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UL 1861

OUTLINE OF INVESTIGATION
FOR
POWER-OPERATED CHEMICAL PUMPS

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Summary of Topics

This third issue of Outline of Investigation for Power-Operated Chemical Pumps, Subject 1861 is being issued to update requirements for pumps intended for use with nonflammable and noncombustible liquids, and the use of nonmetallic materials with these pumps.

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically powered chemical pumps rated 600 V or less and installed in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements do not cover pumps rated more than 600 V. In addition, 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 for use with flammable or combustible liquids intended for motor vehicles, which are evaluated under the Standard for Power Operated Pumps For Petroleum Dispensing Products, UL 79.
- g) Pumps that are 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.
- h) Pumps for handling liquids under cryogenic temperatures less than minus 60°C (minus 76°F).

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this Outline shall comply with the requirements for that component.

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 Outline, or
- b) Is superseded by a requirement in this Outline.

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

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

2.2 Units of measurement

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

2.3 Undated references

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

3 Glossary

3.1 For the purpose of this outline, the following definitions apply.

3.2 INTENDED CARE AND USAGE – Intended care means tasks such as lubrication and cleaning. Intended usage covers the manipulations involved in normal operation of the pump.

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

3.4 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 transformer and a fixed impedance that, as a unit, complies with the performance requirements for Class 2 transformers in accordance with the Standard for Class 2 and Class 3 Transformers, UL 1585.

3.5 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 the 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 68.9.

5 Materials

5.1 General

5.1.1 A part in contact with the fluid to be handled shall be resistant to the action of the fluid if degradation of the part results in:

- a) Leakage;
- b) Unsafe functioning of equipment; or
- c) A risk of injury to persons.

5.1.2 Metallic materials shall comply with 5.2 and can be used with any fluid provided it complies with 5.1.1. Nonmetallic materials, other than for gaskets and seals, shall comply with 5.3. Nonmetallic materials shall also comply with 5.1.1, but shall only be used with nonflammable and noncombustible fluids.

5.1.3 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.

5.1.4 The requirement in 5.1.3 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 27.1; or
- d) Short-circuiting live parts.

5.2 Metallic materials

5.2.1 Except as indicated in 5.2.2, metallic liquid confining parts shall have a melting point (solidus temperature) of not less than 510°C (950°F) and a tensile strength of not less than 10,000 psi (69 MPa) at 204°C (400°F) when the fluid being confined is classified as flammable or combustible. If the fluid is not classified, then no minimum solidus temperature or tensile strength is defined.

5.2.2 A brazing material used for joining flammable or combustible liquid confining parts of a pump shall have a melting point (solidus temperature) exceeding 538°C (1000°F). For pumps intended for use with non-classified liquids, no minimum solidus temperature is defined.

5.2.3 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

5.2.4 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.

5.2.5 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.

5.2.6 A coating as specified in 5.2.5 need not be provided on ferrous materials used for fluid confining parts having the following thicknesses:

- a) Casting having a wall thickness of not less than 6.4 mm (1/4 inch);
- 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 2.36 mm (0.093 inch).

5.2.7 A protective coating as specified in 5.2.5 shall provide resistance to corrosion to a degree not less than that provided by the protective coatings indicated in 5.2.8.

5.2.8 Cadmium plating shall have a thickness of not less than 0.008 mm (0.0003 inch) and zinc plating shall have a thickness of not less than 0.013 mm (0.0005 inch). 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 0.0038 inch (0.00015 inch) as determined by the Metallic Coating Thickness Test, Section 48.

5.2.9 A protective coating indicated in 5.2.7 or other coatings in contact with the liquid shall be resistant to the action of the liquid, as indicated in the Coating Liquid Resistance Test, Section 49.

5.2.10 A part made of drawn brass or machined from brass rod, and consisting of 15% or more zinc content, shall withstand the 10-Day Moist Ammonia-Air Stress Cracking Test, Section 47, without cracking.

5.3 Nonmetallic materials

5.3.1 Nonmetallic materials used as fluid confining parts shall have a thickness that is suitable for showing compliance with 6.1.

5.3.2 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 44, 60, 61, and 62.

5.4 Gaskets and seals

5.4.1 An elastomeric part used in contact with the liquid 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 60°C (140°F), 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 29°C (minus 20°F).
- c) Volume change of 25% maximum and extraction of 10% maximum when tested as specified in the requirements for UL 157, using the fluids that the pump is intended to be used with.

5.4.2 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 60°C (140°F), 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 29°C (minus 20°F).

5.4.3 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 25 mm (1 inch). 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.

6 Bodies, Covers, and Heads

6.1 A pump body assembly shall withstand the deformation, leakage, and hydrostatic strength test requirements of this Outline.

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 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 38.

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 provided with a coating that is equivalent to the coatings indicated in 5.2.7.

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 part coming in contact with a diaphragm shall have no sharp edges, burrs, projections, or 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 68.8.

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 43.

10.2 A hollow float shall withstand an external crushing pressure of not less than 35 psig (240 kPa). See the Float Crushing Test, Section 46.

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 also comply with the Dimensional Stability Test, Section 44, and the Weight Change Test, Section 45.

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 Section 39. When the valve mechanism closes a vent to atmosphere, it shall also be subjected to the leakage test described in Section 37.

12 Pressure Relief

12.1 A pump provided with means to relieve pressures developed within the pump that exceed the rated pressure of the pump, shall comply with one of the following:

- a) The Pressure Relief Test, Section 41;
- b) A bypass valve connected between the discharge and suction ports;
- c) A relief valve arranged to be connected between the discharge side and the supply tank through a separate return line.

12.2 After the valve or other means for pressure relief has been adjusted or set, 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.

13 Mounting and Base

13.1 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.

13.2 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.

14 Guards

14.1 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.

15 Piping and Fittings

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

15.2 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 the tests in Sections 35, 36, 37, 42, and 47 as complete assemblies forming part of the pump.

15.3 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.

15.4 A male thread for attachment to pipe fittings shall have no shoulder within the distance specified in Table 15.1, from the beginning of the thread, including any chamfer, or 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 15.1
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

15.5 A threaded pipe connection shall be made with litharge and glycerin cement, shellac, shellac and inert powder filler, or a suitable pipe-joint sealing compound.

15.6 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.

15.7 Tubing may be used where it is protected by its location in the pump assembly or by its intended installation location.

15.8 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 0.005 mm (0.0002 inch) thick.

15.9 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 15.2.

Table 15.2
Wall thickness for aluminum copper and steel tubing

Outside diameter,		Minimum wall thickness			
		Aluminum and copper,		Steel,	
inch	(mm)	inch ^a	(mm) ^a	inch ^a	(mm) ^a
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

^a Nominal wall thickness of tubing is required to be greater than the thickness indicated to maintain the minimum wall thickness.

15.10 Steel tubing of the wall thickness specified in Table 15.2 shall be protected with a corrosion resistant coating that has been determined to be equivalent to that provided by hot-dip galvanizing.

16 Electrical Equipment

16.1 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.

16.2 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.

16.3 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 specified in the National Electrical Code, NFPA 70. All boxes, fittings, and joints shall be threaded for connection to conduit or cable terminations. At least five full threads shall engage in each threaded joint.

16.4 One end of a wireway, between two parts that are factory attached to an assembly, may be 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.

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

16.6 A terminal box threaded to conduit enclosing wiring 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.

16.7 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 shall be coated with litharge and glycerine.

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

16.9 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.

16.10 A pump assembly intended 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.

16.11 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 16.1. 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 mm²). 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 mm²) when the wire size is marked on the installation wiring diagram.

Table 16.1
Size of junction boxes

Size of conductor,		Free space within box for each conductor			
		Box with hubs,		Box without hubs,	
AWG	(mm ²)	cubic inches	(cm ³)	cubic inches	(cm ³)
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

16.12 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 16.1 as the summation of the volumes required for each field furnished conductor plus the volume utilized by the factory installed wiring and terminal block.

16.13 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 the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

16.14 Upper ends of conduit subject to immersion or to entry of water 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 that has been successfully evaluated for use in this application. See Tests on Sealing Compounds, Section 63.

17 Supply Connections

17.1 General

17.1.1 Products covered under this Outline shall be provided with a flexible power supply cord and a grounding type attachment plug for connection to the supply circuit, or they shall be provided with means for permanent connection to the supply.

Exception: Equipment intended to be used with a detachable power supply cord is acceptable without provision of the detachable power supply cord if the equipment is marked in accordance with 68.13, and the instruction manual contains instructions as described in 66.3.2 concerning the proper selection of the power supply cord.

17.2 Cord connected products

17.2.1 General

17.2.1.1 A flexible cord shall be rated for a voltage not less than the rated voltage of the equipment, and shall have a current rating not less than the current rating of the equipment.

17.2.1.2 The flexible cord shall be Type SJ, SJT, SJO, SJOO, SJTO, or SJTOO, or a type equally serviceable for the application.

17.2.1.3 A flexible cord shall be attached permanently to the equipment or shall be in the form of a separate cord set with means for connection to the equipment.

17.2.1.4 The length of the power supply cord, including the attachment plug, shall not be less than 1.8 m (6 feet).

17.2.2 Strain relief

17.2.2.1 Strain relief shall be provided on a non-detachable flexible cord to reduce the risk of mechanical stress being transmitted to terminals, splices, or interior wiring. See Strain Relief Test, Section 57. A knot in the flexible cord is not considered an acceptable form of strain relief.

17.2.2.2 A metal strain relief clamp or band provided in accordance with 17.2.2.1 shall be provided with auxiliary insulation over the cord if damage to the cord insulation results when the strain relief test is conducted without auxiliary insulation.

17.2.2.3 Means shall be provided to prevent a flexible cord from being pushed into the equipment through the cord entry hole if such displacement would:

- a) Result in mechanical damage to the cord;
- b) Expose the cord to a temperature higher than that for which it is rated; or
- c) Reduce spacings, such as to a metal strain relief clamp, below minimum acceptable values.

To determine compliance, the supply cord shall be tested in accordance with the Strain Relief Test, Section 57.

17.2.3 Bushings

17.2.3.1 At the point where a non-detachable flexible cord passes through an opening in a wall, barrier, or the enclosure, there shall be a bushing or the equivalent that is secured in place, and that has a smooth, well-rounded surface against which the cord may bear. An insulating bushing shall be provided, if the wall or barrier is of metal, or if the construction is such that the cord may be subjected to strain or motion.

17.2.3.2 A hole in porcelain, phenolic composition, or other non-conducting material, having a smooth rounded surface, is considered to be equivalent to a bushing.

17.2.3.3 A bushing of the same material as, and molded integrally with, a supply cord is acceptable if the built-up section is not less than 1.6 mm (1/16 inch) thick at the point where the cord passes through the enclosure.

17.2.3.4 At a point of flexure, no additional flexible cords or wires shall be routed through a bushing or opening with the power supply cord.

17.3 Permanently connected products

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

17.3.2 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.

17.3.3 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.

17.3.4 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 17.3.8.

17.3.5 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 part – to the terminal, are provided as part of the product.

17.3.6 Wiring terminals for the supply conductors – See Grounding, Section 23, 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 mm²) or smaller conductor when upturned lugs or parts that have been determined to be equivalent are provided to hold the wire in place.

17.3.7 A wiring terminal shall be prevented from turning.

17.3.8 A lead inside an outlet box or wiring compartment shall not be smaller than 18 AWG (0.82 mm²), and rated for the maximum operating voltage of the pump assembly. The free length of the lead shall be 150 mm (6 inches) or more when the lead is intended for field connection to an external circuit.

Exception No. 1: A lead that is less than 150 mm 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 mm²) unless arranged or guarded to protect from damage during field wiring.

17.3.9 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 mm²) 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 mm²) conductor. See 17.3.13.

17.3.10 The smallest conductor that is specified in the National Electrical Code, NFPA 70, for use in branch circuit wiring is 14 AWG (2.1 mm²). Therefore, the smallest conductor that is anticipated at a terminal for connection of a power supply wire is 14 AWG.

17.3.11 A wire binding screw shall thread into metal.

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

Exception No. 1: A terminal plate less than 1.27 mm thick but not less than 0.76 mm (0.030 inch) thick may be used when the tapped threads result in a secure connection in which the threads do not strip upon the application of a 2.25 N·m (20 pound-inch) tightening torque.

Exception No. 2: A terminal plate formed from stock not less than 1.27 mm thick may have the metal extruded at the tapped hole to provide two full threads.

17.3.13 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 17.3.4 under the head of the screw or washer.

17.3.14 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.

17.3.15 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.

17.3.16 Conductors intended for field connection to a grounded supply conductor shall be identified (finished a white or natural 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, natural gray, or green with or without one or more yellow stripes.

17.3.17 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.

17.3.18 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 64.

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.

18 Current Carrying Parts

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

18.2 Iron or steel should not be used as a current carrying part unless it is protected by a suitable corrosion resistant coating.

Exception No. 1: This requirement does not apply to parts within a motor.

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

19 Insulating Material

19.1 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 19.1. 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 19.2 complies with 19.1 without additional evaluation.

Table 19.1
Minimum material characteristics for the direct support of uninsulated live parts

Flame class	RTI Electrical	Maximum performance level category (PLC)		
		HWI ^{b,c}	HAI ^{d,e}	CTI ^{f,g,h}
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

Relative Thermal Index (RTI)

^a 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 52.

Hot Wire Ignition (HWI)

^b 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.

^c A material without an HWI Performance Level Category (PLC) value or with a HWI PLC value greater (worse) than the value required by Table 19.1 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.

High Current Arc Resistance to Ignition (HAI)

^d 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.

^e A material without an HAI PLC value or with an HAI PLC value greater (worse) than the value required by Table 19.1 shall be subjected to the end-product Arc Resistance Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Comparative Tracking Index (CTI)

^f 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.

^g A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by Table 19.1 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.

^h 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 19.2
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 52.			

19.2 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.

19.3 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.

19.4 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.

20 Internal Wiring

20.1 Mechanical protection

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

20.1.2 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.

20.1.3 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.

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