UL 778

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Motor-Operated Water Pumps

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UL Standard for Safety for Motor-Operated Water Pumps, UL 778

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

Future Effective Date	References
August 28, 2003	Paragraphs 13.2.4.1, 55.5, 55.5.1, Tables 13.1, 13.2, 13.3

The revisions dated August 27, 2002 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

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American National Standard

APRIL 26, 1996 **ANSI/UL 778-2002**

(Title Page Reprinted: August 27, 2002)

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UL 778

Standard for Motor-Operated Water Pumps

First Edition – October, 1980
Second Edition – October, 1991

Third Edition

April 26, 1996

The most recent approval of UL 778 as an American National Standard (ANSI) occurred on July 10, 2002 and covers the Third Edition including revisions through August 27, 2002. Approval of UL 778 as an American National Standard is maintained using the continuous maintenance process. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-SC Standards Department, 1655 Scott Blvd, Santa Clara, CA 95050.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

The Department of Defense (DoD) has adopted UL 778 on March 11, 1991. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover submersible and nonsubmersible motor-operated pumps intended to be used in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements do not cover pumps rated more than 600 volts, pumps using universal motors rated more than 250 volts, pumps for fire protection service, pumps for use as or with swimming or wading pool equipment, therapeutic baths, and similar equipment, nor pumps covered by other individual requirements. These requirements do not cover pressure controls or pressure tanks that are intended for use in water or other liquid systems.

1.2 revised February 28, 2002

1.3 A pump not covered by any of the definitions in Glossary, Section 3, and a pump intended for use with liquids other than water, shall be evaluated on the basis of its compliance with the requirements in this standard, and further examination and tests required to determine whether it is acceptable for the purpose.

1.4 Deleted February 28, 2002

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 standards covering components used in the products covered by this standard.

2.1.1 revised August 23, 2000

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.

2.1.2 revised August 23, 2000

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

2.1.3 revised August 23, 2000

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.

2.1.4 revised August 23, 2000

2.2 Units of measurement

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

2.2.1 revised August 23, 2000

2.2.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

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 purpose of these requirements, a pump will be categorized in accordance with one or more of the following definitions.

3.2 CONDENSATE PUMP – A pump intended for use with equipment to facilitate the removal of water condensate.

3.3 CORD-CONNECTED PUMP – A pump intended to be connected to a branch circuit supply by means of flexible cord and an attachment plug.

3.4 DEEP-WELL PUMP – A permanently installed, submersible or nonsubmersible pump intended to be used for pumping water from a well for irrigation and other agricultural purposes; for domestic, municipal, and industrial water supplies; and the like.

3.5 EFFLUENT PUMP – A pump intended to pump liquid forms of waste mixed with water.

3.6 FOUNTAIN PUMP – A pump intended for use with a decorative fountain.

3.7 IRRIGATION PUMP – A pump intended to be used directly or indirectly for irrigation to pump water from a surface or a subsurface source, or from a treatment facility to the point of application.

3.8 JET PUMP – A well pump with the driving unit at ground surface level that returns a portion of the water through an ejector submerged or within the normal suction-lift distance of the water.

3.9 PERMANENTLY INSTALLED PUMP – A pump intended for connection to fixed plumbing, or intended to be mechanically-mounted or fastened in a permanent manner.

3.10 PORTABLE PUMP – A cord-connected pump with no provision for permanent mounting or for connection to fixed plumbing, and intended to be moved from place to place frequently, such as contractor and utility pumps.

3.10 revised March 29, 1999

3.11 PRIMARY CIRCUIT – The wiring and components that are conductively connected to the branch circuit.

3.12 SECONDARY CIRCUIT – A circuit that is conductively connected to the secondary winding of an isolating transformer.

3.13 SEWAGE PUMP – A pump intended to pump sewage consisting of solid wastes mixed with water.

3.14 SHALLOW-WELL PUMP – A surface-mounted pump, jet or other, with limited suction-lift capability.

3.15 SUBMERSIBLE CONTRACTOR PUMP – A submersible pump connected to its controls by lengths of water-resistant flexible cable, intended for temporary use near or on a construction site.

3.16 SUBMERSIBLE PUMP – A pump that is intended to operate with its motor submerged in water.

3.17 SUMP PUMP – A pump intended to be installed in a sump or wet location where drainage collects.

3.18 WATER-CIRCULATING PUMP – A pump intended for permanent installation in a plumbing system that may or may not handle heated water.

3.19 For the purpose of these requirements the following definitions apply:

a) Low-Voltage Circuit – A circuit involving a peak open-circuit potential of no more than 42.4 volts supplied by a battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that, as a unit, complies with the performance requirements for Class 2 transformers. 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 considered to be a low-voltage circuit.

b) Line-Voltage Circuit – A circuit involving a potential of no more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

4 Instructions Provided With the Pump

4.1 With reference to the requirement in 3.1, the literature accompanying a pump and covering its intended uses shall be considered in determining its category.

CONSTRUCTION

5 General

5.1 A pump shall use materials found by investigation to be acceptable for the intended application.

6 Adhesives Used to Secure Parts

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

6.2 The requirement in 6.1 also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

a) Energize an accessible dead metal part,

b) Make a live part accessible,

c) Reduce spacings below the minimum acceptable values, or

d) Short-circuit live parts.

7 Enclosure

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

7.2 An electrical part shall be enclosed without depending upon a mounting surface or niche to complete the enclosure.

7.3 When an enclosure containing motor coils, internal splices, starting switches, starting relay coils, capacitors, or other live parts is intended to be submerged, such parts shall be enclosed in a watertight compartment or encapsulated in an acceptable insulating system. When the encapsulation also serves as the enclosure, live parts shall be at least 1/8 inch (3.2 mm) from the surface of the encapsulation.

7.4 A one-piece, molded coil form in contact with water shall have a wall thickness of at least 1/32 inch (0.8 mm).

7.5 For an unreinforced, flat surface in general, cast metal shall be no less than 1/8 inch (3.2 mm) thick, except that malleable iron may be no less than 3/32 inch (2.4 mm) and die-cast metal may be no less than 5/64 inch (2.0 mm) thick. Corresponding thicknesses of no less than 3/32, 1/16 (1.6 mm), and 3/64 inch (1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size, or both, of the surface is such that the necessary mechanical strength is provided.

7.6 An enclosure of sheet metal shall be evaluated with regard to its size, shape, thickness of metal, and acceptability for the application. Uncoated sheet steel less than 0.026 inch (0.6 mm) thick, galvanized sheet steel less than 0.029 inch (0.74 mm) thick, sheet aluminum less than 0.036 inch (0.91 mm) thick, and sheet copper or sheet brass less than 0.033 inch (0.84 mm) thick shall not be used other than in relatively small areas or for surfaces that are curved, ribbed, or otherwise reinforced.

7.7 Sheet-metal to which a wiring system is to be connected in the field shall not be less than 0.032 inch (0.81 mm) thick if uncoated steel, 0.034 inch (0.86 mm) thick if galvanized steel, 0.044 inch (1.2 mm) thick if aluminum sheet, and 0.043 inch (1.09 mm) thick if copper or brass sheet.

7.8 A sheet-steel enclosure intended for outdoor use shall not be less than 0.032 inch (0.81 mm) thick if uncoated, and 0.034 inch (0.86 mm) thick if galvanized.

7.9 Among the factors considered when evaluating the acceptability of a nonmetallic enclosure or an enclosure of magnesium shall be its:

a) Mechanical strength and rigidity,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flammability,

e) Resistance to distortion at temperatures to which the material may be subjected under conditions of actual use, and

f) Resistance to ignition.

7.10 An enclosure of polymeric material shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.11 An enclosure of a pump shall reduce the risk of molten metal, burning insulation, flaming particles, or the like, from falling outside the enclosure or upon material that may be flammable, such as the surface upon which the pump rests or is supported.

7.12 The requirement is 7.11 necessitates the use of a barrier or pan of nonflammable material under a motor unless:

a) The structural parts of the pump or motor provide the equivalent of such a barrier;

b) The overload protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the pump when the motor is energized under open main winding, open start winding, starting-switch short circuit, or split-phase motor capacitor short-circuit conditions; or

c) The motor complies with the requirements for impedance-protected motors in the Standard for Overheating Protection for Motors, UL 2111, and is rated for the application.

7.12 revised March 29, 1999

7.13 The barrier required in 7.12 shall be horizontal or constructed to provide equivalent protection, located as illustrated in Figure 7.1, and shall be not smaller in area than indicated in that figure. Openings for drainage, ventilation, and the like, may be used in the barrier when they are protected by a baffle, a screen, or the like, so that molten metal, burning insulation, and the like, cannot fall outside the enclosure.

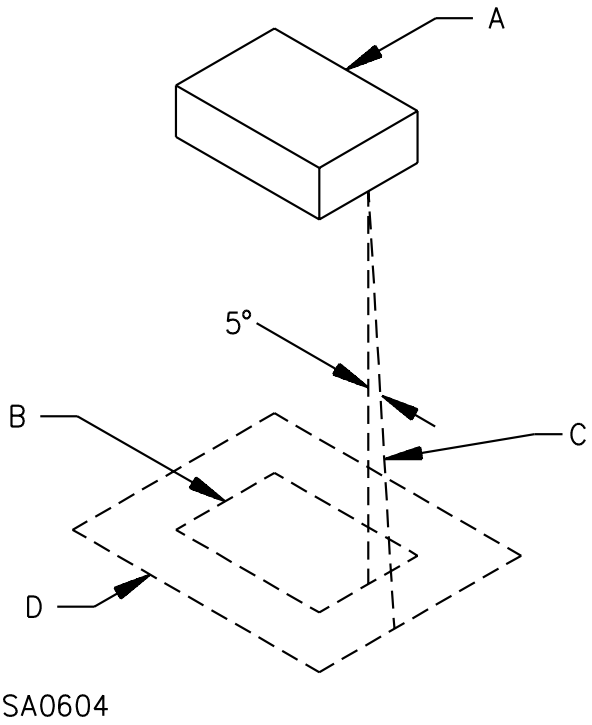
7.14 An opening in the enclosure of an outdoor-use pump or control shall be located or baffled so that rain will not enter the opening.

7.15 An enclosure for electrical components of a nonsubmersible outdoor-use pump or control shall be provided with a drain hole at least 1/8 inch (3.2 mm) in diameter or an opening providing equivalent drainage.

7.16 A panel or cover in the enclosure of an outdoor-use pump, or a control that must be removed or opened for routine maintenance of the pump, shall be attached to the enclosure when open or removed. Removal of such a panel or cover shall require the use of one or more tools.

7.17 A door or cover on an enclosure that gives access to an overload-protective device that requires resetting or renewal shall be hinged, pivoted, or equivalently attached, and shall be held normally closed or be provided with a positive latch.

Figure 7.1
Location and extent of barrier



8 Parts in Contact with Potable Water

8.1 A part of a pump in contact with potable water shall be of a nontoxic, corrosion-resistant material consistent with industry plumbing practice.

9 Provision for Servicing

9.1 A submersible sump pump, a submersible well pump, or a submersible contractor pump shall be provided with a means to permit removal from a sump, a well, or a pit by means other than pulling on the power-supply cord, cable, or on the discharge pipe.

Exception: A submersible pump intended to utilize the power-supply cord or a segment of the cord for such use need not comply with this requirement.

10 Mechanical Assembly

10.1 A pump shall be assembled so that it will not be adversely affected by the vibration of normal operation. See Polymeric Motor Supports, Section 27.

10.2 A switch, a lampholder, a receptacle, a plug connector, and similar components shall be secured and shall be prevented from turning by means other than friction alone between surfaces.

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

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch.

b) Means for mounting the switch makes it unlikely that operation of the switch will loosen it.

c) Normal operation of the switch is by mechanical means rather than directly by a person.

d) Spacings are not reduced below the minimum acceptable values if the switch rotates, and neither a lead nor a connection thereto is stressed.

Exception No. 2: A mercury switch that must move to operate and complies with Exception No. 1(d).

10.3 A switch shall be guarded or mounted in a location where it is not likely to be damaged during normal use of the pump.

10.4 A brush holder or a brush cap in a commutator motor shall be constructed to prevent loosening, and shall be located so as to reduce the likelihood of damage. A close-fitting threaded external tooth brush cap is acceptable.

10.5 A brush and holder of a cord-connected pump shall be constructed so that, in the event of brush wearout, the brush follower, the spring lead end, or other parts cannot leave the brush holder or reduce spacings to noncurrent-carrying metal parts.

11 Protection Against Corrosion

11.1 An iron or steel part shall be protected against corrosion by enameling, painting, galvanizing, plating, or an equivalent means if corrosion of such a part would result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: This requirement does not apply in certain instances where oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable, thickness of metal and temperature also being factors.

Exception No. 2: The requirement for corrosion resistance does not apply to a motor enclosure, nor to bearings, laminations, or other minor parts of iron or steel, such as a washer, a screw, and the like, or to spot welds in coated materials used nonsubmerged and indoors.

Exception No. 3: A stainless steel cabinet or an enclosure may be used without additional corrosion resistance.

11.2 A sheet-steel cabinet or an electrical enclosure intended for outdoor use shall be protected against corrosion by the means specified in Table 11.1 or by other metallic or nonmetallic coatings that have been shown to provide equivalent resistance.

Exception: As specified in Exception Nos. 1 – 3 to 11.1.

Table 11.1
Paragraphs for judging protection against corrosion

Type of cabinet or enclosure	Minimum thickness of steel	
	0.056 inch (1.42 mm) and thicker	Less than 0.056 inch (1.42 mm) thick
Outer cabinet that protects a motor, wiring, or encloses current-carrying parts	11.3	11.4
Inside enclosure that protects current-carrying parts other than a motor	11.3	11.4
Outer cabinet that is the sole enclosure of current-carrying parts	11.4	11.4

11.3 With reference to Table 11.1, as applicable, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G60 or A60 in Table I of the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94, with no less than 40 percent of the zinc on any one side, based on the minimum single-spot test requirement in this designation. The weight of the coating shall be established in accordance with the test method of ASTM Designation A90-69, or by any method that has been determined to be similar. An A60 (alloyed) coating shall also comply with 11.6.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.00041 inch (0.0104 mm) on each surface, with a minimum thickness of 0.00034 inch (0.0086 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 43. An annealed coating shall also comply with 11.6.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint is to be determined by consideration of the composition or, when required, by the corrosion tests specified in 11.5.

d) A single coat of an organic finish of the epoxy or alkyd-resin type over phosphate- or oxide-treated steel in a form that has been shown to be equivalent to mill-galvanized steel as noted in (a).

11.4 With reference to Table 11.1, as applicable, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in Table I of the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94, with no less than 40 percent of the zinc on any side, based on the minimum single-spot-test requirement in this designation. The weight of the zinc coating shall be established in accordance with the test method of ASTM Designation A90-69, or by any method that has been determined to be similar.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.00061 inch (0.01549 mm) on each surface with a minimum thickness of 0.00054 inch (0.01372 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 43. An annealed coating shall also comply with 11.6.

c) A cadmium coating no less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of the coating shall be established in accordance with the Metallic Coating Thickness Test, Section 43.

d) A zinc coating that complies with 11.3 (a) or (b), with one coat of outdoor paint as specified in 11.3(c) on each surface.

e) A cadmium coating no less than 0.00075 inch (0.01905 mm) thick on both surfaces, with one coat of outdoor paint on both surfaces, or no less than 0.0005 inch (0.0127 mm) thick on both surfaces, with two coats of outdoor paint on each surface. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 43, and the paint shall be as specified in 11.3(c).

11.5 With reference to Tables 11.1 and 11.2, other finishes, including paints, metallic finishes, and combinations of the two may be acceptable when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) that are in compliance with 11.3(a) or 11.4(a) indicate that they provide equivalent resistance. Among the factors considered when evaluating the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light, and water.

11.6 A hot-dipped, mill-galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing, and that is not otherwise required to be painted, shall be additionally painted in the bent or formed area when the bending or forming process damages the zinc coating. An area on the inside surface of a cabinet or enclosure that water does not enter during the rain test is not required to be painted.

11.7 When flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall comply with the requirement in 11.6.

11.8 A nonferrous cabinet and enclosure may be used without coatings for protection against corrosion. The use of dissimilar metals in contact with each other where corrosion could produce openings is not acceptable.

11.9 A hinge or other attachment on an outdoor or a submersible appliance shall be resistant to corrosion.

11.10 A metal part of a submersible pump that encloses or supports electrical parts and is normally in contact with water, including assembly rivets, bolts, screws, and the like, shall be of corrosion-resistant metal, such as stainless steel, copper, or aluminum alloy.

Exception: Cast-iron parts at least 1/8 inch (3.2 mm) thick, steel shafts coated with phosphate or black oxide, steel bolts coated with zinc dichromate, and other materials investigated and found to be acceptable.

11.11 Sheet and plate aluminum normally in contact with water shall be an alloy of the 5000 series as given in the Standard Specification for Aluminum Alloy Sheet and Plate, ASTM B-209 and cast aluminum shall be one of the alloys listed in Table 11.2, or shall be an alloy that has been found to have equivalent resistance to corrosion.

11.12 A part of a vessel supplied for use with a pump that is subjected to pressure, including a rivet, a screw, and a surface in contact with water, shall resist corrosion by means as described in 11.1 – 11.8.

Table 11.2
Aluminum alloys

Sand-cast	Permanent-mold cast	Die-cast	Machined-bar and rod stock
319.0	319.0	360.0	5052
356.0	356.0	A360.0	5056
443.0	A356.0	413.0	5456
B443.0	443.0	A413.0	6061
514.0	B443.0	C443.0	6063
B514.0	B514.0	518.0	
520.0	535.0		
535.0			
A712.0			

12 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

12.1 To reduce the likelihood of unintentional contact that may involve a risk of:

a) Electric shock from an uninsulated live part or film-coated wire or

b) Injury to a person from a moving part, an opening in an enclosure shall comply with either (1) or (2):

1) For an opening that has a minor dimension (see 12.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 12.1.

2) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 12.1.

Exception: A motor other than one used in either a hand-held pump or a hand-supported portion of a pump is not required to comply with these requirements when it complies with the requirements in 12.2.

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Figure 12.1
Articulate probe with web stop

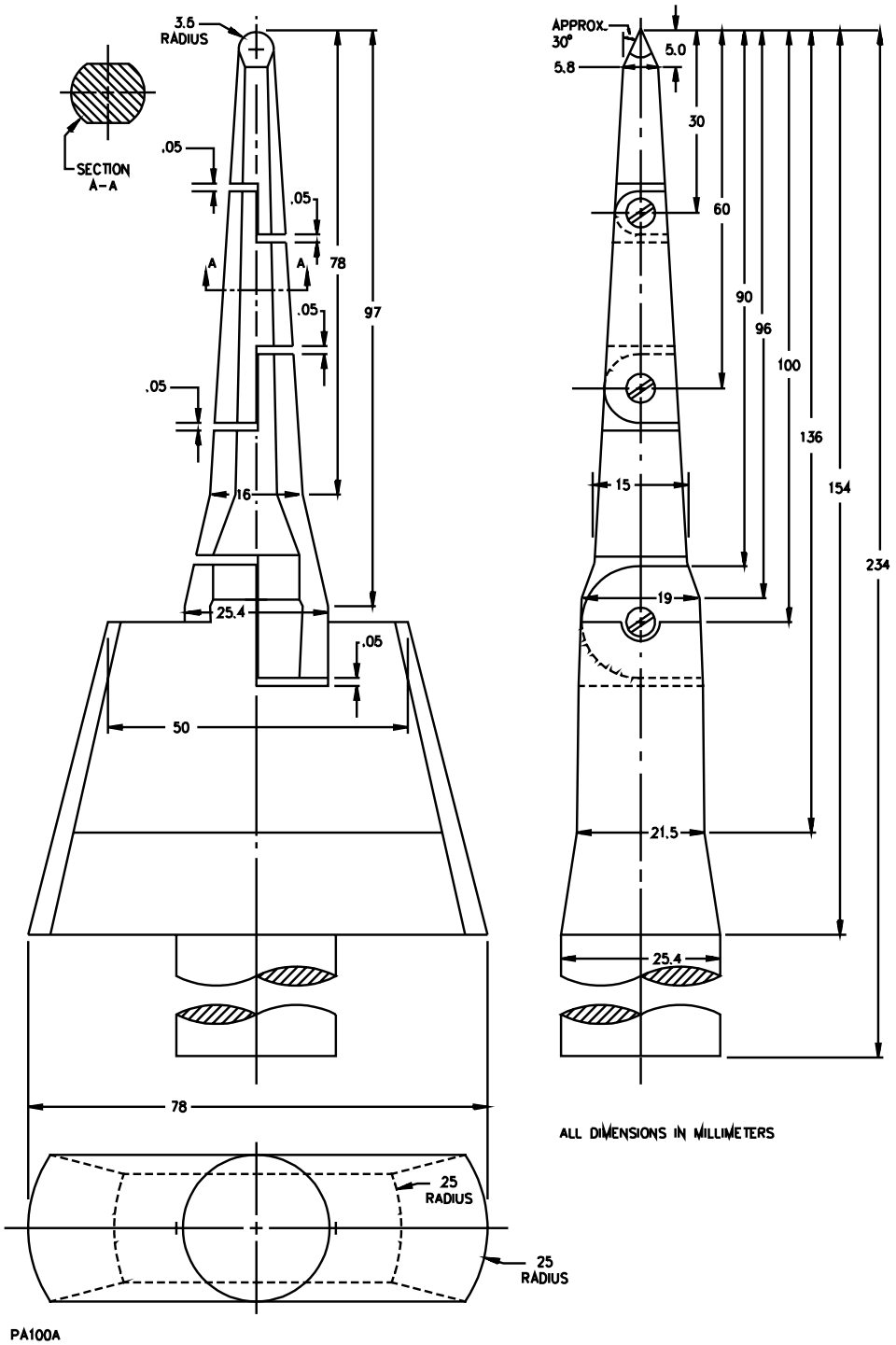


Table 12.1
Minimum distance from an opening to a part that may involve a risk of electric shock or injury to persons

Minor dimension[a] of opening,		Minimum distance from opening to part,	
inches	(mm)[b]	inches	(mm)[b]
3/4[c]	19.1	4-1/2	114.0
1[c]	25.4	6-1/4	165.0
1-1/4	31.8	7-1/2	190.0
1-1/2	38.1	12-1/2	318.0
1-7/8	47.6	15-1/2	394.0
2-1/8	54.0	17-1/2	444.0
d		30	762.0

[a] See 12.5.

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

[c] Any dimension less than 1 inch applies only to a motor.

[d] More than 2-1/8 inches, but not more than 6 inches (152 mm).

12.2 With regard to a part or wire as mentioned in 12.1, in an integral enclosure of a motor as mentioned in the Exception to 12.1:

a) An opening that has a minor dimension (see 12.5) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part or a film-coated wire cannot be contacted by the probe illustrated in Figure 12.2;

2) In an indirectly accessible motor (see 12.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 12.3; and

3) In a directly accessible motor (see 12.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 12.4.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 12.1.

Figure 12.2
Probe for moving parts and film-coated wire

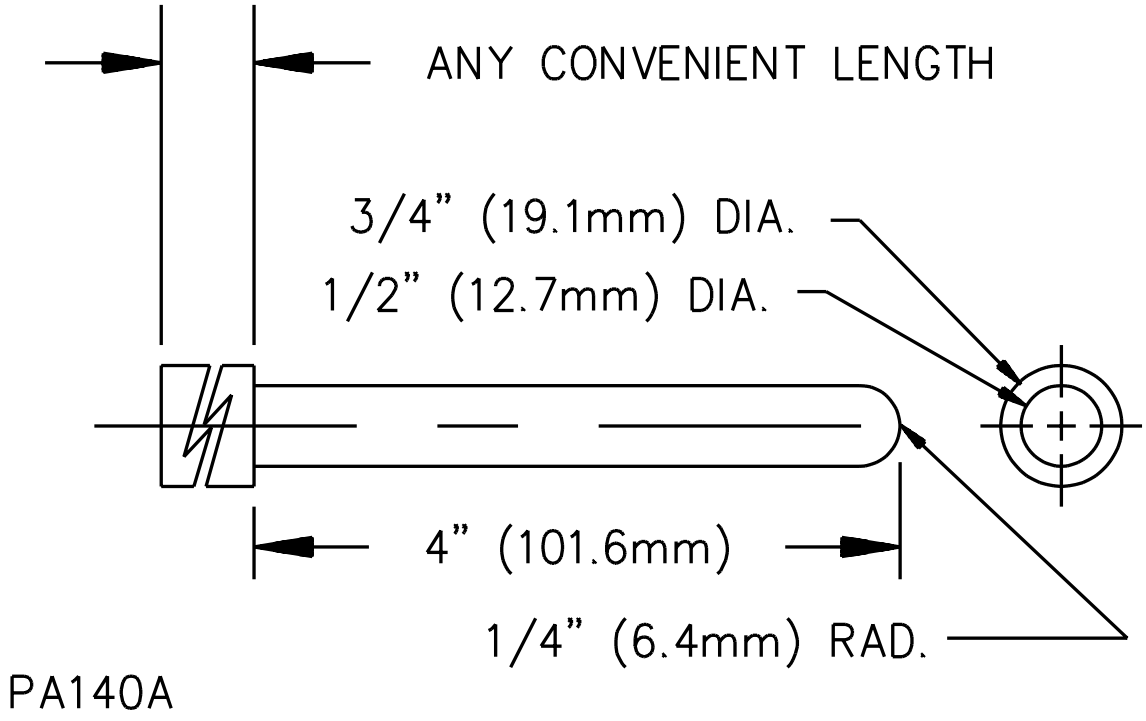


Figure 12.3
Probe for uninsulated live parts

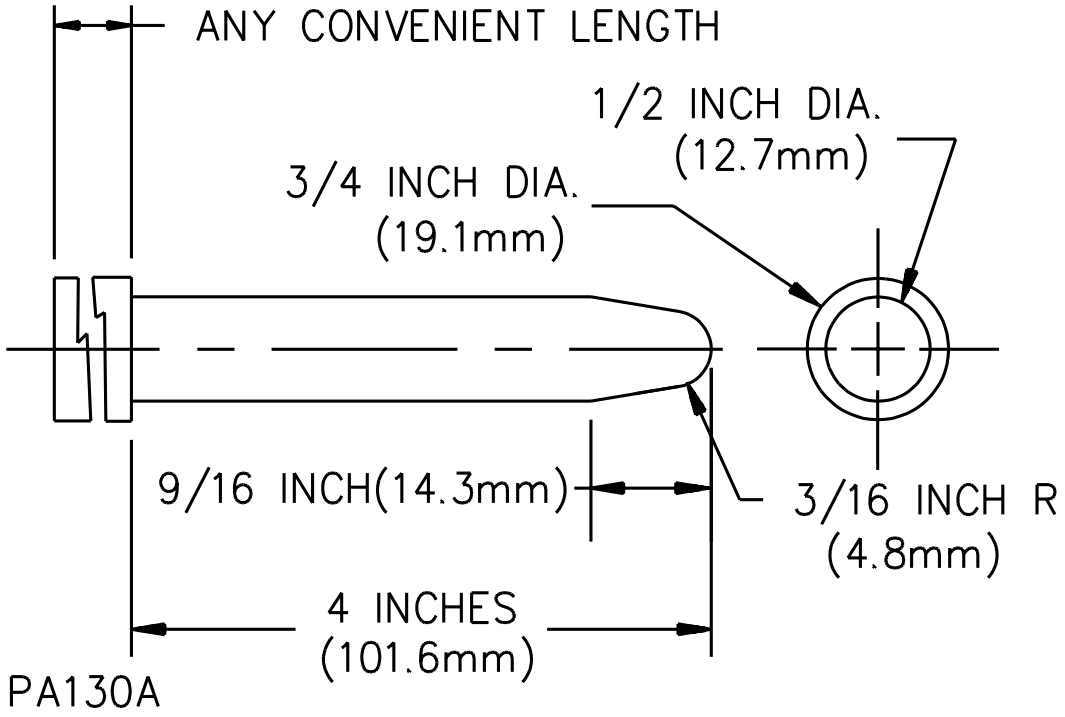
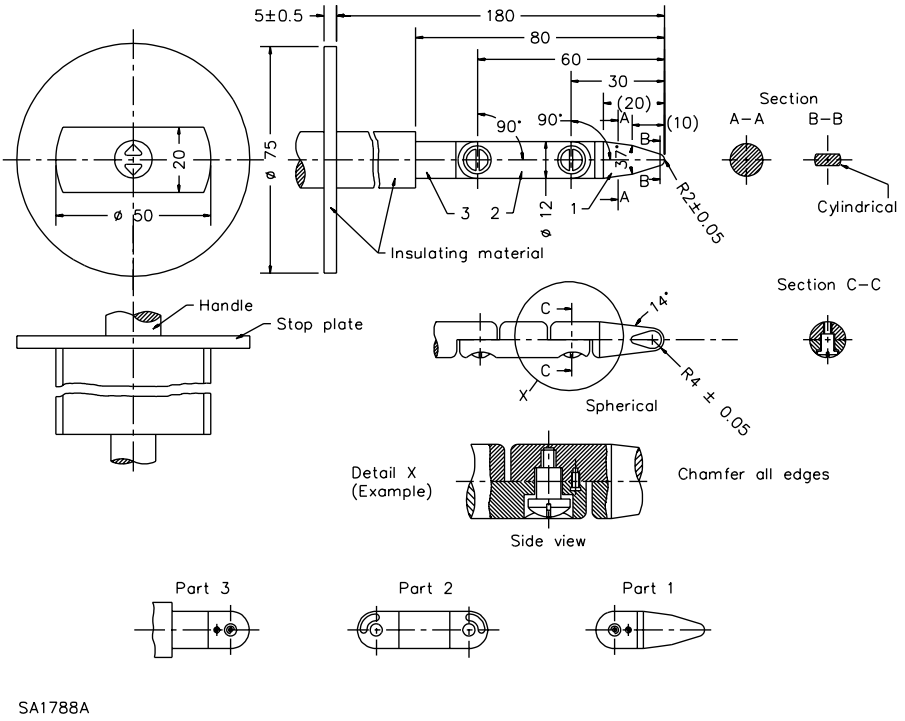


Figure 12.4
International electrotechnical commission (IEC) articulate accessibility probe with stop plate



12.3 The probes specified in 12.1 and 12.2 and illustrated in Figures 12.1 – 12.4 shall be applied to any depth that the opening permits, and shall be rotated or angled before, during, and after insertion through the opening to any position that is required to examine the enclosure. The probes illustrated in Figures 12.1 and 12.4 shall be applied in any possible configuration; and, when required, the configuration shall be changed after insertion through the opening.

12.4 The probes specified in 12.3 and 12.5 shall be used as measuring instruments to evaluate the accessibility provided by an opening, and not as instruments to evaluate the strength of a material; they shall be applied with the minimum force required to determine accessibility.

12.5 With reference to the requirements in 12.1 and 12.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

12.6 With reference to the requirements in 12.2, an indirectly accessible motor is a motor:

a) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool or

b) That is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

A directly accessible motor is a motor that can be contacted without opening or removing any part, or that is located so as to be accessible to contact.

12.7 During the examination of a pump to determine whether it complies with the requirements in 12.1 or 12.2, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

Exception: A snap-on cover on the enclosure of a water-level switch or other motor controller used on an indoor pump assembly need not be removed.

12.8 An opening in an impeller housing shall be judged with normal inlet and discharge connections in place. An opening in a pump intended for fixed installation shall be judged with the pump installed as intended.

Exception: An opening in an impeller housing of a pump that is inaccessible to the user during normal operation, such as a sewage pump, is not required to be additionally enclosed.

12.9 With reference to the requirements in 12.1 and 12.2, insulated brush caps are not required to be additionally enclosed.

13 Supply Connections

13.1 General

13.1.1 Except as noted in 13.1.2, 13.7.1– 13.10.8, and 13.11.1 – 13.11.3, a pump shall have provision for permanent connection of one of the wiring systems that have been determined to be appropriate for the type of pump.

Revised 13.1.1 effective December 1, 1999

13.1.2 A pump is not prohibited from being provided with a flexible cord and an attachment plug for supply connection when:

a) The mounting means of the pump is intended for ready removal from the building structure, and that the removal is capable of being accomplished without the use of tools and

b) The connections to the plumbing system are intended for ease of removal, and that the removal is capable of being accomplished without the need to braze, solder, weld, cut, or otherwise damage the connection.

Exception: It is not prohibited for a permanently-installed pump to be provided with a flexible cord and attachment plug when the wiring compartment is constructed in accordance with the requirements in 13.2.1 – 13.2.8, and the cord is attached in such a manner that it is possible to make a permanent connection to the power supply in accordance with the requirements in 13.3.1 – 13.3.9, 13.4.1, and 13.4.2.

Revised 13.1.2 effective December 1, 1999

13.2 Terminal compartments

13.2.1 A terminal box or wiring compartment to which branch-circuit connections to a permanently wired pump are to be made shall be located so that the connections can be readily inspected without disturbing the wiring or the pump after installation as intended.

13.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the pump so as to be prevented from turning.

13.2.3 Except as indicated in 13.2.4 and 13.2.5, the minimum usable volume of a terminal box or compartment in which field-wiring connections to a power supply are to be made shall be as specified in Table 13.1.

13.2.4 If a terminal compartment in which wire-to-wire connections to the power supply are to be made in the field is part of a motor, it shall have minimum cover dimensions and a minimum usable volume in accordance with Table 13.2.

Table 13.1
Minimum useable volume of terminal compartments

Revised Table 13.1 effective August 28, 2003

Size of conductor,		Volume per power supply conductor,[a]	
AWG	(mm^2)	cubic inches	(cm^3)
14	2.1	2.00	33
12	3.3	2.25	37
10	5.3	2.50	41
8	8.4	3.00	49
6	13.3	5.00	82

[a] Including a grounding conductor.

Note – The useable volume of terminal compartments should be considered the net volume less the volume of any components located within the terminal compartment such as capacitors, switches, relays, and terminal blocks.

Table 13.2
Motor terminal compartments for wire-to-wire connections

Revised Table 13.2 effective August 28, 2003

Horsepower (kW output)	Minimum dimensions for cover openings,		Minimum usable volume,	
	inches	(mm)	cubic inches	(cm^3)
1 (0.7) or less[a]	1-5/8	41	10.5	172
1-1/2, 2, and 3 (1.2, 1.5, and 2.2)[a]	1-3/4	44	16.8	275
5 and 7-1/2 (3.7 and 5.6)	2	51	22.4	367
10 and 15 (7.5 and 11.2)	2-1/2	63.5	36.4	597

Table 13.2 Continued on Next Page

Table 13.2 Continued

Horsepower (kW output)	Minimum dimensions for cover openings, inches	(mm)	Minimum usable volume, cubic inches	(cm^3)
[a] When the terminal compartment is partially or wholly integral with the frame or end shield, the minimum dimension of the cover opening is not specified, and the volume of the terminal compartment shall be no less than: 1) 0.8 cubic inch (13.1 cm^3) per wire-to-wire connection for 1 horsepower or smaller motors. 2) 1.0 cubic inch (16.4 cm^3) per wire-to-wire connection for 1-1/2, 2, and 3 horsepower motors. Note – The useable volume of terminal compartments should be considered the net volume less the volume of any components located within the terminal compartment such as capacitors, switches, relays, and terminal blocks.				

13.2.4.1 For the purposes of the requirements in 13.2, the useable volume of terminal compartments specified in Tables 13.1, 13.2 and 13.3 should be considered the net volume less the volume of any components located within the terminal compartment such as capacitors, switches, relays, terminal blocks, or similar components.

Added 13.2.4.1 effective August 28, 2003

13.2.5 When a terminal compartment in which field-wired, power-supply connections are to be made is part of a motor, and encloses rigidly mounted terminals, the terminal compartment shall possess the size to provide spacings in accordance with the requirements in 17.1.1 and usable volume in accordance with Table 13.3.

Table 13.3
Terminal compartments for rigidly mounted motor terminals

Revised Table 13.3 effective August 28, 2003

Power-supply-conductor size, AWG	(mm^2)	Minimum usable volume per power-supply connector, cubic inches	(cm^3)
14 and smaller	2.1 and smaller	1	16.4
12 and 10	3.3 and 5.3	1-1/4	20.3
8 and 6	8.4 and 13.3	2-1/4	37
Note – The useable volume of terminal compartments should be considered the net volume less the volume of any components located within the terminal compartment such as capacitors, switches, relays, and terminal blocks.			

13.2.6 A permanently-connected, nonsubmersible pump, intended to be installed outdoors, shall have a threaded hole for the connection of rigid metal conduit unless the hole is located entirely below the lowest uninsulated live part within the enclosure and a means for drainage of the enclosure is provided.

13.2.7 When a hole in an enclosure wall is tapped all the way through for connection of conduit, or when an equivalent construction is used, there shall not be fewer than 3-1/2 or more than five threads in the metal, and it shall be constructed so that a conduit bushing can be attached. When threads for the connection of conduit are not tapped all the way through the hole in an enclosure wall, a conduit hub, or the like, there shall not be fewer than five full threads in the metal, and a smooth, rounded inlet hole shall be provided that affords protection for the conductors equivalent to that provided by a standard conduit bushing. The inlet hole shall have an internal diameter the same as that of the corresponding trade size of rigid conduit.

13.2.8 A conduit hub shall be threaded and shall have a wall thickness, before threading, of not less than that of the corresponding trade size of conduit. A conduit hub that is not integral with an enclosure shall not depend upon friction alone to prevent its turning with regard to the enclosure, and shall withstand a torque applied to a short length of rigid metal conduit threaded into the hub in the intended manner without turning the hub and without stripping any thread. The applied torque shall be as specified in Table 13.4.

Table 13.4
Tightening torque

Trade size of conduit, inches	Tightening torque, pound-inches	(N·m)
3/4 and smaller	800	90.4
1, 1-1/4, 1-1/2	1000	113.0
2 and larger	1600	180.8

13.3 Field wiring terminals and leads

13.3.1 A permanently connected pump shall be provided with field-wiring terminals acceptable for the connection of conductors having an ampacity appropriate for the pump or the pump shall be provided with acceptable leads for such connections.

13.3.2 A wiring terminal is considered to be a field-wiring terminal unless both the wire and a means of making the connection, such as a pressure terminal connector, a soldering lug, a soldered loop, a crimped eyelet, or the like, are factory supplied and assembled as a part of the pump.

13.3.3 The free length of a lead inside an outlet box or wiring compartment for field connection to the supply conductors shall be at least 6 inches (152 mm).

Exception: The lead may be less than 6 inches long if it is evident that the use of a longer lead may result in a risk of electric shock.

13.3.4 A field-wiring terminal shall be prevented from turning in accordance with 14.2 and 14.3.

13.3.5 A field-wiring terminal shall be provided with an acceptable soldering lug or pressure terminal connector firmly bolted or held by a screw.

Exception: A wire-binding screw may be used at a wiring terminal intended to accommodate a No. 10 or smaller conductor. If such a binding screw is used, an upturned lug, a cupped washer, or the equivalent shall be provided to hold the wire in position.

13.3.6 An upturned lug or cupped washer shall be capable of retaining a supply conductor of the size intended under the head of the screw or washer above the conductor.

13.3.7 A wire-binding screw shall be no smaller than No. 10.

Exception: A No. 8 screw may be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm^2) conductor. A No. 6 screw may be used for the connection of a No. 16 or No. 18 AWG (1.3 or 0.82 mm^2) conductor.

13.3.8 A terminal plate for a field-wiring binding screw shall be of metal at least 0.050 inch (1.3 mm) thick. There shall be two or more full threads in the plate, which may be extruded if necessary to provide sufficient metal for the threads.

Exception: A plate may be no less than 0.030 inch (0.76 mm) thick if tightening the wire-binding screws with normal torque does not strip the threads from the terminal plate.

13.3.9 A field-wiring terminal shall be acceptable for use with:

a) Copper conductors only,

b) Aluminum conductors only, or

c) Copper or aluminum conductors, and shall be marked as, indicated in 52.15.

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13.4 Identified terminals and leads

13.4.1 A permanently connected pump rated at 125 or 125/250 volts (3-wire) or less and using an Edison screw-shell lampholder or 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 identified terminal or lead shall be the one that is electrically connected to the screw-shells of lampholders and to which no switches or overcurrent protective devices of the single-pole type other than automatic controls without a marked off position are connected.

13.4.2 A field-wiring terminal intended for connection to a grounded supply conductor shall be identified by means of a metallic coating that is essentially white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided instead of terminals, the identified lead shall have a white or natural gray color, and shall be easily distinguishable from the other leads.

13.5 Strain relief

13.5.1 A power-supply cord and a motor-connection cord or cable of a permanently connected pump shall be provided with means to reduce transmittal of tensional or rotational force from the cord to terminals, splices, or wiring within the pump.

13.5.2 The strain relief for a power-supply cord shall reduce flexing or movement of the cord seal, and shall be such that the Strain Relief Test, Section 45, does not result in the water-tight cord seal required by 13.10.5 being disturbed.

13.5.3 A metal strain-relief clamp or band may be used, without additional protection, with a cord that is one of the types specified in 13.10.1.

13.5.4 Means shall be provided to reduce the likelihood of a flexible cord being pushed into a pump through the cord-entry hole, if such displacement can result in mechanical damage to the cord or exposure of the cord to a temperature higher than its rated temperature or can reduce spacings, such as to a metal strain-relief clamp or bushing, below the minimum acceptable values.

13.5.5 The strain-relief means shall be tested as described in the Strain Relief Test, Section 45.

13.6 Bushings

13.6.1 At a point where a flexible cord passes through an opening in a wall, a barrier, or an enclosure, there shall be bushing that has been investigated and determined to be acceptable, or that which has been determined to be the equivalent, that shall be secured in place and have a smooth, rounded surface against which the cord can bear.

13.7 Contractor pumps

13.7.1 Provisions for supply connections on a submersible contractor pump shall be as described in 13.7.2 and 13.7.3.

13.7.2 A submersible contractor pump shall be provided with at least 20 feet (6.10 m) of Type S, SE, SEO, SO, SOO, STO, STOO, or ST cord between the pump and a motor control box. The cord shall be water-resistant and marked with suffix ″W.″

13.7.2 revised March 29, 1999

13.7.3 In addition to the requirement in 13.7.2, the control box may be provided with 3 feet (0.91 m) or more of cord of one of the types specified in 13.7.2 on the supply side, with strain relief and provision for removal to permit watertight connection of conduit when such connection is necessary. An attachment plug rated for the circuit involved may also be provided.

13.8 Deep-well pumps

13.8.1 The provisions for supply connections on a deep-well pump shall consist of the following, and shall include instructions in accordance with 55.1:

a) At least 1 foot (305 mm) of deep-well cable permanently secured with a watertight seal or

b) A detachable supply-cable assembly consisting of a female contact connector rated for use with deep-well cable and an acceptable length of deep-well supply cable. The female connector shall be permanently secured and sealed to the cable, and shall mate with a male connector base mounted on the pump.

All seals and connections are to be watertight. The supply-cable assembly shall be packaged with the pump or available from the manufacturer. A box that has been investigated and determined to be acceptable for supply connection, and a control device, may also be provided.

13.9 Sump pumps and portable pumps

13.9.1 Provisions for supply connections on a sump pump or a portable pump shall comply with 13.10.1 – 13.10.8.

13.10 Cord-connected pumps

13.10.1 A cord-connected pump other than a three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump constructed as described in 13.10.2 and 13.10.2.1 shall be provided with at least 6 feet (1.83 m) of permanently attached flexible cord and an attachment plug for connection to the branch-circuit supply. The cord shall:

a) Deleted

b) Be Type S, SE, SJ, SJE, SJEO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO with suffix ″W;″ and

c) Include an equipment-grounding conductor.

Exception: A submersible fountain pump intended for connection to an underwater junction box or above-ground deck box is not required to have an attachment plug.

13.10.1 revised February 28, 2002

13.10.2 A three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump shall be provided with at least 6 feet (1.83 m) of permanently attached flexible cord. The cord shall:

a) Deleted

b) Be Type S, SE, SJ, SJE, SJEO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO with suffix ″W;″ and

c) Include an equipment-grounding conductor. The cord shall also be provided with:

1) An attachment plug for connection to the branch circuit supply or

2) A junction box, outlet box, enclosure with a wiring compartment that complies with the requirements of 13.2.3, or similar container, and applicable fittings for supply connection. Such provision for supply connection shall reduce the risk of water entry during temporary, limited submersion and shall comply with the applicable requirements of the Standard for Enclosures for Electrical Equipment, UL 50, or the Standard for Metallic Outlet Boxes, UL 514A, and this standard.

Exception No. 1: Provision for supply connection with the cord specified in (c)(2) is not required when:

a) The pump is marked in accordance with 52.17 and

b) The installation instructions provided with the pumps are in accordance with 55.5.

Exception No. 2: Single-phase cord-connected sewage, effluent, and grinder pumps that are intended to be connected to a branch circuit outlet receptacle shall be provided with an attachment plug.

13.10.2 revised February 28, 2002

13.10.2.1 A three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump specified in 13.10.2 that is intended for use with a fixed wire electrical control device shall either be shipped from the factory with the fixed wire electrical control device or shall be marked to indicate that an acceptable motor control must be provided at the time of installation in accordance with 52.17.1. The control device shall have suitable electrical ratings in volts, amperes, frequency and horsepower for the pump it controls.

13.10.2.1 added August 23, 2000

13.10.3 With reference to 13.10.2, the cord shall be provided with strain relief and the pump shall be marked in accordance with 52.18 and provided with installation instructions in accordance with 55.6.

13.10.4 The cord on an outdoor pump shall be marked ″W″ in connection with the type designation.

13.10.4 revised March 29, 1999

13.10.5 A flexible cord shall enter the enclosure of a submersible pump through a watertight cord seal.

13.10.6 A flexible cord shall be rated for use at a voltage not less than the rated voltage of the pump and shall have an ampacity no less than the ampere rating of the pump.

13.10.7 An attachment plug shall be of a grounding type acceptable for use with a current not less than 125 percent of the rated pump current, and at a voltage at least equal to the rated voltage of the pump. If the pump is rated for use on two or more voltages by field alteration of internal connections, the attachment plug provided with the pump shall be rated for the voltage for which the pump is connected when shipped from the factory.

Exception: A three-phase, cord-connected submersible pump constructed in accordance with 13.10.2 is not required to comply with this requirement.

13.10.8 A 3-to-2 wire, grounding-type adapter shall not be provided with a pump.

13.11 Fountain pumps

13.11.1 A submersible pump shall have a flexible cord as described in 13.10.1. If such a pump is intended for outdoor use, the cord shall also comply with the requirement in 13.10.4.

13.11.2 A nonsubmersible pump shall have wiring terminals or leads within a wiring compartment having provisions for connection to a wiring system that has been investigated and determined to be acceptable for the pump.

13.11.3 The instructions for a fountain pump having a flexible cord of other than Type SO or ST shall include a warning as specified in 55.4.

14 Current-Carrying or Live Parts

14.1 A current-carrying part shall be of silver, copper, a copper-base alloy, stainless steel, aluminum, or other materials that have been investigated and determined to be acceptable for the application.

Exception: Plated steel may be used for a primary circuit part, such as a capacitor terminal where a glass-to-metal seal is required, and for a lead or threaded stud of a semiconductor device. Blued steel or steel with equivalent resistance to corrosion may be used for a current-carrying arm of a mechanically- or magnetically-operated leaf switch. Plated steel may be used within a motor and its governor (including motor terminals) or where the operating temperature of the part is in excess of 100°C (212°F). These materials shall not be used for other current-carrying applications.

14.2 An uninsulated live part or a component involving an uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting position so as to reduce electrical spacings below the minimum values. Quick-disconnect terminal blades shall be fixed, and connections to them shall be provided with a mating detent.

14.3 Friction between surface shall not be used as a sole means for preventing shifting or turning as required by 14.2, but a properly applied lock washer may be used.

15 Insulating Material

15.1 An uninsulated live part shall be mounted on porcelain, phenolic composition, or other material that has been investigated and determined to be acceptable for the application.

15.2 A moisture absorptive material shall not be used for electrical insulation where shrinkage, water absorption, or warpage may introduce a risk of fire, electric shock, or injury to persons. A thermoplastic material may only be used for sole support of uninsulated live parts if found to have mechanical strength, rigidity, aging properties, heat resistance, flame propagation resistance, dielectric strength, and other appropriate properties that have been determined to be acceptable for the application.

15.3 A small, molded part such as a brush cap shall be constructed so as to have the mechanical strength and rigidity to withstand the stresses of actual service.

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

16 Internal Wiring

16.1 Mechanical protection

16.1.1 Internal wiring and connections between parts shall be guarded or enclosed.

16.1.2 Wiring shall be protected from sharp edges including screw threads, burrs, fins, moving parts, and the like, that may abrade the insulation on conductors or otherwise damage the wiring.

16.1.3 It is not prohibited for a pump that complies with the requirements in 13.1.2 to be provided with a short length of cord and an attachment plug that comply with the requirements in 13.10.6 and 13.10.7 for connection to a receptacle in a supply connection or control box. See 22.4.

Revised 16.1.3 effective December 1, 1999

16.1.4 All wiring shall be protected from damage and separated by nonflammable material from flammable material other than insulating oil.

16.1.5 A hole in a metal wall through which insulated wires pass shall be provided with a smoothly rounded bushing as described in 13.6.1, or the hole shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear without damage to the insulation.

16.1.6 With reference to exposure of insulated wire through an opening in the enclosure of a pump, the protection of such wiring required by 16.1.1 is acceptable if, when judged as though it were film-coated wire, the wiring would be acceptable under the requirements in 12.4. Wiring not protected as described in this paragraph may be acceptable if it is:

a) In a permanently-wired pump and

b) Secured within the enclosure so that it is unlikely to be subjected to stress or physical abuse.

16.1.7 Insulated internal wiring, including the equipment-grounding conductor, shall consist of wire of a type acceptable for the application when considered with regard to:

a) The temperature and voltage involved;

b) Exposure to oil, grease, and other substances which have a deleterious effect on the insulation;

c) Exposure to moisture; and

d) Other anticipated considerations of actual service.

16.2 Splices and connections

16.2.1 A splice or a connection shall be made mechanically secure and shall provide electrical contact. A soldered connection shall be made mechanically secure before soldering if breaking or loosening of the connection may result in a risk of fire, electric shock, or injury to persons.

16.2.2 In the case of a pump in which excessive vibration is likely to be present, the requirement in 16.2.1 requires the use of one or more lock washers or other similar means to prevent a wire-binding screw or nut from loosening.

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

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

16.2.5 If a wire-binding screw construction, or a pressure-wire connector is used as a terminating device, it shall be acceptable for use with aluminum under the conditions involved, such as temperature, heat cycling, vibration, and the like.

16.2.6 Insulation consisting of two or more layers of friction tape, two or more layers of thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape is acceptable on a splice if the voltage involved is less than 250 volts. In evaluating the use of coated fabric, thermoplastic, or other types of tubing, consideration is to be given to dielectric properties of the material, heat- and moisture-resistance characteristics, and other appropriate factors. Thermoplastic tape is not acceptable if wrapped around or over a sharp edge. Oil resistance of all types of insulation used with an oil-filled enclosure shall be considered in evaluating their acceptability.

16.2.7 When stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands cannot contact other uninsulated metal parts not always of the same polarity. This may be accomplished by the use of a pressure terminal connector, a soldering lug, a crimped eyelet, soldering the strands together, or by other similar means.

17 Spacings

17.1 At field-wiring terminals

17.1.1 The spacings between field-wiring terminals of opposite polarity and between a field-wiring terminal and a dead metal part that may be grounded shall not be less than the values specified in (a) or (b). The following spacings apply to the sum of the spacings involved where an isolated noncurrent-carrying metal part is interposed:

a) Through air or over surface where a potential of 250 volts or less is involved, 1/4 inch (6.4 mm).

b) Through air or over surface where a potential of more than 250 volts is involved, 3/8 inch (9.5 mm).

17.2 In a motor

17.2.1 Spacings within a motor are judged under the requirements in the Standard for Electric Motors, UL 1004.

17.3 Spacings other than in a motor or at field-wiring terminals

17.3.1 At a point other than a field-wiring terminal, and in a motor, the spacings between 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 may become grounded shall be no less than specified in Table 17.1. If a live part is not fixed in position by means other than friction between surfaces, or if a dead metal part is likewise movable, the construction shall be such that the minimum acceptable spacings will be maintained.

Exception: The inherent spacings of a component, such as a snap switch, are judged on the basis of the requirements for the component in question.

Table 17.1
Spacings at points other than in a motor or at field-wiring terminals

	Minimum spacings			
	Over surface,		Through air,	
Potential, volts	inch	(mm)	inch	(mm)
0 – 250	1/4[a]	6.4	3/32[a]	2.4
251 – 600	3/8[a]	9.6	1/4[a]	6.4

[a] Film-coated wire is considered to be an uninsulated live part; however, a spacing of no less than 3/32 inch is acceptable over surface and through air between film-coated wire supported so as to maintain the spacings or held in place on a coil and a dead metal part.

17.3.2 If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, a live part and an exposed dead metal part, or a live part and a dead metal part that may be grounded; the spacing shall be no less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the parts previously mentioned, if the total spacing between the isolated dead metal part and the two other parts is no less than specified in Table 17.1.

17.3.3 An insulated lining or barrier of vulcanized fiber or similar material used where a spacing would otherwise be less than the minimum shall not be less than 1/32 inch (0.8 mm) thick and shall be so located or of such material that it will not be adversely affected by arcing.

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

Exception No. 2: Insulating material thinner than that specified may be used if investigated and found to be acceptable for the application.

17.3.4 The spacing between an uninsulated live part in a line-voltage circuit and an uninsulated live part in a low-voltage circuit shall comply with the requirements for spacing between parts of opposite polarity in 17.1.1, 17.3.1, and 17.3.2, and shall be based on the highest voltage involved.

17.3.5 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified for parts in low-voltage circuits.

17.3.6 Spacings in a secondary circuit shall comply with the spacing requirements for a primary circuit unless the power for the secondary circuit is supplied by a transformer winding that is found to comply with the requirements for Class 2 transformers in the Standard for Class 2 and Class 3 Transformers, UL 1585.

18 Grounding

18.1 General

18.1.1 A pump shall have provision for grounding all dead metal parts that could become energized.

18.1.2 A cord-connected pump shall be provided with a power-supply cord and a grounding attachment plug. A single-phase pump shall use a three-wire cord; a three-phase pump shall use a four-wire cord. The single conductor of the cord that terminates in the grounding pin of the attachment plug shall have insulation colored green or green with one or more yellow stripes. Grounding conductors are not required to be sized larger than the circuit conductors used to supply the pump. This conductor shall terminate at the pump end with a connection to a screw or a connector that is not disturbed during servicing of the pump other than servicing of the power-supply cord. Sheet-metal screws shall not be used to connect grounding conductors to enclosures.

Revised 18.1.2 effective December 1, 1999

18.1.3 A three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump constructed in accordance with 13.10.2 is not required to be provided with an attachment plug. The grounding conductor of the cord shall have insulation colored green or green with one or more yellow stripes. This conductor shall be connected at the pump end to a screw or a connector that has a remote possibility of being disturbed during servicing of the pump other than servicing of the power-supply cord.

18.1.3 revised August 23, 2000

18.1.4 A box or wiring compartment for permanent connection of a pump to its electrical supply source shall be provided with a green colored lead at least as large as the circuit conductors, or a terminal screw or a wire connector to secure such a lead shall be provided. For No. 10 AWG (5.3 mm^2) or smaller wire, a green, hexagonal-headed (or slotted, or both) wire-binding screw with the equivalent of upturned lugs is not prohibited from being used.

18.1.4 revised March 29, 1999

18.1.5 A pressure-wire connector intended for connection of an equipment-grounding conductor shall be identified by:

a) Being marked ″G,″ ″GR,″ ″Ground,″ ″Grounding,″ or similar marking;

b) A marking on a wiring diagram provided on the product; or

c) The symbol shown in Figure 18.1 located on or adjacent to the connector, or on a wiring diagram provided on the product. See 18.1.6.

18.1.5 added March 29, 1999

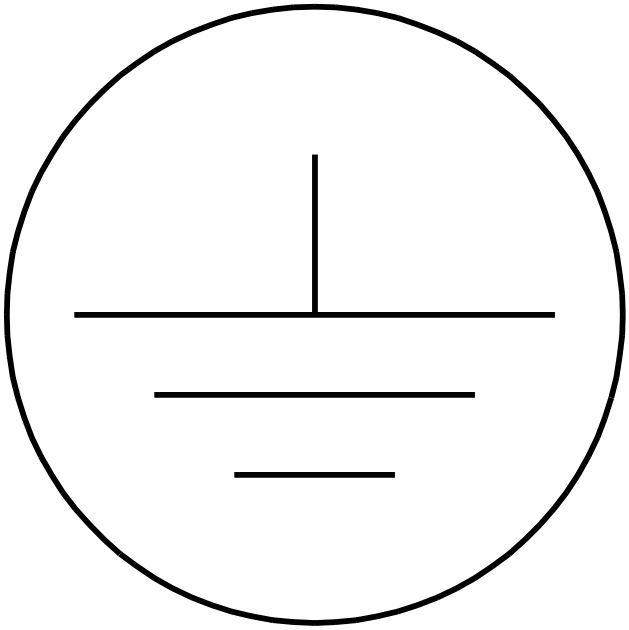
18.1.6 When the symbol shown in Figure 18.1 is used in accordance with 18.1.5(c), the installation instructions provided with the product shall include a definition of the symbol.

Exception: When the symbol in Figure 18.1 is used with one of the other means of identification specified in 18.1.5 (a) and (b), the definition is not required to be provided.

18.1.6 added March 29, 1999

Figure 18.1
Grounding symbol

Figure 18.1 added March 29, 1999



UL0005B

18.2 Bonding

18.2.1 A noncurrent-carrying metal part shall be bonded to the point of connection of the grounding conductor. For a pump equipped with a box for supply connections that is remote from the motor or pump, a green colored lead in the interconnecting cable, terminated as described in 18.1.2, may be used for bonding. A submersible deep-well or shallow-well pump may be provided with a green-identified deep-well cable conductor the same size as the circuit conductors or with terminals on both the outside of the pump housing and the inside or outside of the supply connection box (when provided). The grounding terminal shall comply with the requirements in 18.1.4.

18.2.2 Solder alone shall not be used to secure grounding and bonding connections. Means for accomplishing bonding and grounding shall penetrate all nonconductive coatings such as paint.

18.2.3 A bolted or screwed connection that incorporates a star washer under a screw head, a serrated screw head, or the equivalent is acceptable for penetrating nonconductive coatings as required by 18.2.2.

18.2.4 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal comprise acceptable means of compliance with the requirement in 18.2.2.

18.2.5 The size of a conductor or a strap used to bond an electrical enclosure of a motor frame shall be based on the rating of the branch-circuit overcurrent-protective device by which the equipment is intended to be protected. The size of the conductor or strap shall be in accordance with Table 18.1.

Exception: A clamp or a strap is acceptable if it complies with the requirements in 18.2.6.

18.2.6 A conductor, such as a clamp or a strap, used in place of a separate wire conductor as indicated in 18.2.5, is acceptable if the cross-sectional area of the conductor is at least that of the wire size indicated in Table 18.1.

18.2.7 A type of bonding connection other than those described in 18.2.3 – 18.2.5 may be used if the connection does not open when carrying a current of 135 and 200 percent of the rating of the appropriate branch-circuit protective device for the time specified in Table 18.2.

18.2.8 A bonding conductor may be bare.

18.2.9 A splice shall not be used in wire conductors used to bond electrical enclosures, motor frames, or other electrical components.

18.2.10 The resistance between the point of connection of the equipment-grounding means, at or within the unit, and any other point required to be grounded shall be no more than 0.1 ohm.

Table 18.1
Bonding wire conductor size

Rating of branch-circuit overcurrent protective device, amperes	Minimum size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	6	13.3

[a] Or equivalent cross-sectional area.

Table 18.2
Duration of overcurrent test

Rating or setting of branch-circuit overcurrent – protective device, amperes	Test time, minutes	
	135 percent current[a]	200 percent current[a]
0 – 30	60	2
31 – 60	60	4
61 – 100	120	6
101 – 200	120	8

[a] If a 600-volt fuse rated at 100 amperes or less and plainly marked ″For Use Only on Motor Circuits″ is to be used, test time shall be 8 minutes.

18.2.11 Compliance with the requirement in 18.2.10 may be determined by any acceptable instrument, such as an ohmmeter or bridge.

Exception: If unacceptable results are recorded using the means mentioned in this paragraph, an alternating current of at least 30 amperes from a power supply of no more than 12 volts is to be passed from the point of connection of the equipment grounding means to the metal part of the grounding circuit, and the resulting drop in potential between these points is to be measured. The resistance is then to be calculated using Ohm's Law. The grounding conductor of the power-supply cord is not to be included in this measurement.

18.3 Grounding identification

18.3.1 Insulation or other covering on a bonding conductor shall be green in color, with or without one or more yellow stripes.

18.3.2 If a pump is provided with leads, and one lead is an insulated or covered equipment-grounding conductor, the color of that lead shall be green or green with one or more yellow stripes, and other leads shall be of a color or colors other than, and shall contrast with, the equipment-grounding conductor.

19 Motors

19.1 Construction

19.1.1 A motor shall be acceptable for the application and shall drive its maximum normal load without introducing any risk of fire, electric shock, or injury to persons.

19.1.2 A motor winding shall resist the absorption of moisture.

19.1.3 With reference to the requirement in 19.1.2, film-coated wire is not required to be additionally treated to resist absorption of water, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or other treatment to resist the absorption of water.

Exception: An oil-filled motor requires no absorption-retardant treatment.

19.1.4 In the application of requirements based on horsepower for a motor not rated in horsepower, reference is to be made to Tables 44.1 and 44.2, as appropriate. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used if the motor is marked for use on alternating current only; otherwise, the table applying to a direct-current motor is to be used.

19.2 Overload protection

19.2.1 A pump or its control shall incorporate thermal or overload protection against running-overload and stalled-rotor conditions complying with the requirements in 19.2.2 and 19.2.3.

Exception: A permanently-connected or permanently-installed pump that is intended to be provided with separate protection in accordance with the National Electrical Code, ANSI/NFPA, and is marked in accordance with 52.10, is not required to comply with this requirement.

19.2.1 revised March 29, 1999

19.2.2 The overload protection required by 19.2.1 shall consist of one of the following:

a) Thermal protection or impedance protection complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111;

b) Deleted

c) Protection in accordance with 20.2; or

d) Other protection, such as that requiring immersion of a submersible motor, that is shown by test to be equivalent to the protection specified in (a) – (c).

19.2.2 revised March 29, 1999

19.2.3 A 3-phase motor shall be provided with overload protection as follows:

a) Three properly rated overload units or

b) Thermal protectors, combinations of thermal protectors and overload units, or other methods of protection may be acceptable if the specific protective arrangement used has been investigated and found to provide protection under primary single-phase breakdown conditions when supplied from transformers connected wye-delta or delta-wye. An assembly so investigated shall be marked to indicate that the motor is protected under primary single-phasing conditions. This marking may be a paper sticker or decal, or may be on an attached wiring diagram.

20 Overload-Protective Devices

20.1 A fuse shall not be used as a motor-overload-protective device unless the motor is protected by the time-delay fuse of the largest ampere rating that can be inserted into the fuseholder.

20.2 A separate device incorporated in a pump in accordance with the requirement in 19.2.2(b) shall be responsive to motor current and shall be rated or set in accordance with Table 20.1 (column A).

Exception: If the rating of the device determined in accordance with Table 20.1 (column A) does not correspond to a standard size or rating of fused, nonadjustable circuit breakers, thermal cutouts, thermal relays, or heating elements of thermal-trip motor switches, or is not sufficient to start the motor or carry the load, a device of the next higher size, rating, or setting may be used, provided the trip current does not exceed the value specified in of Table 20.1 (column B). For a multispeed motor, each winding connection is to be considered separately.

Table 20.1
Rating or setting of overload protective devices

Type of motor and marking	Maximum ampere rating of device as a percentage of motor full-load-current rating, A	B
Motor with marked service factor of 1.15 or more, or with marked temperature rise of 40°C (72°F) or less[a]	125	140
Other motors	115	130

[a] Motor manufacturer's applied marking.

20.3 With reference to the requirements in 20.2, each winding connection of a multispeed motor shall be considered separately.

20.4 If a system of fuses is used for running-overload protection, a fuse shall be located in each ungrounded conductor, and if the motor is intended for connection to a 3-wire, 3-phase, alternating-current supply with one conductor grounding, a fuse shall also be provided in the grounded conductor.

20.5 A fuseholder or circuit breaker shall be acceptable for the application.

20.6 If a circuit breaker handle is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

20.7 A plug fuseholder intended for the fuses mentioned in 20.1 shall be Type S or shall be Edison-base with a factory-installed, nonremovable Type S adapter.

20.8 An overload-protective device shall not open the circuit during normal operation of the pump.

20.9 To determine whether a submersible pump that is constructed for water-flow through or past the motor complies with the requirement in 19.2.2, it shall be tested under the maximum normal load conditions described in the Temperature Test, Section 33, with the load controlled by adjustment of the head by means of a valve in the output line of the pump. Locked-rotor tests shall be conducted with the rotor of the motor locked in position.

20.10 If compliance with the requirement in 19.2.1 depends on an attached auxiliary part of the enclosure, such as a rain shield or a drip canopy, the part shall be attached so that removal will necessitate the use of tools. A friction or mechanical fit is acceptable if removal of the part during installation and normal handling is unlikely.

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

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

20.12 Opening a door that gives access to a protective device shall not expose live parts other than the screw shell of an Edison-base fuseholder. Such a screw shell, or the cap of an extractor-type fuseholder, shall be connected toward the load.

20.13 No replaceable protective device other than an extractor-type fuse shall be used in a portable household pump.

20.14 The functioning of a motor-protective device shall not result in any risk of fire, electric shock, or injury to persons.

21 Capacitors

21.1 A capacitor provided as part of a capacitor motor, and a capacitor connected across the line, such as one for radio-interference suppression or power-factor control, shall be housed within an enclosure or container that will protect the plates from mechanical damage and reduce the emission of flame or molten metal resulting from malfunction or breakdown of the capacitor.

21.2 The container mentioned in 21.1 shall be of sheet steel not less than 0.020 inch (0.5 mm) thick or shall be constructed to afford equivalent protection. A nonmetallic or magnesium enclosure shall comply with the requirements in 7.9.

Exception No. 1: An individual container of a capacitor may be of sheet metal that is not as thick as that specified, or may be of other material that has been investigated and determined to be acceptable if the capacitor is intended to be mounted in an enclosure that houses other parts of the pump, and if such an enclosure has been investigated and determined to be acceptable to enclose live parts.

Exception No. 2: An individual enclosure of an electrolytic capacitor with means for venting is required to provide protection against mechanical damage only, and the requirement for minimum enclosure thickness does not apply. An individual enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure and the motor need not comply with the enclosure thickness requirement if it successfully completes the following test:

a) Samples of the capacitor, mounted in the usual manner, and with cotton placed around openings in the enclosure are subjected to such overvoltage as is necessary to cause breakdown.

b) If the cotton ignites upon breakdown, the results are unacceptable, and the enclosure thickness requirements shall apply.

22 Switches and Controls

22.1 A switch or other electrical control shall be acceptable for the application, with a rating no less than that of the load it controls.

22.1.1 Float- and pressure-operated switches shall comply with the applicable requirements in the Standard for Industrial Control Equipment, UL 508.

Added 22.1.1 effective December 1, 1999

22.2 If the handle of a switch is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

22.3 A through-cord switch that is not intended for remote mounting – one in which the supply cord passes through the body of the switch and has one or more conductors broken for the purpose of switching – shall not be used with a pump.

Exception: A submersible sump pump may use a through-cord float-type switch.

22.4 A portable pump using a motor rated more than 1/3 horsepower (249-watt output) shall use a manually-operated motor-control switch mounted on the pump.

Exception: A pump that is marked in accordance with 52.11 and on which a motor control switch would be inaccessible is not required to comply with this requirement. For a pump constructed in accordance with 16.1.3, the control switch is to be in the box accommodating the motor receptacle.

23 Secondary Circuits

23.1 General

23.1.1 A secondary circuit shall comply with the requirements in 23.1.2 – 23.2.2, otherwise 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.

23.1.2 A low-voltage circuit as defined in 3.19 and supplied by a single source consisting of a power transformer or a power supply that includes an isolating transformer need not be investigated.

23.1.3 With reference to 23.1.2, a low voltage circuit that complies with the applicable requirements for secondary circuits of the Standard for Industrial Control Equipment, UL 508, is considered to comply with the requirement.

23.1.4 A Class 2 transformer used in the applications covered by this standard shall comply with the applicable requirements in the Standard for Class 2 and Class 3 Transformers, UL 1585.

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 34.1.

23.1.5 Power supplies and 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 requirements in Internal Wiring, Section 16. Printed-wiring boards and insulated wires used in such circuits shall be used for the application; see 15.4.

23.2 Protection of wiring

23.2.1 With reference to 23.1.5, wiring 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.

23.2.2 In addition to complying with 23.2.1, wiring that is part of a secondary circuit shall be provided with strain relief in accordance with 13.5.1 – 13.5.5 if stresses on the wiring could result in the wiring contacting uninsulated live parts of other circuits.

PROTECTION AGAINST INJURY TO PERSONS

24 Sharp Edges

24.1 An edge, a projection, or a corner of an enclosure, an opening, a frame, a guard, a knob, a handle, or the like, shall be smooth and rounded, and not cause a risk of injury when contacted during normal use or maintenance.

25 Materials

25.1 The material of a part, such as an enclosure, a frame, a guard, or the like, the breakage of which may result in risk of injury to persons, shall have such properties as to meet the demand under expected loading conditions.

25.2 The requirement in 25.1 applies to those portions of a part adjacent to parts involving a risk of electric shock or moving parts considered to involve a risk of injury to persons.

25.3 The impact resistance of a part as mentioned in 25.1 shall be investigated in accordance with 25.4. The results are acceptable if the pump withstands the impact described in 25.4 without:

a) Reduction of spacings below the minimum values;

b) Making live parts accessible to contact;

c) Breakage, cracking, rupture, or the like, such as to produce any adverse effect on the insulation; and

d) Producing any other condition that would result in a risk of electric shock or injury to persons.

25.4 The pump is to be subjected to an impact of 5 foot-pounds (6.8 J) on any surface that is exposed to a blow during use. This impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.54 kg), from the height necessary to produce the specified impact. If the impact cannot be produced on the desired surface by means of a vertical drop, the sphere may be swung as a pendulum to produce a sidewall impact of 5 foot-pounds.

26 Stability

26.1 A fountain pump shall have means for mounting or shall be constructed so that it will be stable while resting on a surface that is tilted 15 degrees from the horizontal.

27 Polymeric Motor Supports

27.1 A polymeric part that supports a motor shall be subjected to the test described in 27.2 and 27.3. The results are acceptable if the motor remains securely mounted.

27.2 If a motor and its supporting polymeric parts are intended to be mounted in the field, they are to be mounted in accordance with the instructions that accompany the unit. All bolts or screws that are intended to be field-mounted are to be tightened to the torque value specified in the instructions. If the motor and polymeric supporting parts are factory-assembled, the unit is to be tested in the factory-assembled condition with the torque on the screws or bolts tightened to the upper manufacturing tolerance limit. The information on torque values is to be provided by the manufacturer for the testing of factory-assembled units.

27.3 The motor and parts are then to be placed for 300 hours in an air-circulating oven maintained at a temperature at least 10°C (18°F) higher than that measured on the polymeric part during the temperature test, but no less than 70°C (158°F). While in the oven, the motor is to be operated through cycles, repeated at 10 minute intervals, consisting of:

a) Starting the motor,

b) Letting it reach maximum speed, and

c) Stopping the motor.

The motor is then to be removed from the oven and examined visually to determine if the means of mounting provides the necessary support under operating conditions.

28 Parts Subject to Pressure

28.1 A pressure vessel having an inside diameter more than 6 inches (152 mm), subjected to a pressure more than 15 psig (102 kPa), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors shall be marked in accordance with the appropriate boiler and pressure vessel code symbol of the American Society of Mechanical Engineers (ASME) for a working pressure no less than the pressure determined in accordance with 28.3.

28.2 A pressure vessel, because of its application, not covered by the scope of the inspection procedure of the ASME code shall be constructed so that it will comply with the requirements in 28.3.

28.3 A part or assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand a pressure equal to the highest of the following that is applicable:

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but no more than five times the marked maximum supply pressure from an external source and no more than five times the pressure setting of a pressure-relief device provided as part of the assembly.

b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with (a).

c) Five times the pressure setting of a required pressure-relief device.

d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly unless the pressure is limited by a pressure-relief device in accordance with (a).

e) Five times the working pressure marked on the part.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints provided the wall thickness of tubing is no less than the value specified in Table 28.1.

Exception No. 2: A pressure vessel bearing the ASME code inspection symbol – other than the UM symbol – need not comply provided the vessel is marked with a value of working pressure no less than that to which it is subjected during normal or abnormal operation.

Table 28.1
Wall thickness for copper and steel tubing

Outside diameter,		Minimum wall thickness,		Maximum pressure to which tubing is subjected					
				Seamless copper,		Butt-welded steel,		Seamless steel,	
inch	(mm)	inch	(mm)	Psig	(MPa)	Psig	(MPa)	Psig	(MPa)
3/8 or smaller	9.5	0.016	0.41	500	3.45	600	4.14	1000	6.90
1/2	12.7	0.016	0.41	400	2.76	480	3.31	800	5.52
5/8	15.9	0.016	0.41	320	2.21	384	2.65	640	4.42
5/8	15.9	0.021	0.53	420	2.90	504	3.48	840	5.80
3/4	19.0	0.021	0.53	360	2.48	432	2.98	720	4.97
3/4	19.0	0.025	0.64	420	2.90	504	3.48	840	5.80
1	25.4	0.021	0.53	260	1.79	312	2.15	520	3.59
1	25.4	0.025	0.64	320	2.21	384	2.65	640	4.42

28.4 If a test is required to determine whether a part complies with requirements in 28.3, two samples of the part are to be subjected to a hydrostatic pressure test. Each sample is to be filled with water so as to exclude air, and is to be connected to a hydraulic pump. With the pressure-relief device bypassed or otherwise prevented from operating, the pressure is to be raised gradually to the specified test value, and is to be held at that value for 1 minute. The results are not acceptable if either sample bursts or leaks.

Exception: Leakage or rupture of a nonmetallic fluid-transfer line and its connections, or at a gasket is acceptable if repeated tests conducted with the media they are intended to contain show no evidence of presenting a risk of electric shock or injury to persons.

28.5 A part supported or actuated hydraulically that could result in a risk of injury to persons due to pressure loss shall comply with the requirement in 28.4 when tested at a pressure equal to five times the maximum pressure capable of being developed in the system.

29 Pressure-Relief Devices

29.1 A means for safely relieving pressure generated by an external source of heat shall be provided for a part that is subject to pressure as described in Parts Subject to Pressure, Section 28.

29.2 A pressure-relief device, fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means may be used to comply with the requirements in 29.1.

29.3 A pressure-relief device is considered to be a pressure-actuated value or rupture member constructed to relieve excessive pressures automatically.

29.4 There shall be no shut-off valve between the pressure-relief means and the parts that it is intended to protect.

29.5 A vessel having an inside diameter of more than 3 inches (76 mm) and subject to air or steam pressure generated or stored within the pump shall be protected by a pressure-relief device.

29.6 The start-to-discharge pressure setting of a pressure-relief device shall be no higher than the working pressure marked on the vessel. The discharge rate of the device shall be adequate to relieve the pressure.

29.7 A pressure-relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and

c) Have its discharge opening located and directed so that:

1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture and

2) The likelihood of scalding persons is reduced.

29.8 A pressure-relief device having an adjustable setting shall be judged on the basis of the maximum setting unless the adjusting means is reliably sealed at a lower setting.

29.9 A control that limits the pressure in a vessel required to have a pressure-relief device shall perform under rated load for 100,000 cycles of operation, and shall operate so that the pressure does not exceed 90 percent of the relief-device setting under any condition of normal operation.

PERFORMANCE

30 Leakage Current Test

30.1 The leakage current of a cord-connected pump rated for a nominal 120- or 240-volt supply, when measured in accordance with 30.2 – 30.9, shall not exceed:

a) 0.5 milliampere for a 3-wire (grounded) portable pump and

b) 0.75 milliampere for a 3-wire (grounded) stationary or fixed pump using a standard attachment plug rated 20 amperes or less.

30.2 Leakage current refers to all currents, including capacitively-coupled currents, that may be conveyed between exposed conductive surfaces of a pump and ground or other exposed conductive surfaces of a pump.

30.3 If electrical isolation of the pump enclosure from ground by disconnection of all hose connections is not possible, the pump is to be supplied from an acceptable isolation transformer with low primary-to-secondary leakage current, and measurements are then to be made to each secondary lead instead of to ground.

30.4 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually, and where the surfaces are simultaneously accessible, collectively. A part is considered to be exposed unless guarded by an enclosure considered acceptable to reduce the risk of electric shock as described in Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 12. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time.

30.5 If part or all of an enclosure is of material other than metal, metal foil measuring 4 by 8 inches (10 by 20 cm) is to be placed on the enclosure so that all of the foil is in close contact with the surface of the pump. Leakage current is then to be measured from the foil to the grounded supply conductor, from the foil and other exposed surfaces to the grounded supply conductor, and from the foil to exposed conductive surfaces of the pump. The foil is not to remain in place long enough to affect the temperature of the pump.

Exception: For a surface smaller than 4 by 8 inches, the foil is to be the same size as the surface.

30.6 The measurement circuit for leakage current is to be as illustrated in Figure 30.1. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument, and it need not have all the attributes of the defined instrument as follows:

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have an error of no more than 5 percent at 60 hertz.

30.7 Unless the meter is being used to measure leakage from one part of a pump to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

30.7.1 A submersible pump is to be tested for leakage current while submersed in a tank filled with water. The top of the pump is to be at least 12 inches (305 mm) below the surface of the water during the test. The test tank shall be isolated from ground and the meter is to be connected between the grounding conductor and the grounded supply conductor of the flexible supply cord.

30.7.1 added March 29, 1999

30.8 A sample of the pump is to be tested for leakage current starting with the as-received condition with all switches closed, but with the grounding conductor open at the attachment plug. The as-received condition is without prior energization except as may occur as part of the production-line testing. The supply voltage is to be 120 or 240 volts as appropriate, depending upon the rated voltage of the pump. The test sequence, with reference to Figure 30.1 is to be as follows:

a) With switch S1 open, the pump is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the pump switching devices in all normal operating positions.

b) Switch S1 is then to be closed, energizing the pump, and within 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the switching devices on the pump in all their normal operating positions.

c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining these measurements. Thermal stabilization is to be obtained by operation of the pump as in the normal temperature test.

30.9 Normally, the complete leakage-current test described in 30.8 shall be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage-current tests may be interrupted for the purpose of conducting other nondestructive tests.

30.10 A permanently connected pump need not be subjected to the leakage current test if all accessible metal parts are connected to the grounding means.

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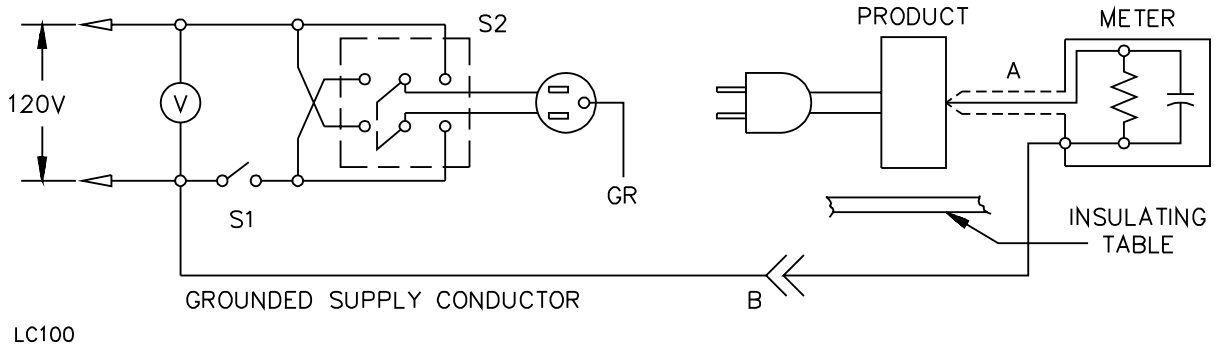
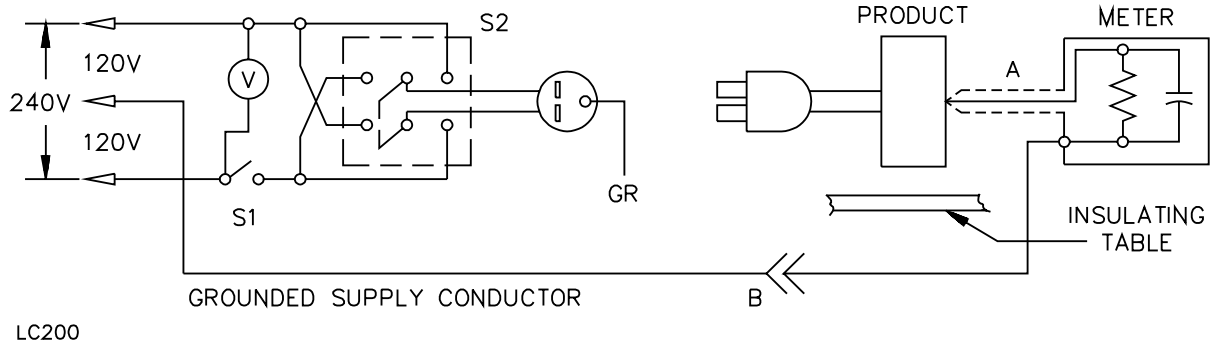
Figure 30.1
Leakage current measurement circuits



LC100



LC200

NOTES:

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of device to another.

31 Leakage Current Test Following Humidity Conditioning

31.1 A pump as described in 30.1 shall comply with the requirements for leakage current in 30.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32±2°C (90 ±4°F).

31.2 To determine whether a pump complies with the requirement in 31.1, a sample of the pump is to be heated to a temperature just above 34°C (93°F) to reduce the risk of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and conditioned for 48 hours under the conditions specified in 31.1. Following the conditioning and while still in the chamber, the sample is to be tested unenergized as described in 30.8(a). Either while the sample is still in the humidity chamber or immediately after it has been removed from the chamber, the sample is to be energized and tested as described in 30.8 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

32 Starting Current Test

32.1 A pump shall be capable of starting and operating normally on a circuit protected by an ordinary (not time-delay) fuse having a current rating corresponding to that of the branch circuit to which the pump is intended to be connected.

Exception: A pump that meets all three of the following conditions:

a) The construction of the pump or the nature of its use is such that the pump is likely to be used continually on the same branch circuit after installation;

b) The pump will start and operate normally on a circuit protected by a time-delay fuse; and

c) The pump is marked in accordance with 52.9.

32.2 To determine compliance with the requirement in 32.1, the pump is to be started three times from a standstill without opening the fuse. The pump is to be at room temperature at the beginning of the test. The test is to be conducted at rated frequency and at the voltage specified in 33.1. Each start is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle in the case of an automatic pump – and the motor is to be allowed to come to rest between successive starts. Tripping of an overload protector provided as part of the pump, or opening of the fuse is not acceptable. Load conditions are to be in accordance with the requirements in 34.2.1.

33 Input Test

33.1 The ampere input to a pump shall not exceed 110 percent of the rated value when the pump is operated under the conditions of maximum normal load as described in 34.2.1 while connected to a branch circuit of maximum rated voltage and rated frequency. Maximum rated voltages are determined as follows:

a) For a pump with a single DC voltage rating or a single AC rating not within the ranges of 110 – 120, 200– 208, 220 – 240, 440 – 480, or 550 – 600 volts, rated voltage is that single voltage.

b) For a pump with a single AC voltage rating that falls within one of the ranges given in (a), the rated voltage is considered to be the highest voltage in the range.

c) For a pump marked with a range of voltages, the highest voltage in the marked range is to be considered as if it were a single voltage rating in (a) or (b).

33.2 A pump having a single frequency rating is to be tested at that frequency. A pump rated AC-DC, DC-60 hertz, or DC-25– 60 hertz, is to be tested either on direct current or at 60 hertz, whichever results in the higher temperatures. A pump rated 25 – 60 hertz or 50 – 60 hertz is to be tested at 60 hertz.

34 Temperature Test

34.1 General

34.1.1 While loaded as described in 34.2.1, a pump shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to damage any materials or parts used in the pump, or to exceed the temperature rises specified in Table 34.1.

34.1.2 All values of temperature rise in Table 34.1 are based on an assumed room ambient temperature of 25°C (77°F). The temperature test is to be conducted at any room temperature within the range of 10 – 40°C (50 – 104°F).

Exception No. 1: The temperature rise for a submersible pump intended for use with unheated water shall not exceed the maximum temperature measured minus the water temperature. The tank shall have enough capacity or be otherwise arranged so that the heat from the pump has a negligible effect on overall ambient water temperature.

Exception No. 2: A submersible sump or deep-well pump is to be tested with water maintained at a temperature in the range of 15 – 25°C (59 – 77°F).

Exception No. 3: A submersible pump intended for use with heated water or assigned a maximum water temperature by the manufacturer is to be tested at the maximum water temperature. The temperature rises specified in Table 34.1 are to be reduced by the amount equal to the difference between the maximum water temperature and 25°C.

34.1.2 revised March 29, 1999

34.1.3 A pump marked for use with heated water in accordance with 52.6 shall be tested while pumping water as close to the marked temperature as practicable. Heated water is considered as being water maintained at a temperature above 30°C (86°F).

34.1.4 For the temperature test, the voltage and frequency of the test circuit are to be as specified for the input test described in the Input Test, Section 33. A pump rated for use at more than one voltage or for a range of voltages and containing a tapped transformer or other means of adaption to different supply voltages is to be tested under the most severe combination of supply voltage and internal adjustment. The pump may be tested by connecting it in accordance with the manufacturer's instructions if:

a) It is marked in accordance with 52.12 and 52.13 and

b) The means provided for adjusting for different supply voltages complies with the requirements for wiring terminals in Supply Connections, Section 13.

Table 34.1
Temperature rises

Table 34.1 revised March 29, 1999

Materials and components	°C	(°F)
A. MOTORS		
1. Class A insulation system on coil windings of an AC motor having a frame diameter 7 inches (178 mm) or less, not including a universal motor, and on a vibrator coil[a,b]:		
a. In an open motor and on a vibrator coil:		
Thermocouple method or resistance method	75	135
b. In a totally enclosed motor:		
Thermocouple method 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, of a DC motor, and of a universal motor[a,b]:		
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 or less not including a universal motor[a,b]:		
a. In an open motor:		
Thermocouple or resistance method	95	171
b. In a totally enclosed motor:		
Thermocouple method or resistance method	100	180
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[a,b]:		
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

Table 34.1 Continued on Next Page

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Table 34.1 Continued

Materials and components	°C	(°F)
5. Class F insulation systems on coil windings of an AC motor having a frame diameter of 7 inches or less, not including a universal motor[b]		
a. In an open motor:		
Thermocouple or resistance method	120	216
b. In a totally enclosed motor:		
Thermocouple or resistance method	125	225
B. COMPONENTS		
1. Capacitors:		
a. Electrolytic[c]	40	72
b. Other types[d]	65	117
2. Fuses		
a. Class G, J, L, T, and CC:		
Tube	100	180
Ferrule or blade	85	153
b. Others[e]	65	117
3. Relay, solenoid, and coils (except motor coil windings and transformers) with:		
a. Class 105 insulated systems		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulation systems		
Thermocouple method	85	153
Resistance method	95	171
4. Coils of a Class 2 transformer		
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. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords[e,f]	35	63
2. Copper		
a. Tinned or bare strands having		
i) A diameter less than 0.015 inch (0.38 mm)	125	225
ii) A diameter of 0.015 inch or more	175	315
b. Plated with nickel, gold, silver, or a combination of these	225	405

Table 34.1 Continued on Next Page

Table 34.1 Continued

Materials and components	°C	(°F)
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber used as electrical insulation	65	117
2. Phenolic composition used as electrical insulation or as a part the deterioration of which is capable of resulting in a risk of fire or electric shock[e]		
a. Laminated	100	180
b. Molded	125	225
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. A surface of flammable material upon which a pump is capable of being placed or mounted in service, and a surface that may be adjacent to the pump when it is so placed or mounted	65	117
2. Any point within a terminal box or wiring compartment of a permanently connected pump in which power-supply conductors are to be connected, including such conductors themselves, unless the pump is marked in accordance with 52.14	35	63
3. Wood or other flammable material, including the inside surface of the test enclosure and the surface supporting the pump	65	117

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple that is greater than the maximum temperature specified in this table complies with the intent of this requirement as long as the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple is not prohibited from being greater than the specified value by:

1. 5°C (9°F) for Class A insulation on coil windings of an AC motor having a diameter of 7 inches or less, open type;
2. 10°C (18°F) for Class B insulation on coil windings of an AC motor having a diameter of 7 inches or less, open type;
3. 15°C (27°F) for Class A insulation on coil windings of an AC motor having a diameter of more than 7 inches, open type;
4. 20°C (36°F) for Class B insulation on coil windings of an AC motor having a diameter of more than 7 inches, open type.

[b] This is the diameter measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and similar parts, used solely for motor mounting, cooling, assembly, or connection.

[c] 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 shall not be more than 65°C (117°F).

[d] A capacitor that operates at a temperature of more than 65°C complies with the intent of this requirement when evaluated on the basis of its marked temperature limit.

[e] These limitations do not apply to compounds and components that have been investigated and rated for use at higher temperatures.

[f] A rubber-insulated conductor with a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor that is subjected to a higher temperature complies with the intent of this requirement when the conductor is provided with sleeving or a braid that has been investigated and rated for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.

34.1.5 A thermocouple is to be used for determining the temperature of a coil or winding if it can be mounted without removal of encapsulating compound or the like:

a) On the integrally applied insulation of a coil without a wrap or

b) On the outer surface of a wrap that is no more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like.

The change-of-resistance method is to be used if the thermocouple measurement cannot be conducted in accordance with the foregoing. For a thermocouple-measured temperature of a motor coil as indicated in (A)(1) and (A)(3) of Table 34.1, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

34.1.6 Thermocouples are to consist of wires no larger than No. 24 AWG (0.21 mm^2) and no smaller than No. 30 AWG (0.05 mm^2). Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of No. 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used.

34.1.7 The water around a submersible pump shall be still and not filled with entrained air, whirls, and the like, from recirculated discharge. The top of the pump shall be at least 12 inches (305 mm) below the surface of the water.

34.1.8 If a pump incorporates a cord reel for the power-supply cord, one-third of the length of the cord is to be unreeled for the temperature test.

34.1.9 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature higher than 60°C (140°F), such as at a terminal, may be used if supplementary heat-resistant insulation that is of dielectric strength and has temperature properties that have been determined to be acceptable is used on the individual conductors of the cord to reduce deterioration of the conductor insulation within the appliance.

34.1.10 Unless investigated and determined to be acceptable for the application, rubber and other material subject to abrasion and deterioration shall be removed from feet and other supports of a pump if absence of the material could result in the pump attaining higher temperatures.

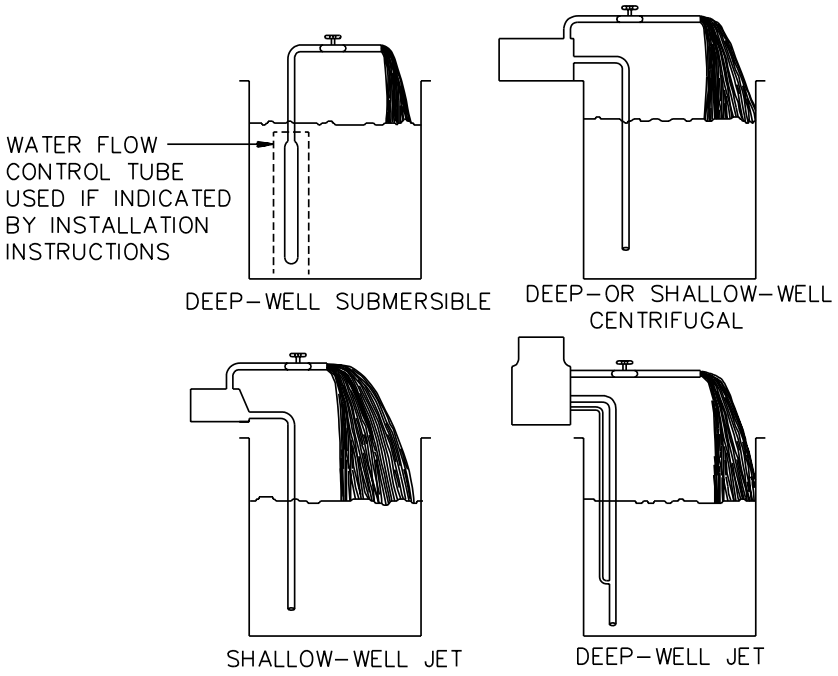
34.1.11 The temperature test is to be conducted using the maximum normal load, and is to be continued until thermal equilibrium is attained.

34.1.12 With reference to those tests that are to be continued until constant temperatures are attained, thermal equilibrium is considered to exist when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but no less than 5-minute intervals, indicate no change.

34.2 Maximum normal load

34.2.1 In tests on a pump, maximum normal load is considered to be that load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions recommended by the manufacturer of the pump. Test loads that have been found to be close approximations of the most severe conditions of normal use are described in 34.2.2 and 34.2.3 for some common types of pumps. Pumps having features not covered by these requirements are to be tested as necessary to meet the intent of the requirements. Sump, sewage, and effluent pumps are to be tested while pumping water. Test setups for various types of pumps are illustrated in Figure 34.1.

Figure 34.1
Maximum normal load test set-ups



34.2.2 A pump is to be mounted as intended, considering any limitations of its use in the installation instructions provided in accordance with 55.1(c). The test tank or sump is to be large enough to permit compliance with Exception No. 1 of 34.1.2 and 34.1.7. The pump is to be operated in the intended manner with the valve located in the water outlet pipe adjusted so that the maximum current is drawn by the pump.

Exception No. 1: For a centrifugal pump other than a sump pump, the water static discharge head distance is to be as short as possible unless the pump is marked for some other discharge head distance, in which case the marked distance is to be used.

Exception No. 2: For a sump pump, the water lift distance is to be 4 – 10 feet (1.2 – 3 m), and is to be adjusted to produce the highest electrical input.

34.2.3 A pump that is intended to circulate heated water – see 52.6 – is to be tested installed in a pipe loop attached to a heating unit adjusted to maintain the maximum water temperature recommended by the manufacturer.

35 Dielectric Voltage-Withstand Test

35.1 General

35.1.1 A pump shall withstand for 1 minute without breakdown the application of a 60-hertz, essentially sinusoidal potential:

a) Between live parts and grounded dead metal and

b) Between the terminals of a capacitor used for radio interference elimination or arc suppression. The test potential shall be as follows:

1) One thousand volts for a nonsubmersible pump rated no more than 250 volts, and no more than 1/2 horsepower (373 watt output).

2) One thousand volts plus twice the rated voltage for a nonsubmersible pump rated more than 250 volts, or more than 1/2 horsepower.

3) One thousand volts plus twice the rated voltage for a submersible pump.

35.1.2 The required test potential may be obtained from any convenient source of sufficient capacity at least 500 volt-amperes capable of maintaining the potential at the required test value except during breakdown. The voltage of the source is to be continuously variable.

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

35.1.3 In the case of a DC pump, the test potential is to be direct current.

35.2 Secondary circuits

35.2.1 Secondary circuits shall withstand for 60 seconds without breakdown the application of a test potential in accordance with 35.2.2:

a) Between primary and secondary circuits,

b) Between secondary circuits and grounded metal with all frame-connected components in place, and

c) Between secondary circuits supplied from separate transformer windings with common connections disconnected and frame connections in place.

The pump is to be at its maximum normal operating temperature during the test. A 60-hertz essentially sinusoidal voltage is to be used for testing alternating-current circuits.

35.2.2 The test potential for a secondary circuit is to be:

a) One thousand volts plus twice the operating voltage if the secondary operates at 251 – 600 volts.

b) One thousand volts if the secondary operates at 51 – 250 volts.

c) Five hundred volts if the secondary operates at 50 volts or less.

36 Oil Dielectric Voltage-Withstand Test

36.1 After conditioning in accordance with 36.2, oil in contact with live parts or motor-coil insulation that is used for heat transfer in a pump shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35.

36.2 One pint (0.42 L) of the oil is to be heated to 90 ±1°C (194 ±2°F), and while hot, two electrodes of No. 12 AWG (3.3 mm^2) solid copper wire, with the insulation removed and tips flat, are to be inserted in the oil with the electrode tips placed 1/16 inch (1.6 mm) apart. The test potential is to be applied between the electrodes in accordance with the requirements in 35.1.1.

37 Resistance to Moisture Test

37.1 A nonsubmersible pump or control intended for outdoor use shall be tested as described in 37.2 – 37.4.

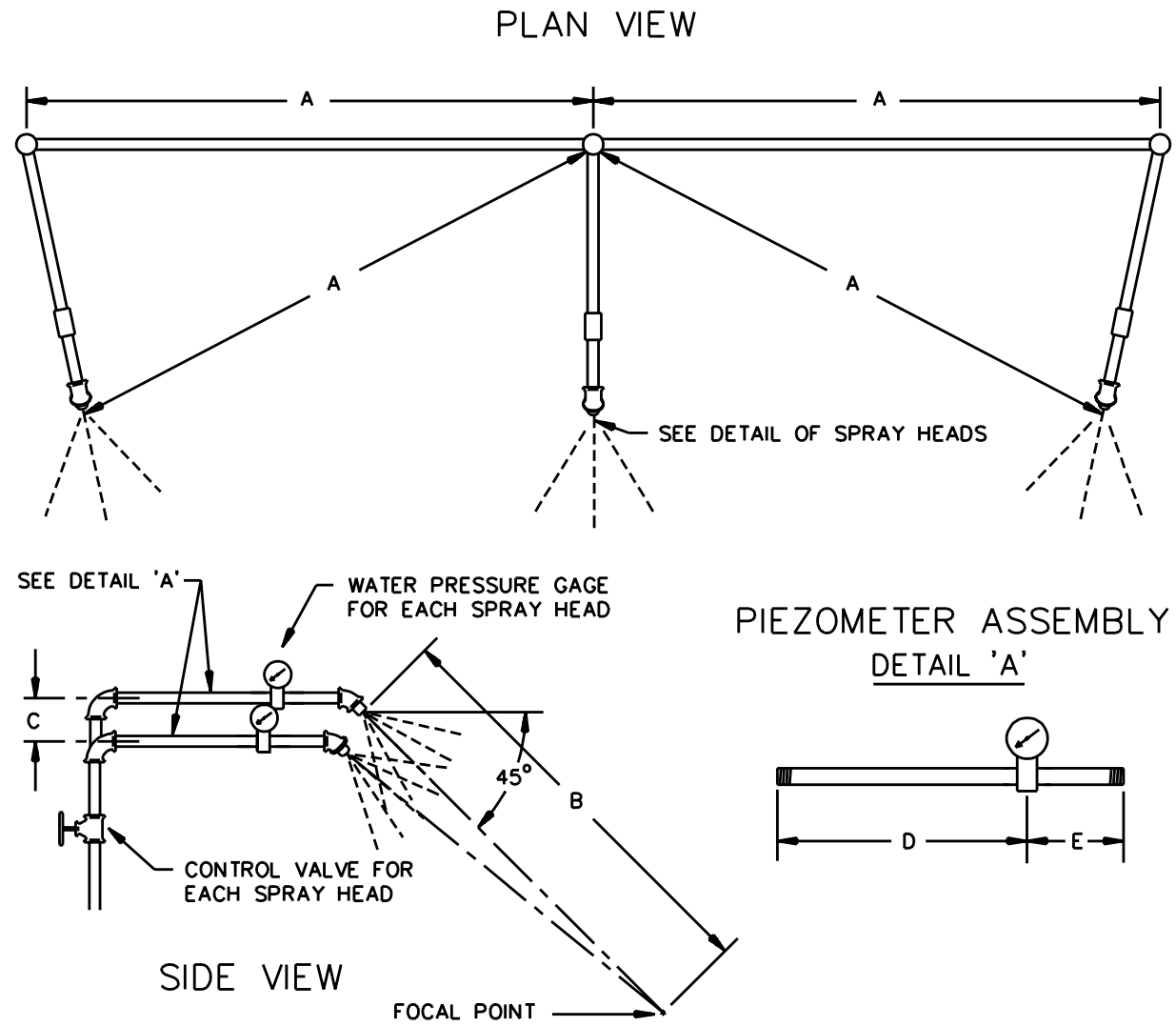
37.2 The pump is to be mounted as intended and is to be subjected to 4 hours of a water spray adjusted to be the equivalent of a beating rain. The water to be used for the test shall have its resistivity adjusted before the test is started to 3500 ohm-centimeters ±5 percent when measured at 25°C (77°F). At the conclusion of the test, the resistivity of the water shall be no less than 3200 ohm-centimeters or more than 3800 ohm-centimeters at 25°C.

37.2 revised March 29, 1999

37.3 A pump intended for outdoor use is to be subjected for 4 hours to a simulated rain by means of the apparatus illustrated in Figures 37.1 and 37.2. The spray is to be applied to the enclosure at an angle of 45 degrees to the vertical, and adjusted to be approximately the equivalent of a beating rain, as maintained by keeping all nozzle pressure at 5 psi (34.5 kPa). The pump under test is to be in a normal position, but oriented so that the likelihood of water entering the enclosure into or onto electrical components and insulation is maximized.

37.4 Upon completion of the test, the leakage-current test for a cord-connected pump, or the insulation resistance test for a permanently installed pump, and the dielectric voltage-withstand test are to be repeated. The interior of the pump is to be inspected for obvious wetting of live parts or insulation.

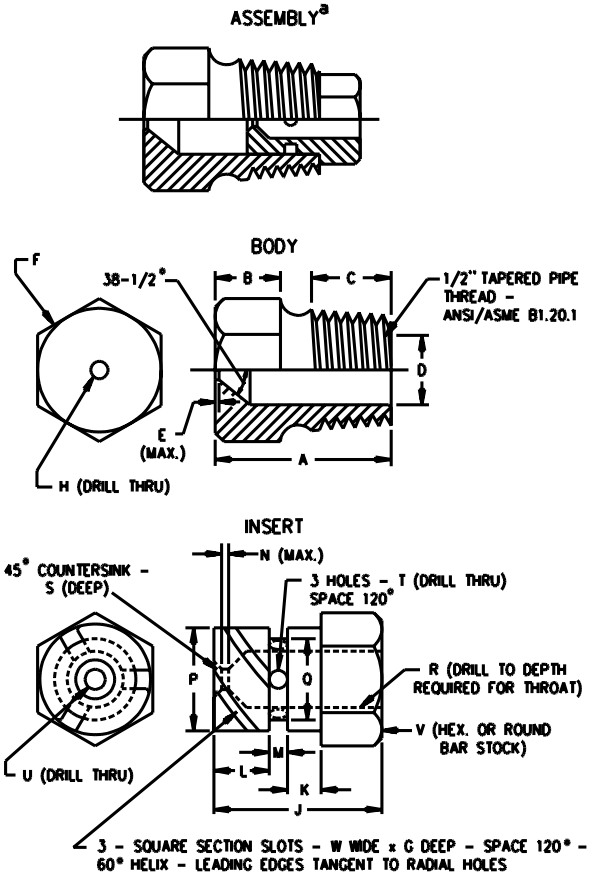
Figure 37.1
Rain-test spray head piping



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

RT101E

Figure 37.2
Rain-test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100E

38 Submersion Test

38.1 A submersible pump, after being operated for 30 days as described in 38.2, shall:

a) Perform acceptably;

b) Comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35, in a repeated dielectric voltage-withstand test;

c) Comply with the leakage-current requirements in the Leakage Current Test, Section 30, if cord-connected, or the insulation resistance requirements in the Insulation Resistance Test, Section 40, if permanently installed; and

d) Not show evidence of the entrance of liquid into the interior of the motor or other electrical part such that it could contact live parts or film-coated wire.

38.2 During conditioning, the pump is to be cycled on and off continuously for 30 days in water at 23 – 27°C (74 – 84°F). The on time is to be long enough for the motor windings to attain a temperature of at least 80 percent of the value measured during the temperature test, and the off cycle is to be long enough for the windings to cool to 30°C (86°F) or less. The pump is to be operated at maximum normal load as described in 34.2.1, and is to be submerged so that the top of the pump is at least 12 inches (305 mm) below the surface of the water.

38.2 revised March 29, 1999

39 Flooding Test

39.1 A nonsubmersible pump, after being operated for 1 hour with any field-connected inlet or discharge fitting for hose or flexible tubing loosened to simulate a fault or loose connection, shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35, and in the Leakage Current Test, Section 30, or the Insulation Resistance Test, Section 40, as applicable.

39.2 While conducting the test described in 39.1, the pump is to be in a normal position but oriented to be most likely to cause entrance of water into, or on, electrical components and insulation.

39.3 The deterioration or breakdown of a component, such as a timer switch, a float- or pressure-operated switch, a hose, flexible tubing, a gasket, a boot, a seal, a diaphragm, or the like, shall not result in a risk of electric shock due to:

a) Current leakage,

b) Insulation breakdown, or

c) Obvious wetting of any electrical component resulting from such deterioration or breakdown.

Exception: A part that has been investigated and determined to be acceptable for the purpose. See Sections 41, 42, and 47.

39.4 Test procedures for the requirements in 39.3 shall be those described in the Test for Deterioration of Parts Subject to Flexing, Section 41, and the Test for Reliability of Parts Not Subject to Flexing, Section 42. See the Abnormal Operation Test, Section 47.

39.5 Obvious wetting, as used in 39.3(c), means wetting by a stream, spray, or dripping of water that will obviously be repeated during each flooding. Obvious wetting is not meant to include wetting by random drops of water that may not be regularly repeated during subsequent flooding.

40 Insulation Resistance Test

40.1 Following the temperature test and the simulated rain, submersion, or flooding, as appropriate, a pump intended for permanent installation shall have an insulation resistance of at least 50,000 ohms between current-carrying parts and noncurrent-carrying parts.

40.2 Insulation resistance is to be measured by applying a direct-current potential of 125 volts between live parts and the enclosure and other exposed dead metal parts, using two voltmeters – one voltmeter being connected across the supply line and the other connected in series with one of the leads to the pump being tested. See Figure 40.1. Designating the reading of the line voltage as V_1, the reading of the other voltmeter as V_s, and the resistance of the latter as R_s, the insulation resistance is to be calculated by the formula:

$$\text{Insulation Resistance} = \frac{(V_1 - V_S)R_S}{V_S}$$

Exception: Self-contained laboratory grade instrumentation that produces equivalent results, such as a megohmmeter with an open circuit output of 500 volts DC, is not prohibited from being used in place of the two-voltmeter circuit shown in Figure 40.1.

40.2 revised March 29, 1999

41 Test for Deterioration of Parts Subject to Flexing

41.1 To determine whether a pump complies with the requirements in 39.3 with regard to parts subject to flexing, the deterioration of a part made of rubber, plastic, or similar material shall be simulated by operating the pump with the part completely removed.

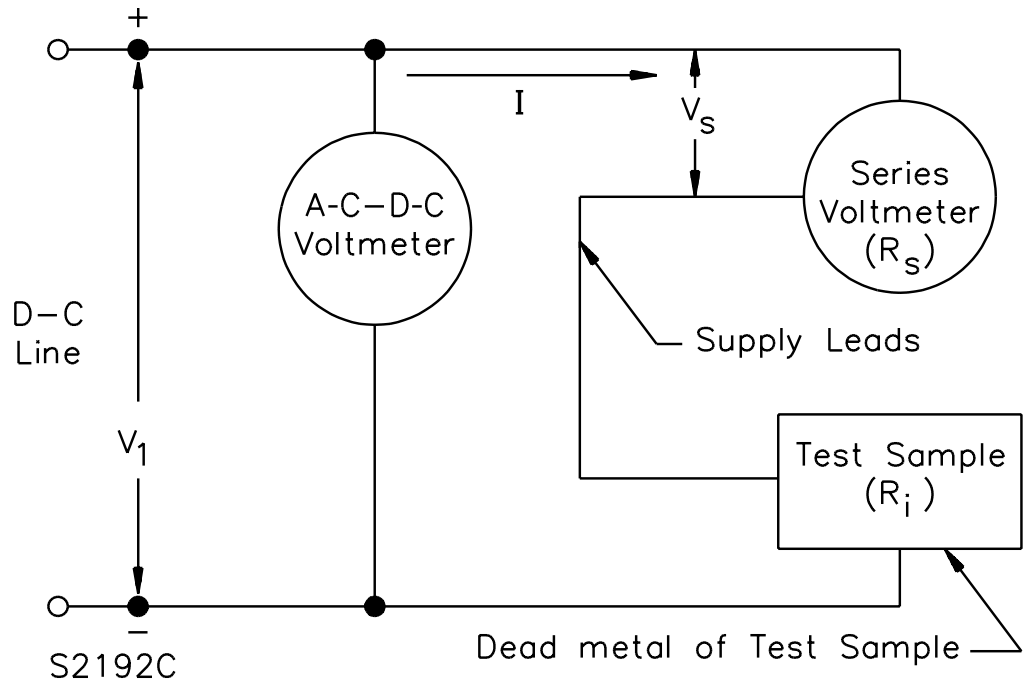
Exception No. 1: Infrequent motion of small amplitude, such as that encountered during normal operation of a diaphragm covering a pressure-operated switch, is not considered to constitute flexing.

Exception No. 2: A part that has been investigated to determine that flexing does not result in a risk of electric shock need not be subjected to this test.

41.2 While being tested as described in 41.1, the leakage current of a cord-connected pump, when determined by the method described in the Leakage Current Test, Section 30, shall not exceed 5.0 milliamperes.

Figure 40.1
Two-voltmeter method of measuring insulation resistance

Figure 40.1 added March 29, 1999



41.3 After being tested in accordance with 41.1, a permanently-installed pump shall:

a) Have an insulation resistance between live parts and exposed dead metal parts of at least 50,000 ohms, measured as described in the Insulation Resistance Test, Section 40, and

b) Comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35.

42 Test for Reliability of Parts Not Subject to Flexing

42.1 To determine acceptability in accordance with the Exception to 39.3, a material, used for a gasket, a diaphragm, a seal, or the like shall have physical properties as specified in Table 42.1 before and after the accelerated aging specified in Table 42.2. The material shall not harden, deform, melt, or otherwise deteriorate to a degree that will adversely affect the sealing properties.

Exception No. 1: A material of a component not under compression need not be subjected to the compression set requirements.

Exception No. 2: A material that has been investigated in accordance with 42.5 may have physical properties other than as specified in Table 42.1.

Exception No. 3: A noncomposite material that has been found to comply with the requirements in Table 4.1 of the Standard for Gaskets and Seals, UL 157, and that complies with the minimum acceptable elongation, tensile strength, set, and compression set after aging as specified in Table 42.1 is considered in compliance with these requirements.

42.1 revised March 29, 1999

Table 42.1
Physical properties for gaskets and seals

Table 42.1 revised February 28, 2002

Physical properties	Elastomers (neoprene, rubber, ethylene, propylene and the like), Before conditioning	Elastomers (neoprene, rubber, ethylene, propylene and the like), After conditioning	Nonelastomers (polyvinyl chloride, and the like, excluding cork, fiber, and similar materials), Before conditioning	Nonelastomers (polyvinyl chloride, and the like, excluding cork, fiber, and similar materials), After conditioning
Minimum acceptable elongation[a]	250 percent	65 percent of original	200 percent	65 percent of original
Minimum acceptable tensile strength	1500 psi (10.3 MPa)	75 percent of original	1500 psi (10.3 MPa)	75 percent of original
Maximum acceptable set[b]	1/4 inch (6.4 mm)	–	Not specified	–
Maximum acceptable compression set[c]	15 percent	–	Not specified	–

[a] Percent increase in distance between gauge marks at break compared to initial distance of 1 inch (25.4 mm). For example, a distance at break of 3.5 inches (89 mm) is 250 percent elongation.

[b] Difference between 1 inch and final distance when the specimen is stretched so that gauge marks initially 1 inch apart are 2 inches (50.4 mm) apart, held for 2 minutes, and measured 2 minutes after release.

[c] Percent set measure after Type 1 button specimens are compressed to one-fourth of original thickness, unless the construction of the gasket joint effectively limits initial compression to less than one-third of original, in which case actual compression will be used, and heat conditioned for 22 ±½ hours at 70°C (158°F) or 10°C (18°F) higher than normal operating temperature, whichever is higher, following the procedure in Method B of the Standard Test Methods for Rubber Property – Compression Set, ASTM D395.

42.2 A gasket of material other than those specified in Table 42.1, such as bonded cork or impregnated fiber, that is not known to be reliable, shall be investigated in accordance with the requirements for tensile strength in the Standard for Gaskets and Seals, UL 157. Test samples shall be taken from sheets in both the transverse and longitudinal directions. Absorptive materials, such as cork or fiber shall not be used where they are capable of contacting a live part.

42.2 revised February 28, 2002

42.3 A boot shall comply with requirements for nonelastomeric material, and a diaphragm that is compressed at the circumference shall comply with requirements for elastomeric material.

42.4 The temperatures specified in Table 42.2 correspond to the maximum temperature rise measured on the material during the Temperature Test, Section 34.

42.5 To determine acceptability in accordance with Exception No. 2 to 42.1, a gasket, a diaphragm, or a seal is to be subjected to accelerated-aging conditions specified in Table 42.2. The gasket, diaphragm, or seal is then to be installed in the associated pump and subjected to the Submersion Test, Section 38, for 60 days. It is not prohibited to subject the entire pump assembly to the accelerated-aging conditions. When an entire pump assembly is subjected to the accelerated-aging test, the gasket, diaphragm, or seal temperature shall be monitored and maintained at the values indicated in Table 42.2.

42.5 revised March 29, 1999

Table 42.2
Accelerated-aging conditions

Table 42.2 revised February 28, 2002

Measured temperature rise, °C	Measured temperature rise, (°F)	Test program[a] Non-elastomers, °C	Non-elastomers, (°F)	Elastomers, °C	Elastomers, (°F)
35 or less	63 or less	168 hours at 87	189[c]	70 hours at 100	212 [b,c]
36 – 50	64.8 – 90	240 hours at 100	212[c]	168 hours at 100	212 [b,c]
51 – 55	91.8 – 99	168 hours at 113	235[c]	168 hours at 113	235[c]
56 – 65	100.8 – 117	168 hours at 121	250[c]	168 hours at 121	250[c]
		or 1440 hours at 97	207[c]		
66 – 80	118.8 – 144	168 hours at 136	277[c]	168 hours at 136	277[c]
81 – 90	145.8 – 162	1440 hours at 121	250[c]	1440 hours at 123	253[c]
				or 360 hours at 143	289[c]
91 – 100	163.8 – 180	1440 hours at 131	268[c]	1440 hours at 133	271[c]
				or 360 hours at 153	307[c]
101 – 110	181.8 – 198	1440 hours at 141	286[c]	1440 hours at 143	289[c]
				or 360 hours at 163	325[c]
110 – 120	199.8 – 216	1440 hours at 150	302[c]	1440 hours at 153	307[c]
				or 360 hours at 173	343[c]

[a] Temperatures specified have a tolerance of ±1.0°C (±1.8°F), except where otherwise noted. The test temperature is not prohibited from being reduced by 10°C (18°F) when the test duration is doubled. For example, a rubber gasket that measured 60°C (140°F) in the pump is not prohibited from being tested at 100°C (212°F) for 70 hours or at 90°C (194°F) for 140 hours.

[b] Specified temperature has a tolerance of ±2°C (±3.6°F).

[c] An air-circulating oven should be used for all temperatures.

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43 Metallic Coating Thickness Test

43.1 The method of determining the thickness of a zinc coating as required by Protection Against Corrosion, Section 11 shall be as described in 43.2 – 43.9.

43.2 The solution used is to be made up of 200 grams per liter of reagent grade chromic acid, CrO_3 and 50 grams per liter of reagent grade concentrated sulfuric acid, H_2SO_4 in distilled water. The sulfuric acid is equivalent to 27 milliliters per liter of concentrated sulfuric acid, specific gravity 1.84, containing 96 percent H_2SO_4.

43.3 The test solution is to be placed in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube with an inside bore of 0.025 inch (0.635 mm) and a length of 5.5 inches (139.7 mm). The lower end of the capillary tube is tapered to form a tip, the drops from which are about 0.05 milliliter each. To preserve 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 then to be adjusted so that when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

43.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, and this temperature is to be recorded. The test is to be conducted at a room temperature between 21.1 and 32.2°C (70 and 90°F).

43.5 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 acceptable solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care is to be taken to avoid contact of the cleaned surface with the hands or any foreign material.

43.6 The sample to be tested is to be supported between 0.7 and 1 inch (17.8 and 25.4 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from horizontal.

43.7 After cleaning, the sample to be tested is to be put in place under the orifice. The stopcock is to be opened, and the time in seconds is to be measured with a stopwatch until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end of the timing period is the first appearance of the base metal, recognizable by a change in color at that point.

43.8 Each sample of a test lot is to be subjected to the test 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 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 are likely to have thin coatings.

43.9 To calculate the thickness of the coating, the appropriate thickness factor is to be selected from Table 43.1, considering the temperature at which the test was conducted. This factor is then to be multiplied by the time in seconds required to expose base metal during the test.

Table 43.1
Metallic-coating-thickness-test factors

Temperature,		Thickness factors, 0.00001 inch (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

44 Switches and Controls Test

44.1 A switch or other device that controls a pump motor, unless previously judged acceptable for the application or unless interlocked so that it will never break the locked-rotor motor current, shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the pump. There shall be no electrical or mechanical malfunction of the control device, nor undue pitting or burning of the contacts.

44.2 In a test to determine whether a switch or other control device performs acceptably in the overload test, the pump is to be connected to a grounded supply circuit of rated frequency and maximum rated voltage – see 33.1. The rotor of the motor is to be locked. During the test, exposed dead metal parts of the pump are to be connected to ground through a 3-ampere fuse of the appropriate voltage rating, and the connection is to be such that any single-pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit.

If the pump is intended for use on direct current or on direct current as well as alternating current, the exposed dead metal parts of the pump are to be connected so as to be positive with regard to a single-pole current-rupturing device. The device under test is to be operated at a rate of no more than 10 cycles per minute. The performance of the switch or other control device is unacceptable if the fuse in the grounding circuit opens during the test.

Exception: The device under test may be cycled at a faster rate than that specified if agreeable to all concerned.

44.3 To determine that a horsepower-rated switch or other control device is acceptable for the application, it will be necessary to determine the horsepower rating of the motor intended to be controlled. Reference is to be made to Tables 44.1 and 44.2 for this purpose. The switch ratings shall at least equal the full-load current or horsepower rating of the pump, whichever represents the higher current.

Table 44.1
Full-load motor-running currents in amperes corresponding to various AC horsepower ratings

	110 – 120 volts			220 – 240 volts[a]			440 – 480 volts			550 – 600 volts		
Horsepower	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase
1/10	3.0	–	–	1.5	–	–	–	–	–	–	–	–
1/8	3.8	–	–	1.9	–	–	–	–	–	–	–	–
1/6	4.4	–	–	2.2	–	–	–	–	–	–	–	–
1/4	5.8	–	–	2.9	–	–	–	–	–	–	–	–
1/3	7.2	–	–	3.6	–	–	–	–	–	–	–	–
1/2	9.8	4.0	4.0	4.9	2.0	2.0	2.5	1.0	1.0	2.0	0.8	0.8
3/4	13.8	4.8	5.6	6.9	2.4	2.8	3.5	1.2	1.4	2.8	1.0	1.1
1	16.0	6.4	7.2	8.0	3.2	3.6	4.0	1.6	1.8	3.2	1.3	1.4
1-1/2	20.0	9.0	10.4	10.0	4.5	5.2	5.0	2.3	2.6	4.0	1.8	2.1
2	24.0	11.8	13.6	12.0	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
3	34.0	16.6	19.2	17.0	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56.0	26.4	30.4	28.0	13.2	15.2	14.0	6.6	7.6	11.2	5.3	6.1
7-1/2	80.0	38.0	44.0	40.0	19.0	22.0	21.0	9.0	11.0	16.0	8.0	9.0
10	100.0	48.0	56.0	50.0	24.0	28.0	26.0	12.0	14.0	20.0	10.0	11.0
15	135.0	72.0	84.0	68.0	36.0	42.0	34.0	18.0	21.0	27.0	14.0	17.0

NOTE – A motor for a submersible pump may have a higher full-load running current value, in which case the marked value shall be used.

[a] To obtain full-load currents for 200- and 208-volt motors, increase corresponding 220– 240 volt ratings by 15 and 10 percent, respectively.

Table 44.2
Full-load motor-running currents in amperes corresponding to various DC horsepower ratings

Horsepower	110 – 120 volts	220 – 240 volts	550 – 600 volts
1/10	2.0	1.0	–
1/8	2.2	1.1	–
1/6	2.4	1.2	–
1/4	2.9	1.5	–
1/3	3.6	1.6	–
1/2	5.2	2.6	–
3/4	7.4	3.7	1.6
1	9.4	4.7	2.0
1-1/2	13.2	6.6	2.7
2	17.0	8.5	3.6
3	25.0	12.2	5.2
5	40.0	20.0	8.2

Table 44.2 Continued on Next Page

Table 44.2 Continued

Horsepower	110 – 120 volts	220 – 240 volts	550 – 600 volts
7-1/2	58.0	29.0	12.0
10	76.0	38.0	16.0
15	112.0	55.0	23.0

45 Strain Relief Tests

45.1 When tested in accordance with 45.2, the strain-relief means provided on a flexible cord is to withstand for 1 minute, without displacement of the cord, a direct force of 35 pounds (156 N) applied to the cord with the connections within the pump severed.

45.2 A 35 pound (15.9 kg) weight is to be suspended from the cord and supported by the pump so that the strain-relief means is stressed from any angle that the construction of the pump permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections or the watertight seal is damaged.

45.3 Strain relief at the entrance of a cord or cable of a contractor-type pump shall support the pump for 1 minute without damage to the seal or transmission of stress to the internal connections.

45.4 Strain relief at the entrance of deep-well cable to a deep-well, submersible-type pump shall withstand a 35 pound (156 N) force applied to each conductor for 1 minute without damage to the seal or transmission of stress to the internal connections. The test shall be conducted on each conductor of a twisted-singles construction and on the complete cable of the integral parallel conductor type.

46 Operation Test

46.1 Operation of a pump as described in 46.2 shall not increase the risk of fire, electric shock, or injury to persons.

46.2 With reference to 46.1, an as-received sample of the pump is to be set up or installed in accordance with the manufacturer's instructions. The sample is to be operated in accordance with the manufacturer's instructions with regard to the intended uses of the pump, including maintenance and cleaning recommended by the manufacturer and lack of such maintenance and cleaning, and with all accessories recommended by the manufacturer for use with the pump. The pump is to be manipulated as it would be in actual use, including manipulation of all controls and operation under the various loading conditions that can be expected. The pump is to be operated only for the length of time, or number of cycles needed to determine the appropriateness of the manufacturer's instructions.

47 Abnormal Operation Test

47.1 A pump that can be operated dry shall not create a risk of fire or electric shock when operated and tested in accordance with 47.3.

47.2 It shall be assumed that a pump can be operated dry if it does not incorporate a device that will open the supply circuit when water or water pressure falls below operating limits.

47.3 To determine if a pump complies with the requirement in 47.1, it is to be installed in a manner representative of typical operation and allowed to pump from a limited water supply until all water capable of being removed is gone. Operation is to continue for 7 hours without adding water. After cooling to ambient temperature, the pump is to be operated for 1 hour, pumping water normally, unless it is damaged so that water cannot reach the impeller. The pump shall comply with the requirements in 47.4 and 47.5. In addition, an inspection of the pump shall indicate that no water has entered the enclosure where it may contact an uninsulated live part or film-coated wiring.

Exception: A pump provided with a water-level switch, or a pressure-sensitive control so that the pump cannot operate with the water intake supply interrupted need not be subjected to this test.

47.4 While being tested as described in 47.3, the leakage current of a cord-connected pump, when determined by the method described in the Leakage Current Test, Section 30, shall not exceed 5.0 milliamperes. The pump shall also comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35, after the test.

47.5 After being tested as described in 47.3, a permanently-installed pump shall:

a) Have an insulation resistance between live parts and exposed dead-metal parts of at least 50,000 ohms, measured as described in the Insulation Resistance Test, Section 40, and

b) Comply with the requirements in the Dielectric Voltage-Withstand Test, Section 35.

48 Permanence of Markings

48.1 A nameplate on a pump intended for outdoor use shall be of corrosion-resistant material and shall be attached by means not depending upon adhesive unless such means have been investigated and determined to be acceptable for the purpose.

48.2 A required marking is to be molded, die-stamped, paint-stenciled, stamped, or etched on metal, or indelibly stamped on a pressure-sensitive label secured by adhesive that, upon investigation, is found to be acceptable. Ordinary usage, handling, storage, and the like, of the pump shall be considered in determination of the permanence of a marking.

48.3 Unless it has been investigated and found to be acceptable for the application, a pressure-sensitive label or a label secured by cement or adhesive that is required to be permanent shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969.

MANUFACTURING AND PRODUCTION TESTS

49 Dielectric Voltage-Withstand Test

49.1 Each pump shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 hertz:

a) Between the primary wiring, including connected components, and accessible dead-metal parts that are likely to become energized and

b) Between primary wiring and accessible low-voltage metal parts, including terminals.

49.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 49.1.

Table 49.1
Production-line test conditions

Appliance rating and form	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
105 – 130 volts, with or without a motor rated 1/2 horsepower (373 W output) or less	1000	60	1200	1
105 – 130 volts with motor rated more than 1/2 horsepower (373 W output)	1000 + 2V[a]	60	1200 + 2.4V[a]	1
210 – 600 volts	1000 + 2V[b]	60	1200 + 2.4V[b]	1

[a] Maximum marked voltage but no less than 120 volts.

[b] Maximum marked voltage but no less than 240 volts.

49.3 A pump may be in a heated or unheated condition for the test.

49.4 The test shall be conducted when the pump is fully assembled. It is not intended that it be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction-fit knob that interferes with conducting the test is not required to be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed pump.

49.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visible indicator of electrical breakdown, and either a manually-reset device to restore the equipment after electrical breakdown or an automatic reject feature activated by an unacceptable unit.

49.6 If the output of the test-equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

49.7 If the output of the test-equipment transformer is 500 volt-amperes or larger, the test potential may be indicated by:

a) A voltmeter in the primary circuit or in a tertiary-winding circuit,

b) A selector switch marked to indicate the test potential, or

c) In the case of equipment having a single test-potential output, a marking in a readily visible location to indicate the test potential.

When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually-reset switch has been reset following a dielectric breakdown.

49.8 Test equipment other than that described in 49.5 – 49.7 may be used if found acceptable to accomplish the intended factory control.

49.9 During the test, the primary switch is to be in the on position, both sides of the primary circuit of the pump are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

Exception: A pump – resistive, high-impedance winding, and the like – that has circuitry not subject to excessive secondary-voltage buildup in case of electrical breakdown during the test may be tested:

a) With a single-pole primary switch, if used, in the off position or

b) With only one side of the primary circuit connected to the test equipment when the primary switch is in the on position, or when a primary switch is not used.

50 Grounding Continuity Test

50.1 Each pump that has a power-supply cord having a grounding conductor shall be tested, as a routine production-line test, to determine that grounding continuity between the grounding blade of the attachment plug and the accessible dead metal parts of the pump that are likely to become energized. Factory-made connections of cords for connection between components shall also be tested.

50.2 Only a single test need be conducted if the accessible metal selected is conductively connected by design to all other accessible metal.

50.3 Any acceptable indicating device, such as an ohmmeter, a battery-and-buzzer combination, or the like, may be used to determine compliance with the grounding-continuity requirement in 50.1.

RATINGS

51 Details

51.1 A cord-connected pump shall be rated in amperes, volts, and frequency in one of the following terms: hertz, Hz, cycles per second, cps, cycles/second, c/s, AC-DC, or AC only.

51.2 A permanently-connected pump shall be rated in amperes, volts, and frequency in one of the following terms: hertz, Hz, cycles per second, cps, cycles/second, c/s, AC-DC, or AC only. The number of phases shall also be included in the rating if the unit is for use on a polyphase circuit. The voltage rating shall be any appropriate single voltage or voltage range, such as 110 – 120, 208, 220 – 240, 254 – 277, 440 – 480, or 550 – 660.

Exception: A fountain pump shall not be rated over 300 volts.

51.3 In the case of a pump with a full-load power factor of 80 percent or more, or of a cord-connected unit with a power rating of 50 watts or less, the pump may be rated in watts instead of amperes as required by 51.1. All other pumps shall be rated in amperes.

51.4 For a motor-operated pump that is marked with both the motor horsepower and the full-load current, the marked motor full-load current shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the overload protection, and the ground-fault protection.

51.4 added February 28, 2002

MARKINGS

52 Details

52.1 A pump, or the control or supply box above water in the case of a pump used below water, shall be legibly and permanently marked where readily visible after installation in the case of a permanently-installed pump, with:

a) The manufacturer's name, trade name, or trademark;

b) The date or other dating period of manufacturer not exceeding any three consecutive months and not repeating in less than 24 years;

c) A distinctive catalog number or the equivalent; and

d) The electrical rating.

Exception No. 1: A submersible pump having no above-ground control shall have the marking on the pump.

Exception No. 2: The manufacturer's identification may be in a traceable code if the pump is identified by the brand or trademark owned by a private labeler.

Exception No. 3: The date of manufacture may be abbreviated or in an established or otherwise acceptable code.

52.2 If a pump uses a single motor as its only electric-energy consuming component, the electrical ratings given on the motor nameplate need not be shown elsewhere on the pump if the motor nameplate is readily visible after installation.

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52.3 If a permanently-connected pump uses a dual-voltage motor, and if the motor nameplate is used to give the ratings of the pump as provided in 52.2, the pump shall also be marked to indicate the particular voltage for which it has been connected at the factory.

52.4 If a manufacturer produces or assembles pumps at more than one factory, each finished pump shall have a distinctive marking to identify it as the product of a particular factory.

52.5 A nonsubmersible pump intended for outdoor use shall be marked ″Acceptable for outdoor use″ or the equivalent.

52.6 A pump that is intended to circulate heated water shall be permanently marked with the following or equivalent: ″For use with maximum ____ °F water.″ The blank shall be filled with the temperature in degrees Fahrenheit of the water with which the pump has been investigated and determined to be acceptable.

52.7 A submersible pump intended for conduit connection to the electrical supply shall be permanently marked with the following or equivalent statement: ″For electrical connection, use rigid metal conduit joined with watertight seal.″

52.8 A submersible pump, with or without a water-level actuated switch, that has electrical parts intended to be above water level, shall be marked on its exterior to show the intended level of submersion.

52.9 If a pump will not start and attain normal running speed when connected to a circuit protected by an ordinary (not time-delay) fuse, the pump shall be plainly marked with the following or equivalent statement: ″If connected to a circuit protected by a fuse, use a time-delay fuse with this pump.″

52.10 A pump not provided with motor protection in accordance with the Exception to 19.2.1 shall be marked:

a) To indicate that motor protection must be provided by the installer and

b) With all motor ratings and information necessary for proper selection of protection by the installer.

52.11 A pump as mentioned in the Exception to 22.4 shall be marked with the following or the equivalent: ″An acceptable motor-control switch shall be provided at the time of installation.″

52.12 A pump rated for use at more than one voltage or for a range of voltages and containing a tapped transformer or other means of adaption to different supply voltages shall be marked adjacent to the cord or supply compartment to indicate that internal adjustments must be made when the pump is installed or moved.

52.13 A pump as described in 52.12 shall be permanently marked with detailed instructions that clearly show the adjustment that must be made for various supply voltages. Such instructions may be on the outside or the inside of the pump where visible at the point where adjustments for supply voltage must be made.

52.14 If any point within a terminal box or wiring compartment of a permanently connected pump in which the power-supply conductors are intended to be connected, including such conductors themselves, reaches a temperature rise of more than 35°C (63°F) during the temperature test, the pump shall be marked with the following or equivalent statement: ″For supply connection, use wires acceptable for at least ____°C (____F°).″ The temperature value shall be in accordance with Table 52.1. This statement shall be located at or near the point where the supply connections are to be made, and shall be clearly visible both during and after installation of the pump.

Table 52.1
Supply-wire temperature marking

Temperature rise reached during test in terminal box or wiring compartment	Required temperature marking
36 – 50°C (64 – 90°F)	75°C (167°F)
51 – 65°C (91 – 117°F)	90°C (194°F)

52.15 The field-wiring terminals or the area adjacent to the field-wiring terminals shall be marked with the following or equivalent statement, as applicable: ″Use copper conductors only,″ ″Use aluminum conductors only,″ or ″For use with aluminum or copper conductors.″ This marking shall be independent of any marking for terminal connectors and shall be permanent and visible when field-wiring connections are made.

Exception: This marking is not required to be provided for a terminal intended for the connection of a grounding conductor.

52.16 Information regarding the liquids with which a pump has been investigated for use shall be permanently marked on the unit or included in the installation instructions provided with the unit.

Exception: A pump (such as an irrigation pump) that is obviously intended for use with water only need not be marked or provided with additional information in the installation instructions.

52.16.1 Pumps that are capable of being used with liquids other than water, such as chemical feed pumps, shall be marked in accordance with 52.16 or be marked with the word ″CAUTION″ and the following or the equivalent: ″This Pump Has Been Evaluated for Use With Water Only.″ This information is not prohibited from being included in the installation instructions as specified in 55.7.

Added 52.16.1 effective December 1, 1999

52.17 With reference to Exception No. 1 of 13.10.2, a three-phase, cord-connected submersible pump constructed as described in 13.10.2 without provision for supply connection with the cord shall be marked to indicate that one of the methods specified in 13.10.2 shall be provided with the cord by the installer for supply connection. The marking shall state that only qualified persons shall conduct service and installation and refer to the installation instructions for further details. It is not prohibited to combine the marking with the marking specified in 52.10 or 52.11.

Revised 52.17 effective August 23, 2001

52.17.1 With reference to 13.10.2.1, a three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump shall be marked to indicate that an acceptable motor control shall be provided at the time of installation. The marking shall also specify that service and installation shall be conducted by a qualified person.

52.17.1 added August 23, 2000

52.18 With reference to 13.10.3, a three-phase, cord-connected submersible pump shall be marked: ″CAUTION″ and with the following or equivalent: ″Risk of Shock. Do not remove cord and strain relief. Do not connect conduit to pump.″

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53 Cautionary

53.1 A pump having a hidden or unexpected risk of injury to persons shall be marked to inform the user of the risk.

53.2 A cautionary marking shall be permanent and legible and shall be located on a part that cannot be removed without impairing the operation of the pump.

53.3 A cautionary marking intended to warn the operator shall be legible and visible from the position normally assumed by the operator when starting the pump. Other markings (for example, those intended for persons servicing or adjusting the pump) shall be legible and visible to an individual performing such work.

53.4 A marking intended to protect against injury to persons or to warn of specific risk shall be prefixed by the words ″CAUTION,″ ″WARNING,″ or ″DANGER″ in capital letters not less than 3/32 inch (2.4 mm) high.

53.5 A marking is not required to include a specified signal word – ″CAUTION,″ ″WARNING,″ or ″DANGER″ – more than once.

53.6 If the construction of a pump contemplates cleaning or servicing, such as the replacement of a pilot lamp or fuse, by the user, and if such cleaning or servicing would involve the exposure of normally enclosed or protected live parts to inadvertent contact, the pump shall be plainly marked to indicate that such servicing or cleaning should be done with the pump disconnected from the supply circuit. The marking shall include the word ″CAUTION″ and the following or equivalent: ″To reduce risk of electric shock, pull plug before servicing this pump.″

53.7 A nonsubmersible sump pump shall be plainly marked ″CAUTION″ and the following or equivalent: ″To reduce risk of electric shock, install with motor and all electrical components above the top grade level of the sump. This pump is not submersible.″

53.8 A pump, such as a sump pump, contractor pump, or other pump that could be used in a swimming pool but not so evaluated shall be permanently marked with the word ″WARNING″ and the following or equivalent: ″Risk of electric shock – This pump has not been investigated for use in swimming pool areas.″

53.9 A pump intended for permanent installation shall be marked ″WARNING″ and the following or equivalent: ″To reduce risk of electric shock, see instruction manual for proper installation.″ This marking shall be visible with the pump in its normal operating position.

53.10 A cord- and plug-connected pump shall be permanently marked ″WARNING″ and the following or equivalent: ″To reduce risk of electric shock, connect only to a properly grounded, grounding-type receptacle.″ This marking shall be visible with the pump in its normal operating position.

53.10 revised March 29, 1999

53.11 If, when energized, a pump has a moving part that can cause injury to persons, a switch (other than a momentary contact type) controlling the motor that drives that part shall have a plainly marked off position.

INSTRUCTION MANUAL

54 General

54.1 A pump shall be provided with legible instructions as specified in Installation and Operating Instructions, Section 55, and Grounding Instructions, Section 56.

54.2 The cautionary prefix ″WARNING,″ required in 56.1, shall be in capital letters no less than 3/32 inch (2.4 mm) high.

55 Installation and Operating Instructions

55.1 A permanently installed pump, a submersible contractor pump, and a pump requiring on-site wiring shall be provided with the following:

a) A wiring diagram that shows intended methods of connection to the supply circuit.

b) For a submersible well pump, instructions for connection of well cable to the motor, and proper support and protection of the cable against damage between the motor and the point of supply connection at ground level.

c) For a pump requiring a minimum rate of flow through or past it, or a certain maximum diameter casing around the pump to permit such flow, information needed to obtain the required flow.

55.2 Instructions shall be provided for the correct installation of a control device needed for proper operation of a pump but not provided with the pump.

55.3 A pump that is intended to pump sewage shall be provided with instructions specifying that the tank is to be vented in accordance with local plumbing codes and shall warn the user that the pump is not to be installed in locations classified as hazardous in accordance with the National Electrical Code, ANSI/NFPA 70.

55.4 The instructions for a fountain pump that has a flexible cord of other than Type SO or ST, as specified in 13.10.1, shall include the word ″WARNING″ and the following or equivalent: ″To reduce the risk of electric shock, use only on portable self-contained fountains no larger than 5 feet in any dimension.″

55.5 With reference to the Exception to No. 1 of 13.10.2, a three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump constructed in the manner described in 13.10.2 without provision for supply connection with the cord shall be provided with instructions for the installation of the devices that are provided in accordance with 52.17. These instructions shall specify the location of the devices (such as a box for use inside pump tanks or basin systems), the type of the devices (such as box type, strain relief, water-tight fittings, and similar components) to be used during installation. The installation instructions shall also state that the pump is to be installed in accordance with state and local codes and that only qualified personnel shall service and install the pump.

Revised 55.5 effective August 28, 2003

55.5.1 With reference to 13.10.2.1, a three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump shall be provided with instructions for the installation of the fixed wire electrical control device. The instructions shall also indicate that an acceptable motor control shall be provided at the time of installation. The instructions shall specify that the pump is to be installed in accordance with state and local codes and that installation and servicing shall be conducted by a qualified person.

Revised 55.5.1 effective August 28, 2003

55.6 With reference to 13.10.3, a three-phase cord-connected submersible pump shall be provided with installation instructions that state: ″CAUTION″ and the following or equivalent: ″Risk of Electric Shock. Do not remove cord and strain relief. Do not connect conduit to pump.″

55.7 With reference to 52.16.1, pumps that have not been evaluated for use with liquids other than water shall be provided with instructions including the word ″CAUTION″ and the following or equivalent: ″This Pump Has Been Evaluated for Use With Water Only.″

Added 55.7 effective December 1, 1999

56 Grounding Instructions

56.1 The grounding instructions shall include those Instructions in (a) and (b) applicable to the pump, or the applicable instructions shall be included in the installation and operating instructions. See 54.2.

a) For a submersible well pump, the word ″WARNING″ and the following instructions or the equivalent: ″Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding:

1) When the means of connection to the supply-connection box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor, at least the size of the circuit conductors supplying the pump, to the grounding screw provided within the wiring compartment.

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2) This pump is provided with a means for grounding. To reduce the risk of electric shock from contact with adjacent metal parts, bond supply box to the pump-motor-grounding means and to all metal parts accessible at the well head, including metal discharge pipes, metal well casing, and similar parts, by means of:

i) An equipment-grounding conductor at least the size of the well-cable conductors, or the equivalent, that runs down the well with the well cable and

ii) A clamp, a weld, or both when required, secured to the equipment-grounding lead, the equipment-grounding terminal, or the grounding conductor on the pump housing.

The equipment-grounding lead, when one is provided, is the conductor that has an outer surface of insulation that is green with or without one or more yellow stripes.″

b) For a cord and plug-connected pump, the word ″WARNING″ and the following instructions or the equivalent: ″Risk of electric shock – This pump is supplied with a grounding conductor and grounding-type attachment plug. To reduce the risk of electric shock, be certain that it is connected only to a properly grounded, grounding-type receptacle.″

56.1 revised March 29, 1999

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Conduit, Flexible Metal – UL 1
Conduit, Liquid-Tight Flexible Nonmetallic – UL 1660
Cord Sets and Power-Supply Cords – UL 817
Fittings for Cable and Conduit – UL 514B
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Gaskets and Seals – UL 157
Industrial Control Equipment – UL 508
Lampholders, Edison-Base – UL 496
Motors, Electric – UL 1004
Outlet Boxes, Metallic – UL 514A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed-Wiring Boards – UL 796
Switches, Special-Use – UL 1054
Systems of Insulating Materials – General – UL 1446
Terminal Blocks – UL 1059
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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Superseded requirements for the Standard for Motor-Operated Water Pumps

UL 778, Third Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

Table 13.1
Minimum useable volume of terminal compartments

Size of conductor, AWG	Size of conductor, (mm^2)	Volume per power supply conductor,[a] cubic inches	Volume per power supply conductor,[a] (cm^3)
14	2.1	2.00	33
12	3.3	2.25	37
10	5.3	2.50	41
8	8.4	3.00	49
6	13.3	5.00	82

Table 13.2
Motor terminal compartments for wire-to-wire connections

Horsepower (kW output)	Minimum dimensions for cover openings, inches	Minimum dimensions for cover openings, (mm)	Minimum usable volume, cubic inches	Minimum usable volume, (cm^3)
1 (0.7) or less[a]	1-5/8	41	7-1/2	123
1-1/2, 2, and 3 (1.2, 1.5, and 2.2)[a]	1-3/4	44	12	197
5 and 7-1/2 (3.7 and 5.6)	2	51	16	262
10 and 15 (7.5 and 11.2)	2-1/2	63.5	26	426

[a] When the terminal compartment is partially or wholly integral with the frame or end shield, the minimum dimension of the cover opening is not specified, and the volume of the terminal compartment shall be no less than:

1) 0.8 cubic inch (13.1 cm^3) per wire-to-wire connection for 1 horsepower or smaller motors.

2) 1.0 cubic inch (16.4 cm^3) per wire-to-wire connection for 1-1/2, 2, and 3 horsepower motors.

Table 13.3
Terminal compartments for rigidly mounted motor terminals

Power-supply-conductor size, AWG	(mm^2)	Minimum usable volume per power-supply connector, cubic inches	(mm^3)
14 and smaller	2.1 and smaller	1	16.4
12 and 10	3.3 and 5.3	1-1/4	20.3
8 and 6	8.4 and 13.3	2-1/4	37

55.5 With reference to Exception No. 1 of 13.10.2, a three-phase cord-connected submersible pump constructed in the manner described in 13.10.2 without provision for supply connection with the cord shall be provided with instructions for the installation of the devices that are provided in accordance with 52.17. These instructions shall specify the location of the devices (such as a box for use inside pump tanks or basin systems), the type of the devices (such as box type, strain relief, water-tight fittings, and similar components) to be used during installation. The installation instructions shall also state that only qualified personnel shall service and install the pump.

55.5.1 With reference to 13.10.2.1, a three-phase cord-connected submersible pump or a single-phase cord-connected sewage, effluent, and grinder pump shall be provided with instructions for the installation of the fixed wire electrical control device. The instructions shall also indicate that an acceptable motor control shall be provided at the time of installation. The instructions shall specify that the pump is to be installed in accordance with state and local codes and that installation and servicing shall be conducted by a qualified person.