valve. The locking mechanism shall be constructed so that a simple locking operation for each pump control prevents the motor from starting and prevents the discharging of even small quantities of gasoline through the pump outlet. When the locking means is based upon the use of a padlock, the padlock [which has a minimum 1/4 inch (6.4 mm) diameter shackle] is not required to be supplied with the product.

### 38 Control Application

38.1 When a pump assembly has provision for storing a hose-nozzle valve, the motor shall not be energized when the nozzle valve is in the stored position and shall not be able to start simultaneously with the lifting of the hose or its nozzle from its position on the device. A separate intentional manual operation shall be required for closing the starting switch. The motor circuit shall be opened at the time or before the hose is returned to its position on the device following operation.

38.2 As a means of complying with [38.1](#), the motor circuit is not prohibited from being opened by the weight of the hose and nozzle upon replacement in their intended position. Also, interference devices are not prohibited from being provided to prevent replacement of the nozzle until the opening of the motor circuit has been accomplished.

38.3 The discharge of liquid shall occur only when:

- a) The hose-nozzle valve is manually held in the open position or
- b) The hose-nozzle valve is of the automatic-closing type with latch-open device, when the valve mechanism is latched to maintain the valve in the open position.



The discharge of liquid shall be stopped immediately upon the release of the hand control by the operator or the functioning of an automatic-closing mechanism.

## 39 Secondary Circuits

### 39.1 General

39.1.1 A secondary circuit shall either comply with the requirements in [39.1.2](#) – [39.2.2](#), or it shall comply with the requirements for a primary circuit. Any circuit that is relied upon to reduce the risk of fire, electric shock, or injury to persons shall comply with the requirements for a primary circuit.

39.1.2 A low-voltage circuit as defined in [3.5](#) and supplied by a single source consisting of a power transformer or a power supply that includes an isolating transformer is not required to be investigated.

39.1.3 With reference to [39.1.2](#), a low-voltage circuit that complies with the applicable requirements for secondary circuits in the Standard for Industrial Control Equipment, UL 508, is determined to be in compliance with the requirement.

39.1.4 A Class 2 transformer shall comply with the applicable requirements in 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.

*Exception: The temperature rise measured by the resistance method for coils of a Class 2 transformer employing Class 105 insulation systems shall not exceed 85°C (153°F) as specified in [Table 60.1](#).*

39.1.5 Power distribution components, such as bus bars, wiring, connectors, and similar parts, up to and including printed-wiring receptacles and connectors, shall comply with the applicable requirements in Internal Wiring, Section [24](#). Printed-wiring boards and insulated wires used in such circuits shall be rated for the application. See [23.4](#).

### 39.2 Protection of wiring

39.2.1 With reference to [39.1.5](#), wiring located in a secondary circuit shall be routed away from the wiring of other circuits or shall be provided with insulation that is rated for use at the highest voltage of the circuits involved.

39.2.2 In addition to complying with [39.2.1](#), wiring that is part of a secondary circuit shall be provided with strain relief when stresses on the wiring are capable of resulting in the wiring contacting uninsulated live parts of other circuits.

## PERFORMANCE

### 40 General

40.1 A representative sample of each size and specific design of pump is to be subjected to the tests described in these requirements. Additional samples of parts constructed of nonmetallic materials are required for physical and chemical tests.

40.2 Water, kerosene, or Soltrol 170 is to be used for developing the required pressure in a leakage test of liquid confining parts or hydrostatic pressure test. All hydrostatic pressures are to be maintained for at least 10 minutes.

40.3 Clean air or nitrogen is to be used for developing the required pressure in a leakage test of vapor or pneumatic handling parts of a pump. All joints and body surfaces are to be brushed with soap and water or other leak detection solution and determined to be free of any bubbles.

40.4 Endurance tests are to employ kerosene, or the equivalent, as the test medium.

40.5 The investigation of a pump is to be limited to the intended end-use conditions of speed and maximum discharge pressure for which it is recommended.

40.6 All tests on electrically-operated pump assemblies are to be conducted with the product connected to a supply circuit of rated frequency. The voltage and frequency of the supply circuit is to be:

- a) 120 volts, 60 hertz for a product rated from 110 volts up to and including 120 volts, 60 hertz;
- b) 240 volts, 60 hertz for a product rated from 220 volts up to and including 240 volts, 60 hertz; or
- c) The maximum rated voltage for a product rated 60 hertz and other than as specified in (a) or (b).

40.7 A product rated 50/60 hertz is to be tested at the maximum rated voltage for each frequency for the Input Test. Except for the Dielectric Voltage-Withstand Test, Section 61, all other tests shall use the voltage-frequency rating at which the highest input wattage was measured during the Input Test.

40.8 A product rated DC/50 hertz is to be tested at the maximum rated voltage and at the rated frequency.

#### 41 Retention Test for Screws and Bolts

41.1 Screws or bolts used to attach parts which are detached for maintenance or servicing of the pump shall perform their intended function upon the application of the torques indicated in [Table 41.1](#) after their removal and replacement.

**Table 41.1**  
**Maximum torque requirements for screws or bolts**

American standard screw size,		Torque,		I.S.O. screw size,	Torque,	
No.	(mm)	lb-in	(N·m)	mm	N·m	(lb-in)
—	—	—	—	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
inch	(mm)					
1/4	6.4	100	11.3	6	8.7	77
—	—	—	—	7	15.0	133
5/16	7.9	200	22.6	8	23.5	208
—	—	—	—	9	33.6	297
3/8	9.5	350	39.6	10	45.2	400
7/16	11.1	575	65.0	12	81.0	715
1/2	12.7	850	96.0	14	128.0	1130
9/16	14.3	1200	136.0	—	—	—
5/8	15.9	1600	181.0	16	185.0	1640

## 42 Deformation Test

42.1 Joints in a pump shall not leak, nor shall there be evidence of damage resulting from the turning effort exerted on pipe-threaded sections that have been tested as described in [42.2](#) and [42.3](#).

42.2 The sample pump used in this test is to be rigidly anchored or otherwise supported. The male threads shall have pipe joint sealing compound or polytetrafluoroethylene (PTFE) tape applied to them first or be coated as specified by the manufacturer. A section of Schedule 80 pipe of sufficient length for wrench engagement is to be connected to a female pipe-threaded section of the pump. Each pipe then is to be tightened to the torque specified in [Table 42.1](#).

42.3 After the torque force has been applied to each connected pipe or fitting, the pump is to be subjected to the Leakage Test, Section [43](#).

**Table 42.1**  
**Torque requirements for pipe connections**

Pipe size ANSI B36.10M, nominal inches	Outside diameter,		Torque,	
	inches	(mm)	pound-inches	(N·m)
1/8	0.405	10.29	150	17
1/4	0.540	13.72	250	28
3/8	0.675	17.15	450	51
1/2	0.840	21.34	800	90
3/4	1.050	26.67	1000	113
1	1.315	33.40	1200	137
1-1/4	1.660	42.16	1450	164
1-1/2	1.900	48.26	1550	175
2	2.375	60.33	1650	186
2-1/2	2.875	73.03	1750	198
3	3.500	88.90	1800	203
4	4.500	114.30	1900	215

## 43 Leakage Test

43.1 Before being subjected to the Endurance Test, Section [45](#), the liquid confining parts of a pump shall withstand an internal hydrostatic pressure of 1.5 times the maximum discharge or inlet pressure without leakage to the outside, to air confining parts of the pump, or to wiring compartments, and without evidence of casting porosity. This test is to be conducted as described in [43.4](#).

43.2 The air-confining parts of a pneumatically-powered pump shall not leak externally at a rate in excess of 1.5 feet<sup>3</sup> (42,500 cm<sup>3</sup>) per hour when tested with air or nitrogen at the maximum rated pressure.

43.3 In preparing for this test, the means provided for the prevention of or the relief of pressures as described in Pressure Relief, Section [14](#), are to be nullified, and any extractable section of a submersible-type pump is to be disconnected, withdrawn, and reinserted 10 times. Following the tenth withdrawal, there shall be no damage to gaskets, seal rings, or other sealing devices or surfaces, as determined by visual examination.

43.4 The test pump is to be connected to a source of hydrostatic pressure. A positive shutoff valve and a pressure indicating device are to be installed in the supply piping. The pressure indicating device is to be

installed in the piping between the shutoff valve and the test pump. The pressure indicating device shall comply with one of the following.

- a) An analog gauge having a pressure range such that the test pressure is between 30 and 70 percent of the maximum scale reading of the gauge;
- b) A digital pressure transducer, or other digital gauge, that is calibrated over a range of pressure that includes the test pressure; or
- c) Other device that is equivalent to the devices in (a) or (b).

While the pump is under the applied test pressure, the drive shaft or an operating shaft stuffing box or seal, and all joints and body casting surfaces are to be examined for evidence of leakage. See [40.2](#).

43.5 Conduit connections and wiring compartments subject to immersion in or contact with petroleum products, and motors intended to be isolated from such liquids, are to be sealed to prevent leakage at differential pressures up to the maximum discharge pressure or the pressures developed at the maximum immersion depth when tested in accordance with [43.8](#). See Electrical Equipment, Section [20](#).

43.6 For pump assemblies subject to pressure, the conditions specified in [43.5](#) are to be introduced by applying to the external sections of the conduit, compartment, or motor, for at least 1 minute, an aerostatics pressure varying from zero up to the value specified.

43.7 For assemblies subject to immersion, the conditions specified in [43.5](#) comply with the intent of this requirement when no water has entered the conduit, compartment, or motor at the conclusion of the test specified in [43.8](#).

43.8 The complete product is to be mounted in a tank with the conduit connected using a pipe thread sealing compound. The conduit is to be tightened with the torque specified in [Table 42.1](#). The tank is to be filled with water so that the highest point on the enclosure is at the maximum rated immersion depth below the surface of the water or when installed as intended. The enclosure is not required to be submersed to this depth when an equivalent pressure differential between the interior and the exterior of the enclosure is maintained for the required period of time. This differential is capable of being achieved either by reducing the air pressure inside the product or by pressurizing the water surrounding the product. After 30 minutes, the product is to be removed from the tank, the excess water is to be removed from the exterior surface of the product, and the product is to be opened.

43.9 A pump that shows evidence of leakage under conditions of a ruptured diaphragm or bellows, from an untreated vent opening, or around any pins, stems, or linkage passing through the housing in excess of the following rates does not comply with the intent of the requirements in [8.2](#) when the pump is tested to its maximum rated discharge pressure:

- a) One thousand cubic centimeters per hour of water for a pump for use with flammable or combustible liquids, such as gasoline, kerosene, Soltrol 170, and Nos. 1 and 2 fuel oil; or
- b) Two thousand cubic centimeters per hour of the lightest grade of fuel oil heavier than No. 2 for which a pump is to be used.

43.10 Valve mechanisms of an air separator that vents to atmosphere shall withstand a hydrostatic pressure of 75 psig (520 kPa) for one minute without displaying any evidence of leakage within the pump in which the device is located. Prior to the test, the pump in which the valve mechanism is installed is to be prepared in the manner described in [43.3](#) and [43.4](#).

#### 44 Leakage of Wire Seal Test

44.1 A wire seal shall not enable the passage of more than 0.007 cubic foot (200 cc) of air per hour at a pressure of 6 inches (152 mm) of water.

44.2 The number and sizes of wires that are to be sealed in each wire seal are to be as specified in [Table 44.1](#), or shall be the maximum number and size of wires and wire insulation used in the product. The ends of the wires are not prohibited from being sealed during the test.

**Table 44.1**  
**Internal wiring for wire seals**

Conduit trade size of fittings,		Number of wires	Size of wires,	
inches	(mm OD)		(AWG)	(mm <sup>2</sup> )
1/2	21.3	7	18	0.82
3/4	26.7	10	16	1.3
1	33.4	10	14	2.1
1-1/4	42.4	13	10	5.3
1-1/2	48.3	10	8	8.4

#### 45 Endurance Test

45.1 The pump assembly, other than submersible pumps used in parts cleaners, shall not leak after the pump has been subjected to the test described in [45.2](#) and [45.3](#).

45.2 This test is to be conducted on a sample previously subjected to the Deformation Test, Section [42](#), and the Leakage Test, Section [43](#). The test pump is to be connected to an electric motor sized to operate the pump under the following conditions without causing the motor to overheat, or to an air inlet liquid source at the maximum inlet pressure and flow capacity to enable operation of the pump under the following conditions. The pump is to be operated for 300 hours; 250 hours at a pressure differential of 20 percent of the maximum discharge pressure developed by the pump and 50 hours at the maximum discharge pressure developed by the pump. Serviceable components of the pump, except seals, may be replaced upon failure and are defined as rotors, vanes, and shaft keys provided that dynamic seals are undisturbed.

45.3 During this test, operating parts of a pump are to be kept "wet" by a continuous flow of liquid. Other conditions of the test are to simulate, insofar as practicable, those of intended end-use application.

45.4 A test for leakage, as described in the Leakage Test, Section [43](#), is to be conducted on the pump assembly immediately after completion of the Endurance Test, Section [45](#). The pump assembly, other than submersible pumps used in parts cleaners, shall comply with the applicable requirements in Section [43](#).

#### 46 Endurance Test for Air Separators

46.1 The valve mechanism of an air separator constructed as described in [11.2](#) shall be subjected to 100,000 cycles of operation. At the conclusion of the test, the valve mechanism shall continue to function as intended by the manufacturer.

## 47 Blocked Outlet Test

47.1 With an outlet control valve fully closed to direct all of the pump discharge through a bypass or relief valve or to stop the pumping action by the means provided, the discharge pressure of a power-operated pump shall not exceed the maximum discharge pressure.

47.2 This test is to be conducted with normal energy supply (rated voltage, or maximum air or liquid inlet pressure) to the pump using the test liquid employed in the Endurance Test, Section [45](#).

## 48 Pressure Relief Test

48.1 A pump assembly, when de-energized, shall prevent an increase of pressure in excess of the maximum discharge pressure as the result of thermal expansion of the liquid remaining in a closed discharge system. See also [3.1](#).

48.2 Compliance with the requirements in [48.1](#) shall be demonstrated by test unless the pump unit is provided with a bypass valve, a fixed bypass opening, or a relief valve as described in [14.2](#) (a) and (b). The test is to be conducted with the pump unit de-energized and the inlet connection open to observation. A short, valved pipe section is to be connected to the pump discharge opening and connected to a liquid pressure supply. The liquid is to be admitted to the discharge section of the pump until the section has been pressurized to at least 120 percent of the maximum discharge pressure.

48.3 Immediate evidence of liquid being discharged from the inlet connection, the immediate reduction in pressure in the discharge pipe connection to the maximum discharge pressure or lower, or both, are determined to be criteria for compliance with the requirements of this test.

## 49 Hydrostatic Strength Test

49.1 Liquid-handling parts of a pump shall withstand, without rupture or permanent distortion, a hydrostatic pressure five times the maximum discharge pressure for one minute.

49.2 Pneumatic-handling parts of a pump shall withstand, without rupture, a hydrostatic pressure of five times the maximum air inlet pressure applied for one minute.

49.3 The pump sample previously subjected to tests described in Sections [41](#) – [48](#) is to be connected to a source of hydrostatic pressure. A positive shutoff valve and a pressure indicating device, are to be installed in the hydrostatic pressure supply piping. The pressure gauge is to be installed in the piping between the shutoff valve and the pump under test. The pressure indicating device shall comply with one of the following:

- a) An analog gauge having a pressure range such that the test pressure is between 30 and 70 percent of the maximum scale reading of the gauge;
- b) A digital pressure transducer, or other digital gauge, that is calibrated over a range of pressure that includes the test pressure; or
- c) Other device that is equivalent to the devices in (a) or (b).

49.4 External leakage observed during this test does not constitute a failure when, following the hydrostatic test, the pump complies with the requirements specified in the Leakage Test, Section [43](#).

49.5 A conduit seal in a factory sealed device shall withstand for 1 minute, without rupture or permanent distortion, a hydrostatic test pressure of four times the maximum explosion pressure obtained on each side of the seal. When unintended leakage results in the inability of the test apparatus to maintain the

required test pressure in a test of a seal for 2 inches (60.3 mm outside diameter) or larger trade size conduit with wires sealed in place, a device with a seal but without wires is not prohibited from being used. The hydrostatic pressure is to be gradually increased until the required internal pressure is reached. Gaskets or other means are not prohibited from being used when required to prevent leakage of water during application of pressure.

*Exception: A device having a factory installed conduit seal that is not subject to explosion tests on the conduit side of the seal shall withstand without rupture or permanent distortion a hydrostatic test pressure of 600 psig (4140 kPa).*

49.6 An air separator housing that is vented to atmosphere shall withstand rupture or permanent distortion a hydrostatic pressure of 100 psig (690 kPa). An air separator housing that is not vented to atmosphere shall withstand without rupture or distortion a hydrostatic pressure of 250 psig (1720 kPa).

## 50 Float Buoyancy Test

50.1 During this test, the float is to be removed from the actuating mechanism and the force required to actuate the mechanism is to be measured by a force gauge.

50.2 Each float shall be attached to a weight equal to 1.5 times the force measured in accordance with [50.1](#). The float and weight for all three samples are to be placed in the test fluid. The top of the float is not to be beneath the surface of the test fluid.

50.3 The weight noted in [50.2](#) is to be equal to 1.23 times the weight when the test fluid is kerosene or 1.47 times the weight when the test fluid is water.

## 51 Dimensional Stability Test

51.1 A set of three samples of the plastic part for each test fluid shall be used for this test. Prior to the immersion conditioning described in [51.2](#), the dimensions (length and diameter or thickness) of each sample are to be determined with appropriate measuring instruments. Immediately following the immersion conditioning, and after drying in air for  $70 \pm 1.2$  hours at  $23 \pm 2^\circ\text{C}$  ( $73 \pm 3.6^\circ\text{F}$ ), the dimensions of each sample shall be measured. The percentage change in dimensions is to be calculated as specified in the following equation for each of the three samples and averaged.

$$\frac{[(Mb - Ma) \times 100]}{Mb}$$

in which:

*Mb is the dimension of the sample before the immersion conditioning and*

*Ma is the dimension of the sample after the immersion conditioning.*

51.2 Three samples shall be immersed (completely submerged) in vessels containing the test fluids shown in [Table 51.1](#) for 168 hours at  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ )

**Table 51.1**  
**Flammable and combustible liquids<sup>a</sup>**

IRM 903 Oil
ASTM Reference Fuel A
ASTM Reference Fuel C
ASTM Reference Fuel H (85 percent fuel C, 15 percent ethanol)
ASTM reference Fuel I (85 percent fuel C, 15 percent methanol) – only products rated for methanol blends
<sup>a</sup> The fuels and oils referenced in this table are described in Standard Test Method for Rubber Property – Effects of Liquids, ASTM D471.

51.3 At the conclusion of the test described in [51.2](#), the percentage change in dimension shall not change by more than 2 percent.

## 52 Weight Change Test

52.1 A set of three samples of the float for each test fluid shall be used for this test. Prior to the immersion test described in [52.2](#), the weight of each sample is to be determined with an analytical balance. Immediately following the immersion conditioning, and after being dried in air for  $70 \pm 1.2$  hours at  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ), the weight of each sample is to be measured. The percentage change in weight is to be calculated as specified in the following equation for each of the three samples and then averaged.

$$\frac{[(Mb - Ma) \times 100]}{Mb}$$

in which:

*Mb is the weight of the sample before the immersion conditioning and*

*Ma is the weight of the sample after the immersion conditioning.*

52.2 The samples shall be immersed (completely submerged) in vessels containing the test fluids shown in [Table 52.1](#) for 168 hours at  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ).

**Table 52.1**  
**Flammable and combustible liquids for the weight change test<sup>a</sup>**

ASTM Reference Fuel C
ASTM Reference Fuel H (85 percent Fuel C, 15 percent ethanol)
ASTM Reference Fuel I (85 percent Fuel C, 15 percent methanol)
<sup>a</sup> The fuels and oils referenced in this table are described in Standard Test Method for Rubber Property – Effects of Liquids, ASTM D471.

52.3 At the conclusion of the test described in [52.2](#), the percentage change in weight shall not increase by more than 25 percent or decrease by more than 10 percent.

## 53 Float Crushing Test

53.1 Two samples of a hollow float are to be subjected to this test. Each float is to be first checked for freedom from leakage by being suddenly immersed in water heated to a temperature immediately below the boiling point and observed for 3 minutes for the appearance of bubbles. When no leakage is observed, each float then is to be placed in a container of a size and strength suitable for its intended use. The



container is to be connected to a source of hydrostatic pressure, and a calibrated pressure gauge is to be installed in the pressure supply piping. The container is to be completely filled with liquid to expel all air. The pressure then is to be gradually increased over a period of at least 1 minute to 35 psig (240 kPa) and maintained for 1 minute.

53.2 Subsequent to the test, the floats are to be removed from the container and examined for evidence of distortion and leakage. No distortion or leakage is to be observable before and after the float is cut in half.

#### 54 Moist Ammonia-Air Stress Cracking Test

54.1 After being subjected to the conditions described in [54.2](#) – [54.4](#), a pressure confining brass part containing more than 15 percent zinc shall:

- a) Show no evidence of cracking, delamination, or degradation, or
- b) Perform as intended when tested as described in [54.4](#).

54.2 One test sample of each size is to be subjected to the physical stresses normally imposed on or within a part as the result of assembly with other components. Samples with female threads, intended to be used for installing the product in the field, are to have the threads engaged and tightened as specified in [Table 42.1](#). Samples with female threads other than tapered pipe threads shall be torqued as specified by the manufacturer. Polytetrafluoroethylene (PTFE) tape or pipe compound are not to be used on any threads. Samples with male threads are evaluated as received.

54.3 The samples are then to be tested in accordance with Apparatus, Section 6, Reagents and Materials, Section 7, Test Media, Section 8, Test Sample Preparation (9.3 – 9.4), Test Procedure (10.1 – 10.4) of the Standard Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys, ASTM B858-06, except the pH level of the test solution shall be High  $10.5 \pm 0.1$  and the exposure temperature shall be  $25 \pm 1^\circ\text{C}$ .

54.4 After the exposure period, the samples are to be examined for cracks or other signs of stress corrosion using a microscope having a magnification of 25X. Pressure-confining parts exhibiting degradation as indicated in [54.1](#) as a result of the test exposure described in [54.2](#) and [54.3](#) shall withstand, without rupture, a hydrostatic test pressure of five times the rated pressure of the valve, for 1 minute.

#### 55 Tests on Sealing Compounds

55.1 A sealing compound used as a conduit seal as covered in [20.9](#) shall comply with the requirements in [55.2](#) – [55.7](#).

55.2 The resistance to crushing of the sealing compound is to be determined on as-received specimens and specimens exposed to test vapors. The crushing force after exposure is to be at least 85 percent of the value determined using as-received samples. In addition, changes in dimensions and weight after exposure are to be determined. Shrinkage or loss of weight of more than 1 percent or an increase in weight or swelling that changes the intended properties of the sealing compound does not comply with the intent of this requirement. See [55.8](#).

55.3 Cylindrical specimens 1/2 inch (12.7 mm) in diameter and 3/4 inch (19.1 mm) long are to be used for the tests. At least 33 specimens are required – six for each chemical test, and three for the as-received tests.

55.4 The specimens are to be exposed for 168 hours to saturated vapors of the chemicals specified below:

- a) ASTM Reference Fuel C;
- b) ASTM Reference Fuel A;
- c) IRM 903 Oil;
- d) 85 percent ASTM reference fuel C and 15 percent ethanol; and
- e) 85 percent ASTM reference fuel C and 15 percent methanol.

55.5 During and after the exposure, the specimens are to be observed for discoloration, swelling, crazing, leaching, or dissolving.

55.6 After the exposure, three specimens from each chemical exposure are to be weighed and measured immediately after removal from the chemical vapor.

55.7 The other three exposed specimens and the as-received specimens are to be placed between two parallel plates and crushed with a compression-testing machine having a crosshead speed 0.1 inch (2.54 mm) per minute. The load is to be applied perpendicular to the axis of the cylindrical specimens and the compressive force required to crack and break the specimens is to be recorded.

55.8 As an alternative to the requirements of [55.2](#) – [55.7](#), the hydrostatic pressure test described in [55.9](#) is to be used to determine resistance of the sealing compound to chemicals. The hydrostatic pressure test is to be conducted on two complete samples of the pump that incorporate the sealing compound after the samples are exposed to saturated vapors of the chemicals specified in [55.4](#) for 168 hours at 25°C (77°F) and then dried in air for 24 hours after each exposure. This constitutes one cycle. One sample is to be subjected to eight cycles and the other sample to sixteen cycles of exposure and drying for a total of 1536 hours (64 days), and for a total of 3072 hours (128 days). There shall be no rupture, cracking, breakage, or other damage to the sealing compound.

55.9 A conduit seal in a factory-sealed product shall withstand for 1 minute, without rupture or permanent distortion, a hydrostatic test pressure of 600 psig (4140 kPa). When leakage results in the inability of the test apparatus to maintain the required pressure in a test of a seal for 2 inches (60.3 mm outside diameter) or larger trade-size conduit with wires sealed in place, a device with a seal and without wires is to be used.

## 56 Metallic Coating Thickness Test

56.1 The solution to be used for this test is to be made from distilled water and is to contain 200 grams per liter of chemically pure chromic acid ( $\text{CrO}_3$ ); and 50 grams per liter of chemically pure concentrated sulfuric acid ( $\text{H}_2\text{SO}_4$ ). The latter is equivalent to 27 milliliters per liter of chemically pure concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of  $\text{H}_2\text{SO}_4$ .

56.2 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are to be approximately 0.025 milliliters. To maintain an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that the rate of dropping is  $100 \pm 5$  drops per minute when the stopcock is open. When desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

56.3 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room maintained at an ambient temperature of 70 – 90°F (21.1 – 32.2°C).

56.4 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint and other nonmetallic coatings are to be removed completely by means of solvents. Samples then are to be thoroughly rinsed in water and dried. The cleaned surface is not to contact the hands or any foreign material.

56.5 The sample to be tested is to be supported from 0.7 – 1 inch (18 – 25 mm) below the orifice, so that the drops of solution strike the point to be tested and run off. The surface to be tested is to be inclined approximately 45 degrees from horizontal.

56.6 The stopcock is to be opened and the time, in seconds, required for the dropping solution to dissolve the protective metallic coating and expose the base metal is to be measured. Exposure of the base metal is to be considered as the first appearance of the base metal recognizable by the change in color at that point.

56.7 Each sample of a test lot is to be tested at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface, and at an equal number of points on the outside surface, at places on both surfaces where the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

56.8 The thickness of the coating being tested is to be calculated by selecting from [Table 56.1](#) the thickness factor appropriate for the temperature at which the test was conducted, and multiplying that thickness factor by the time, in seconds, required to expose base metal as noted in [56.6](#).

**Table 56.1**  
**Thickness of coatings**

Temperature,		Thickness factors, 0.00001 inches (0.0003 mm) per second	
°F	(°C)	Cadmium platings	Zinc platings
70	21.1	1.331	0.980
71	21.7	1.340	0.990
72	22.2	1.352	1.000
73	22.8	1.362	1.010
74	23.3	1.372	1.015
75	23.9	1.383	1.025
76	24.4	1.395	1.033
77	25.0	1.405	1.042
78	25.6	1.416	1.050
79	26.1	1.427	1.060
80	26.7	1.438	1.070
81	27.2	1.450	1.080
82	27.8	1.460	1.085
83	28.3	1.470	1.095
84	28.9	1.480	1.100
85	29.4	1.490	1.110
86	30.0	1.501	1.120
87	30.6	1.513	1.130
88	31.1	1.524	1.141
89	31.7	1.534	1.150
90	32.2	1.546	1.160

## 57 Coating Liquid Resistance Test

57.1 A protective coating in contact with the liquid shall not show any softening, flaking, or loss of material indicated by a change in the color of the test fluid as a result of immersion in gasoline, gasoline/alcohol blends, diesel fuel, fuel oil, or lubricating oil as specified in the Standard for Gaskets and Seals, UL 157.

57.2 A sample of the protective coating applied to each of the materials used as fluid containing parts shall be filled with the test liquids for 70 hours and the liquids are to be maintained at a temperature of  $23 \pm 2^{\circ}\text{C}$  ( $73.4 \pm 3.6^{\circ}\text{F}$ ). The test fluid and the coating on the sample are to be examined immediately after emptying the sample.

## 58 Starting Current Test

58.1 A pump shall start and operate as intended by the manufacturer on a circuit protected by a non-time-delay fuse having a current rating corresponding to that of the branch circuit to which the pump is intended to be connected. The performance does not comply with the intent of this requirement when the fuse opens or an overload protector provided as part of the pump trips.

*Exception: A pump that meets all of the following conditions is not required to comply with these requirements:*

- a) The construction of the pump or the nature of its use is such that the pump is used continuously on the same branch circuit after installation;*
- b) The pump starts and operates as intended on a circuit protected by a time-delay fuse; and*
- c) The product is marked in accordance with [74.10](#).*

58.2 To determine compliance with the requirement in [58.1](#), the pump is to be started three times from a standstill without the opening of the fuse. The pump is to be at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation, and the motor is to come to rest between successive starts. The outlet of the pump is to be blocked.

## 59 Input Test

59.1 The current or wattage input to a product shall not be more than 110 percent of the rated value when the product is operated until well heated, under the condition of maximum normal load as described in [60.2.1](#) and when connected to a supply as specified in [40.6](#).

## 60 Temperature Test

### 60.1 General

60.1.1 A pump, when tested under the conditions of maximum normal load, as described in [60.2.1](#), shall not exceed the temperature rises specified in [Table 60.1](#).

*Exception: A maximum temperature measured on a pump that exceeds the temperature rises specified in [Table 60.1](#) complies with the intent of this requirement when the elevated temperature is determined not to result in a risk of fire or damage to materials used in the product in which the pump is installed.*

60.1.2 A thermal- or overload-protective device shall not open the circuit during the temperature test.

60.1.3 All values of temperature rise in [Table 60.1](#) are based on an assumed ambient temperature of 25° C (77°F). Tests that are conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F) meet the intent of this requirement. The test fluid being pumped is to be maintained at a temperature in the range of 15 – 25°C (59 – 77°F).

**Table 60.1**  
**Temperature rises**

Materials and components	°C	(°F)
<b>A. MOTORS</b>		
1. Class A insulation systems on a coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor and on a vibrator coil <sup>a, b</sup>		
a) In an open motor and on vibrator coil:		
Thermocouple or resistance method	75	135
b) In a totally enclosed motor:		
Thermocouple or resistance method	80	144
2. Class A insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm), of a DC motor and of a universal motor <sup>a, b</sup>		
a) In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
b) In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
3. Class B insulation systems on coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor <sup>a, b</sup>		
a) In an open motor:		
Thermocouple or resistance method	95	171
b) In a totally enclosed motor:	100	180
Thermocouple or resistance method		
4. Class B insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm), of a DC motor, and of a universal motor <sup>a, b</sup>		
a) In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
b) In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
5. Class F insulation systems on coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor <sup>b</sup>		
a) In open motor:	120	216
Thermocouple or Resistance Method	125	225
b) In totally enclosed motor:		
Thermocouple or Resistance Method	125	225
<b>B. COMPONENTS</b>		
1. Capacitors:		

**Table 60.1 Continued on Next Page**

Table 60.1 Continued

Materials and components	°C	(°F)
a) Electrolytic	40 <sup>c</sup>	72 <sup>c</sup>
b) Other types	65 <sup>d</sup>	117 <sup>d</sup>
2. Fuses	65 <sup>e</sup>	117 <sup>e</sup>
3. Relay, solenoid, and coils (except motor coil windings and transformers) with		
a) Class 105 insulation systems:		
Thermocouple method	65	117
Resistance method	85	153
b) Class 130 insulation systems:		
Thermocouple method	85	153
Resistance method	95	171
c) Class 155 insulation systems:		
Thermocouple method	95	171
Resistance method	115	207
d) Class 180 insulation systems:		
Thermocouple method	115	207
Resistance method	135	243
4. Sealing Compound	40	104 less than melting point
5. Synthetic rubber materials	35 <sup>f</sup>	63 <sup>f</sup>
6. Transformers		
a) Class 155 insulation systems:		
Thermocouple method	110	198
Resistance method	115	207
b) Class 180 insulation systems:		
Thermocouple method	125	225
Resistance method		
C. CONDUCTORS	135	243
Rubber- or thermoplastic insulated wires and cords	35	63 <sup>f,g</sup>
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	65	117
2. Phenolic composition employed as electrical insulation or as a part, the deterioration of which results in a risk of fire or electric shock <sup>e</sup>		
Laminated	100	180
Molded	125	225
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. A surface upon which a product may be or mounted in service, and a surface that may be adjacent to the product when it is so placed or mounted	65	117
2. Any point within a terminal box or wiring compartment of a permanently connected product in which power-supply conductors are to be connected, including such conductors themselves, unless the product is marked in accordance with 74.13.	35	63
3. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the product	65	117

<sup>a</sup> See 60.1.4 and 60.2.

Table 60.1 Continued on Next Page

**Table 60.1 Continued**

Materials and components	°C	(°F)
<sup>b</sup> For a motor rated 1/3 horsepower (250 watts output) or less, these spacings are not prohibited from being less than 1/16 inch (1.6 mm). <sup>c</sup> For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum temperature rise on insulating material integral with the capacitor enclosure is not to be more than 65°C (117°F). <sup>d</sup> A capacitor that operates at a temperature rise of more than 65°C (117°F) is not prohibited from being judged on the basis of its marked maximum temperature limit. <sup>e</sup> A fuse that has been investigated and successfully evaluated for use at a higher temperature is not prohibited from being used at that temperature. These limitations do not apply to compounds and compounds such as fuses that have been successfully investigated for use at a higher temperature. <sup>f</sup> A synthetic rubber material that operates at a temperature rise of more than 35°C (63°F) complies with the intent of this requirement when investigated for the higher service temperature in accordance with the Standard for Gaskets and Seals, UL 157. <sup>g</sup> A rubber-insulated conductor within a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord when entering a motor are not prohibited from being subjected to a higher temperature when the conductor is provided with sleeving or a braid that has been investigated and successfully evaluated for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.		

60.1.4 At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by a means of a thermocouple that is more than the maximum temperature specified in [Table 60.1](#) meets the intent of this requirement when the temperature, as measured by the resistance method, is not more than that specified in [Table 60.2](#).

**Table 60.2**  
**Maximum coil temperatures**

Subitem of item in <a href="#">Table 60.1</a>	Additional temperature rise,	
	°C	(°F)
1. (a) of item A1	5	9
2. (a) of item A3	10	18
3. (a) of item A2	15	27
4. (a) of item A4	20	36

60.1.5 For the temperature test, the voltage shall be as indicated in [40.6](#).

60.1.6 A product having a single frequency rating is to be tested at that frequency. A product rated AC/DC or DC or 60 hertz is to be tested on direct current or 60-hertz AC, whichever results in higher temperatures. A product rated 25 – 60 hertz or 50 – 60 hertz is to be tested at the voltage and frequency rating at which the highest input wattage was measured during the Input Test, Section [59](#).

60.1.7 For a product that is obviously not intended for continuous operation, the probable intermittent or short-time operation of the product is to be taken into consideration when conducting the temperature test.

60.1.8 With reference to those tests that are to be continued until constant temperatures are attained, thermal equilibrium exists when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, however, not less than 5-minute intervals, indicate no change.

60.1.9 Coil winding temperatures are to be measured by thermocouples or by using the change-of-resistance method, whichever is appropriate. For a thermocouple-measured temperature of a coil of an alternating-current motor having a diameter of 7 inches (178 mm) or less, and a universal motor – see items 1 and 3 in [Table 60.1](#) – the thermocouple is to be mounted on the integrally applied insulation on the

conductor. For any other motor, the thermocouple is to be applied on the outer surface of a wrap that is not more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or similar materials.

60.1.10 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm<sup>2</sup>) and not smaller than 30 AWG (0.05 mm<sup>2</sup>). Whenever referee temperature measurements by thermocouples are required, thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

60.1.11 When using the resistance method, the windings are to be at room temperature at the start of the test, and the temperature rise of a winding is to be calculated using the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

$\Delta T$  is the temperature rise in °C,

$R$  is the resistance of the coil in ohms at the end of the test,

$r$  is the resistance of the coil in ohms at the beginning of the test

$k$  is 234.5 for copper and 225.0 for electrical conductor grade (C) aluminum; values of the constant for other conductors are to be determined,

$t_1$  is the temperature in °C of the coil at the time resistance " $r$ " is being measured, and

$t_2$  is the room temperature in °C at the time resistance " $R$ " is being measured.

## 60.2 Maximum normal load

60.2.1 Maximum normal load is determined to be the load that approximates as closely as possible the most severe conditions of intended use. It is not a deliberate overload except as the conditions of actual use are somewhat more severe than the maximum load conditions that are specified by the manufacturer of the product. A product having features not contemplated in these test procedures is not prohibited from being tested as required to meet the intent of these requirements.

## 61 Dielectric Voltage-Withstand Test

61.1 A pump shall withstand for 1 minute without breakdown the application of a 60-hertz primarily sinusoidal potential between:

- a) Live parts and dead metal parts;
- b) Circuits that operate at different potentials and are not electrically connected; or
- c) Live parts of opposite polarity,

with the product at the maximum operating temperature reached during intended use.

61.2 The potential for the test described in [61.1](#) is to be:

- a) One thousand volts for a pump employing a motor rated 1/2 horsepower (373 watts output) or less and 250 volts or less;



- b) One thousand volts plus twice the rated voltage for a pump employing a motor rated at more than 1/2 horsepower or more than 250 volts; or
- c) One thousand volts plus twice the rated voltage between the terminals of a capacitor used for radio-interference elimination or arc suppression.

61.3 The test potential for the secondary circuit of a product employing a transformer shall be:

- a) One thousand volts plus twice the operating voltage when the secondary operates at 251 – 600 volts;
- b) One thousand volts when the secondary operates at 51 – 250 volts; or
- c) Five hundred volts when the secondary operates at 50 volts or less.

*Exception: This does not apply when the secondary circuit is supplied from a Class 2 transformer.*

61.4 To determine whether a product complies with the requirements in [61.1](#) – [61.3](#), the product is to be tested by means of a 500 volt-ampere or larger transformer, having an output voltage that is primarily sinusoidal and is capable of being varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by a voltmeter.

*Exception: A 500 volt-ampere or larger capacity transformer is not required to be used when the transformer is provided with a voltmeter to measure directly the applied output potential.*

61.5 When the secondary circuit is grounded at one or more points, the grounding points are to be removed for the test covered in [61.3](#) and [61.4](#).

## 62 Grounding Continuity Test

62.1 The resistance between the point of connection of the equipment-grounding means at or within the product and any other point in the grounding circuit of the product shall not be more than 0.1 ohm.

62.2 Determination of whether the product complies with the requirement in [62.1](#) is to be made by an ohmmeter or similar test equipment, except that when results that do not comply with the requirements in [62.1](#) are observed, an alternating current of 20 amperes or more from a power supply of 12 volts or less is to be passed from the point of connection of the equipment grounding means to the metal part in the grounding circuit, and the resulting drop in potential is to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

## 63 Rain Test

63.1 A product intended for outdoor use is to be conditioned as described in [63.3](#). There shall be no obvious wetting of any electrical component, and no water shall enter a compartment that houses field-installed wiring. Following the test, the product shall comply with the requirements of the Dielectric Voltage Withstand Test, Section [61](#), and the Insulation Resistance Test, Section [66](#).

63.2 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as illustrated in [Figure 63.1](#). The spray heads are to be constructed in accordance with the details illustrated in [Figure 63.2](#). The water pressure for all tests is to be maintained at 5 psig (34.5 Pa) at each spray head. The product is to be brought into the focal area of the three spray heads in such a position and under such

conditions that result in the entrance of water into the enclosure. The spray is to be directed at a 45 degree angle to the vertical toward the product. The total exposure is to be for 1 hour.

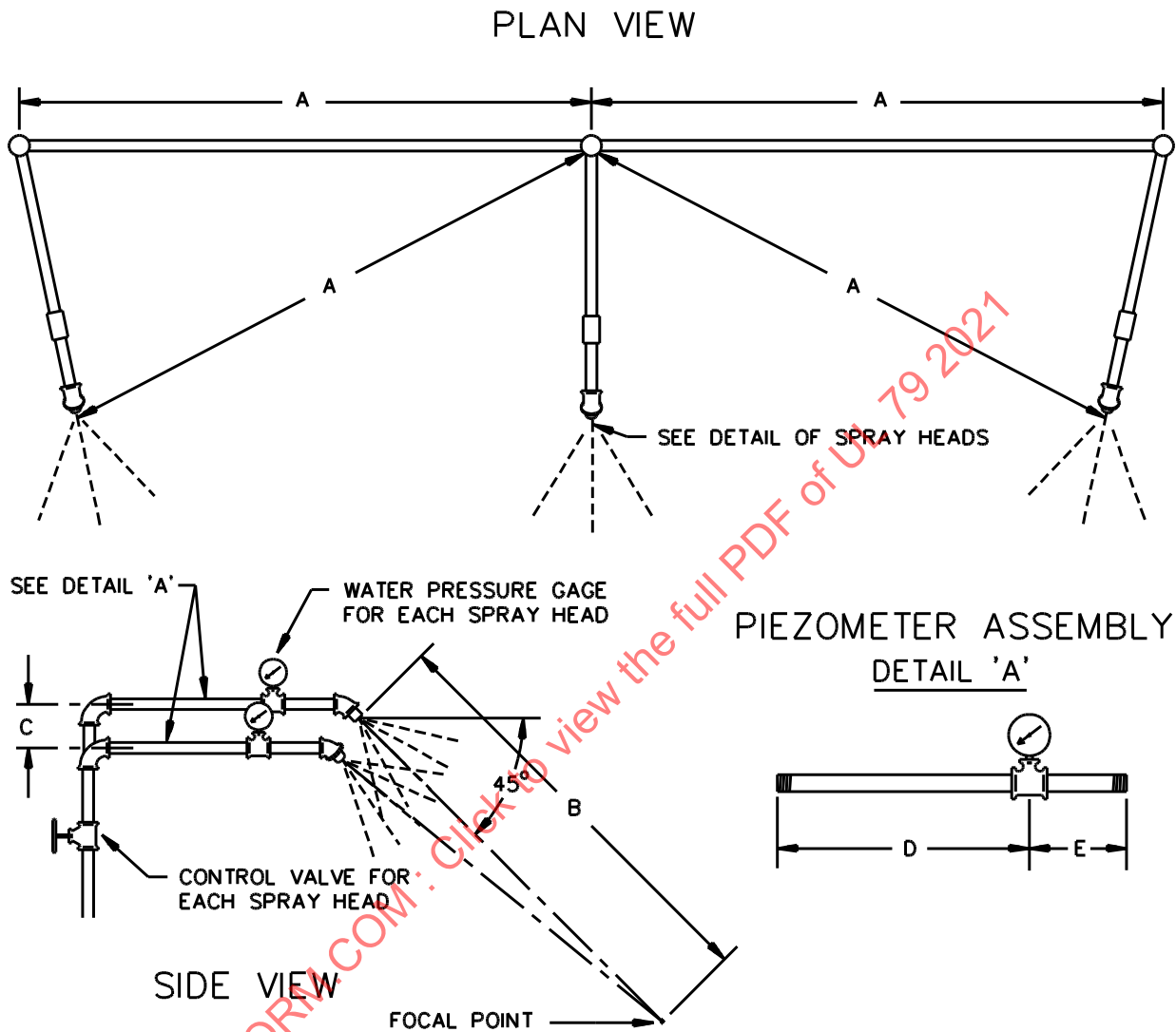
63.3 With reference to the test described in [63.2](#);

- a) The product is not prohibited from being operated in various positions or under various modes of operation or
- b) More than one sample is not prohibited from being tested

when alternate modes are possible. The product is to be de-energized when such a condition is capable of leading to more adverse conditions.

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Figure 63.1  
Rain-test spray-head piping



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