UL 428A

STANDARD FOR SAFETY

Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85)

UL Standard for Safety for Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85), UL 428A

First Edition, Dated June 4, 2015

Summary of Topics

This revision of ANSI/UL 428A dated February 3, 2021 is issued to Equate Long Term Exposure Testing Duration – Valve and End Product; 27.3.3

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

The revised requirements are substantially in accordance with Proposal (s) on this subject dated November 6, 2020.

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UL 428A

Standard for Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85)

Prior to the first edition, the requirements for the products covered by this standard were included in the Outline of Investigation for Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85), UL 428A.

First Edition

June 4, 2015

This ANSI/UL Standard for Safety consists of the First Edition including revisions through February 3, 2021.

The most recent designation of ANSI/UL 428A as an American National Standard (ANSI) occurred on January 22, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

MANUFACTURING AND PRODUCTION

ELECTRICAL RATINGS

MARKING

SUPPLEMENT SA – MARINE USE ELECTRICALLY OPERATED SHUT-OFF VALVES FOR GASOLINE AND GASOLINE/ETHANOL BLENDS WITH NOMINAL ETHANOL CONCENTRATIONS UP TO 85 PERCENT (E0 – E85)

SUPPLEMENT SB – Test Fluids

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated general purpose and safety valves rated 600 volts or less and intended for the control of the fluids specified in 1.2. Electrically operated valves, other than automotive fuel valves, covered by these requirements are intended to be used in other than hazardous locations as defined in accordance with the National Electrical Code, NFPA 70.

1.2 Electrically operated valves for use in dispensing devices are intended for use with one or more of the following:

a) Gasoline formulated in accordance with the Standard Specification for Automotive Spark Ignition Fuel, ANSI/ASTM D4814;

b) Gasoline/ethanol blends with nominal ethanol concentrations up to 25 percent ethanol (E25), consisting of gasoline formulated in accordance with the Standard Specification for Automotive Spark Ignition Fuel, ANSI/ASTM D4814, when blended with denatured fuel ethanol formulated to be consistent with the Standard Specification for Denatured Fuel Ethanol for Blending With Gasoline For Use as Automotive Spark Ignition Engine Fuel, ANSI/ASTM D4806; or

c) Gasoline/ethanol blends with nominal ethanol concentrations above 25 percent formulated in accordance with the Standard Specification in item (b) or formulated in accordance with the Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark Ignition Engines, ANSI/ASTM D5798, as applicable.

1.3 These requirements cover valves whose coils are powered by a Class 2 (low-voltage) source. Valves incorporating a high-voltage transformer with a low-voltage secondary as an integral part of the valve assembly, are also covered by these requirements.

1.4 These requirements do not cover valves for use with fluids other than as specified in 1.2.

1.5 These requirements do not cover valves employing electrical parts, including coils, switch contacts and resistance elements, located in the flammable gas containing compartment of a valve. Valves constructed as such shall comply with the requirements in the Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations, UL 913.

2 General

2.1 Components

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

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

2.2.2 Unless indicated otherwise 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.

2.4 Automotive-fuel valve

2.4.1 An automotive fuel valve shall comply with the requirements applicable to safety valves in the Standard for Electrically Operated Valves, UL 429.

3 Glossary

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

3.2 AUTOMOTIVE-FUEL VALVE – An electrically operated valve rated for use with a direct current (DC) circuit and intended for use as a fuel-line shutoff valve on mobile equipment.

3.3 BLENDING OPTION – Dispensing devices may be provided with an option that blends two specific fuels into one fuel to be dispensed. This blending occurs at the dispenser level and can be in two forms:

a)Fixed blending – Blending at the dispenser level that blends two specific fuels into one fuel to be dispensed, and that fuel to be dispensed is fixed. For example, fixed blending includes blend options where gasoline and denatured fuel ethanol can be blended to achieve E85, which is the actual dispensed fuel.

b)Variable blending – Blending at the dispenser level that blends two specific fuels into the fuel to be dispensed, but the fuel to be dispensed can be any of a number of previously set points. For example, variable blending includes blend options where gasoline and E85 can be blended to achieve E40, E60, and E85 as the actual dispensed fuel.

3.4 ELECTRICAL CIRCUITS –

a) Class 2 Circuit – A circuit involving a potential of not more than 42.4 volts peak supplied by:

1) An isolating source that complies with the requirements in the Standard for Class 2 Power Units, UL 1310, or the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3

2) A dry cell battery having output characteristics no greater than those of an inherently limited Class 2 transformer; or

3) A combination of a rechargeable battery and a fixed impedance or regulating network that complies with the applicable performance requirements for an inherently limited Class 2 transformer.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts ac (42.4 volts peak or direct current) and supplied from transformer output windings which are electrically isolated (i.e. insulated from ground). A circuit derived from a source of supply classified as a high voltage circuit, by connecting 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. Unless the isolating transformer is provided as part of the valve or marked per 49.7, the circuit shall be considered a high voltage circuit.

c) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

d) Intrinsically Safe Circuit – A circuit in which any spark or thermal effect produced either normally or in specified fault conditions, is incapable of causing ignition of a mixture of flammable or combustible material in air in the mixtures most easily ignited concentration under the test conditions specified in the Standard for Intrinsically Safe Apparatus and Associated Apparatus, for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations, UL 913.

e) Safety-Control Circuit – A circuit involving one or more safety controls.

3.5 GASOLINE/ETHANOL BLENDS – Blended fuels composed of a gasoline component and an ethanol component. The numerical value corresponding to the ethanol component determines the blend rating (such as E85 for 85% ethanol, 15% gasoline).

3.6 GENERAL PURPOSE VALVE – Either a normally open or normally closed valve intended to control the flow of a fluid.

3.7 MAXIMUM OPERATING PRESSURE DIFFERENTIAL– The maximum difference between the pressure at an inlet port and the pressure at an outlet port against which an electrically operated valve is intended to operate.

3.8 MAXIMUM RATED PRESSURE – The maximum pressure to which the valve assembly may be subjected as specified by the manufacturer.

3.9 MINIMUM OPERATING PRESSURE DIFFERENTIAL – The minimum difference between the pressure at an inlet port and the pressure at an outlet port required for operation of the valve.

3.10 RAINPROOF ENCLOSURE – An enclosure that prevents rain from interfering with the intended operation of apparatus within the enclosure.

3.11 RAINTIGHT ENCLOSURE – An enclosure that, when exposed to a beating rain, does not permit water to enter the enclosure.

3.12 SAFETY VALVE – A normally closed valve intended to be actuated by a safety control or by an emergency device to prevent the delivery of a fluid that can result in risk of fire.

3.13 SEALS, DYNAMIC – A seal that is subject to mechanical movement or other applied forces that result in movement or flexing of the seal under normal use conditions.

3.14 SEALS, STATIC – A seal that is not subject to mechanical movement or other applied forces other than compression forces that are applied during installation and maintained during normal use conditions.

3.15 SWITCH – A contact device actuated by the valve mechanism and intended to control electrical loads that are internal or external to the valve.

a) Safety Switch – A switch that opens and closes a safety-control circuit, or one intended for use as an interlock in a safety-control circuit.

b) Nonsafety Switch – A switch not associated with a safety-control circuit.

3.16 WATERTIGHT ENCLOSURE– An enclosure that, when subjected to the application of a hose stream as described in the Hosedown Test, Section 40, does not permit water to enter the enclosure.

CONSTRUCTION

4 General

4.1 Valves shall be constructed so that they comply with the rules for installation and use of such equipment as given in the National Electrical Code, ANSI/NFPA 70.

4.2 Fluid confining parts, except gaskets and seals, shall be constructed of metallic materials.

5 Assembly

5.1 All valves

5.1.1 A valve shall include all the components necessary for its intended function and installation. The components shall be constructed for assembly as a unit.

5.1.2 Two or more subassemblies intended to be assembled in the field as a unit shall be capable of being joined together without requiring any of the subassemblies to be cut, drilled, welded, or otherwise altered.

5.1.3 If two or more valves or actuating devices, or both, are intended to be used together as one unit, the entire assembly is to be considered and tested as one valve.

5.1.4 The construction of a valve shall be such that parts can be reassembled after being dismantled to the extent needed for servicing.

5.1.5 A screwed cap or cover that constitutes a fluid-confining part, and that is intended to be removed for servicing a valve, shall require the use of a tool for removal.

5.1.6 A seat disc shall be attached to its poppet or holder or be otherwise assembled to prevent it from becoming dislocated under service conditions. The disc may be secured by crimping, staking, or the equivalent, or by means of a chemical bond achieved by vulcanization in a controlled molding process. Cement or adhesive shall not be used as the sole means for securing a disc.

5.1.7 The valve assembly shall withstand the stresses and vibration of intended operation, as determined by compliance with the Endurance Test, Section 29.

5.2 Safety valves

5.2.1 A safety valve shall not depend on an outside source of energy, such as electricity, to function as a safety shutoff.

5.2.2 A safety valve shall close independently of the energy supplied by the medium flowing. However, the medium flowing may be used to exert supplementary closing forces on the valve seat.

5.2.3 A safety valve shall not be equipped with a bypass or with a means to prevent it from closing completely. This requirement does not apply to a feature provided to permit a takeoff to recirculate fluid or to supply a pilot or other individually controlled outlet.

5.2.4 An automatic shutoff mechanism shall be guarded to prevent unintended obstruction of moving parts.

5.2.5 A safety valve shall also function as a safety shutoff if intended to function as a safety shutoff, regardless of the position of any damper or external operating lever or any reset device. The manipulation of a manual-reset device shall not cause the valve to function as an automatic-reset valve.

5.2.6 A safety valve shall not be equipped with means for manually latching the valve in the open position if such latching may prevent the valve from functioning as a safety shutoff.

5.2.7 The appropriate positions or the direction of movement for a manual operating lever or reset handle included in a safety valve shall be clearly indicated.

5.2.8 If a mechanically actuated indicator is provided to indicate whether the main valve is open or shut, the indicator shall be visible from a distance of at least 5 feet (1.5 m).

5.3 Class 2 (low-voltage) valves

5.3.1 Valves whose coils are powered by a Class 2 (low-voltage) source shall comply with the construction and testing requirements defined in this standard, Section 19.

6 Materials

6.1 Metallic materials

6.1.1 General

6.1.1.1 A metallic part, in contact with the fuels anticipated by these requirements, shall be resistant to the action of the fuel if degradation of the material will result in leakage of the fuel or if it will impair the function of the device. For all fuel ratings, see Corrosion due to fluid, 6.1.2.1. For valves rated for gasoline/ethanol blends with nominal ethanol concentrations greater than 40%, see Metallic materials – system level, 6.1.3.

6.1.1.2 The exposed surfaces of metallic parts shall be resistant to atmospheric corrosion if this corrosion will lead to leakage of the fluid or if it will impair the function of the device. The material shall comply with the requirements in Atmospheric corrosion, 6.1.2.2.

6.1.1.3 Metallic parts in contact with the fuels anticipated by these requirements shall not be constructed of lead, or materials that are substantially lead. In addition, no coatings or platings containing lead shall be used, such as terne-plated steel.

6.1.2 Metallic materials – material level

6.1.2.1 Corrosion due to fluid

6.1.2.1.1 All metallic materials used for fluid confining parts shall be resistant to corrosion caused by the fuels anticipated by these requirements. In addition, metallic materials, used internally in fluid confining parts, that are required to operate in some manner to address safety (e.g. plunger on a valve) shall be resistant to corrosion caused by these fuels. Compliance is verified by the Long Term Exposure Test, Section 27.

6.1.2.1.2 A coating or plating, applied to a base metal, shall be resistant to the action of the fuels anticipated by these requirements as determined by the Long Term Exposure Test, Section 27.

6.1.2.2 Atmospheric corrosion

6.1.2.2.1 Metallic materials used for fluid confining parts shall be resistant to atmospheric corrosion. Ferrous materials of the thickness specified in the following items are acceptable for the preceding when uncoated:

a) A casting having a wall thickness of not less than 1/4 inch (6.4 mm) if shown by production test to be free of leakage, and

b) Fabricated sheet steel parts having a minimum wall thickness of 0.093 inch (2.36 mm).

6.1.2.2.2 A protective coating shall provide resistance against atmospheric corrosion to a degree not less than that provided by the protective coatings specified in 6.1.2.2.3.

6.1.2.2.3 Cadmium plating shall not be less than 0.0003 inch (0.008 mm) thick, and zinc plating shall not be less than 0.0005 inch (0.013 mm) thick, except on parts where threads constitute the major portion of the area in which case the cadmium or zinc plating shall not be less than 0.00015 inch (0.0038 mm) thick. Metallic parts are considered to comply with 6.1.2.2.1 when they are protected against atmospheric corrosion by:

a) Hot dipped, mill galvanized sheet steel complying with the coating designation G90 in Table I of the Specification for Sheet Steel, Zinc Coated (Galvanized) or Zinc-Iron-Alloy Coated (Galvannealed) by the Hot Dip Process, ASTM A653/A653M; or

b) Coatings which have been determined to be equivalent to G90 under the requirements of the Standard for Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment, UL 1332.

6.1.2.2.4 A metallic material other than as described in 6.1.2.2.1 – 6.1.2.2.3 shall be painted or protected in a manner that has been determined to be equivalent.

6.1.3 Metallic materials – system level

6.1.3.1 Combinations of metallic materials in products rated for use with gasoline/ethanol blends with nominal ethanol concentrations greater than 40% shall be chosen to reduce degradation due to galvanic corrosion in accordance with 6.1.3.2 – 6.1.3.4.

6.1.3.2 Table 6.1 shows the galvanic series for metallic materials exposed to a conductive solution of sea water. The most active material in a given combination will experience increased levels of corrosion, while the most passive material in the combination will experience reduced levels of corrosion. The greater the separation of the materials are in the galvanic series of Table 6.1, the more pronounced the effects would be. Table 6.1 serves as a guide in selecting the appropriate test conditions based on manufacturer specified material combinations.

Table 6.1
Galvanic series of metal materials

Most passive	Platinum
–	Gold
–	Graphite
–	Silver
–	Stainless Steel Type 316 (Passive)
–	Stainless Steel Type 304 (Passive)
–	Titanium
–	13% Chromium Stainless Steel (Passive)
–	76 Ni – 16 Cr – 7 Fe Alloy (Passive)
–	Nickel (Passive)
–	Silver Solder
–	M-Bronze
–	G-Bronze
–	70:30 Cupro Nickel
–	Silicon Bronze
–	Copper
–	Red Brass
–	Aluminum Brass
–	Admiralty Brass
–	Yellow Brass
–	60 Ni – 30 Mo – 6 Fe – 1 Mn
–	76 Ni – 16 Cr – 7 Fe Alloy (Active)
–	Nickel (Active)
–	Manganese Bronze
–	Tin
–	Stainless Steel Type 316 (Active)
–	Stainless Steel Type 304 (Active)
–	13% Chromium Stainless Steel (Active)
–	Cast Iron
–	Wrought Iron
–	Mild Steel
–	Aluminum 2024
–	Cadmium
–	Alclad
–	Aluminum 6053
–	Aluminum 1100
–	Galvanized Steel
–	Zinc
–	Magnesium Alloys
Most active	Magnesium
Note – Reprinted with permission from NACE. Based on table titled "Galvanic Series of Metals Exposed to Seawater" from NACE Corrosion Engineer's Reference Book, Third Edition ©NACE International 2002, page 127.	

6.1.3.3 Platings, such as nickel plating, can be used to reduce or eliminate dissimilar metal contact areas, as long as the plating material complies with 6.1.3.2 as the contact metal. If used, the plating shall comply with the Long Term Exposure Test, Section 27.

6.1.3.4 Gaskets or nonmetallic spacers used to reduce or eliminate dissimilar metal contact areas, where permitted, shall be subjected to the applicable requirements for static seals in Nonmetallic materials, 6.2, when they are in contact with the fluid.

6.2 Nonmetallic materials

6.2.1 General

6.2.1.1 A nonmetallic part in contact with the fuels anticipated by these requirements, shall be resistant to the action of the fuel if degradation of the material will result in leakage of the fuel, or if it will impair the function of the device.

6.2.1.2 Gaskets or seals shall be designated as dynamic and/or static seals. See 3.9 and 3.10 respectively. If the type of seal cannot be determined, then the material shall be treated as both a static and a dynamic seal.

6.2.1.3 Gaskets and seals shall comply with the requirements as outlined in Nonmetallic materials – material level, 6.2.2 and Nonmetallic materials – system level, 6.2.3.

6.2.1.4 Nonmetallic materials in contact with the fuels anticipated by these requirements shall not be constructed of the following:

a) Polysulfide rubber;

b) Ethylene propylene diene monomer (EPDM) rubber;

c) Methyl-Methacrylate;

d) Polyvinyl Chloride (PVC);

e) Nylon 6/6; or

f) Polyurethane.

6.2.2 Nonmetallic materials – fluid compatibility – material level

6.2.2.1 Static seals

6.2.2.1.1 Static seals shall be evaluated in accordance with the Standard for Gaskets and Seals, UL 157, modified as indicated in 6.2.2.1.2 – 6.2.2.1.4. If a specific material complies with these requirements, the material can be considered to be qualified for system testing.

6.2.2.1.2 A static seal shall be constructed of a material that is acceptable in accordance with the scope of Standard for Gaskets and Seals, UL 157.

6.2.2.1.3 Static seals shall be subjected to the Volume Change and Extraction Test in accordance with the Standard for Gaskets and Seals, UL 157, except for the following modifications:

a) The test duration shall be 1000 hours;

b) The applicable test fluids shall be as described in Supplement SB; and

c) For all materials, the average volume change shall not exceed 40% swell (increase in volume) or 1% shrinkage (decrease in volume). In addition, the weight loss shall not exceed 10%. For coated fabrics, alternate limits can be used with the average volume change not exceeding 60% swell or 5% shrinkage, and the weight loss shall not exceed 20%. There shall be no visual evidence of cracking or other degradation as a result of the exposure for any material including coated fabrics.

6.2.2.1.4 Static seals shall be subjected to the Compression Set Test in accordance with the Standard for Gaskets and Seals, UL 157, except for the following modifications:

a) The test duration shall be 1000 hours.

b) The samples shall be immersed, at room temperature, in the test fluids (see item c) while compressed for the entire test duration. No oven conditioning is required.

c) The applicable test fluids shall be as described in Supplement SB.

d) The recovery period shall consist of removing the sample from the compression device and immersing it in the applicable test fluid for 30 minutes at room temperature. The sample shall not be allowed to dry out due to exposure to air. The 30-minute immersion should use the same fluid as the test fluid for each sample.

e) For all materials, the average compressions set is calculated and shall not exceed 35 percent. For coated fabrics, alternate limits can be used with the average compression set not exceeding 70%.

Exception: This requirement does not apply to composite gasket materials as defined in accordance with the Standard for Gaskets and Seals, UL 157.

6.2.2.2 Dynamic seals

6.2.2.2.1 Dynamic seals shall be evaluated in accordance with the Standard for Gaskets and Seals, UL 157 modified as indicated in 6.2.2.2.2 – 6.2.2.2.4. If a specific material complies with these requirements, the material can be considered to be qualified for system testing.

6.2.2.2.2 A dynamic seal shall be constructed of a material that is acceptable in accordance with the scope of the Standard for Gaskets and Seals, UL 157.

6.2.2.2.3 Dynamic seals shall be subjected to the Volume Change and Extraction Test in accordance with the Standard for Gaskets and Seals, UL 157, except for the following modifications:

a) The test duration shall be 1000 hours;

b) The applicable test fluids shall be as described in Supplement SB; and

c) For all materials, the average volume change for a gasket or seal material shall not exceed 40% swell (increase in volume) or 1% shrinkage (decrease in volume). In addition, the weight loss shall not exceed 10%. For coated fabrics, alternate limits can be used with the average volume change not exceeding 60% swell or 5% shrinkage, and the weight loss shall not exceed 20%. There shall be no visual evidence of cracking or other degradation as a result of the exposure for any material including coated fabrics.

6.2.2.2.4 Dynamic seals shall be subjected to the Tensile Strength and Elongation Test in accordance with the Standard for Gaskets and Seals, UL 157, except for the following modifications:

a) The test duration shall be 1000 hours;

b) The applicable test fluids shall be as described in Supplement SB; and

c) For all materials, the average tensile strength and the average elongation of materials shall not be less than 60 percent of the as-received values. For coated fabrics, alternate limits can be used with the average tensile strength and the average elongation not less than 30% of the as-received values.

6.2.3 Nonmetallic materials – fluid compatibility – system level

6.2.3.1 For all materials, gaskets and seals that have been shown to comply with the applicable requirements for static seals in the Standard for Gaskets and Seals, UL 157, or with the requirements under material level tests shall be subjected to the system level tests for the applicable component after the Long Term Exposure Test, Section 27.

6.3 Casting impregnation materials

6.3.1 Material level fluid compatibility

6.3.1.1 Casting impregnation materials shall be evaluated at the material level in accordance with the requirements in the Standard for for Power Operated Dispensing Devices for Gasoline and Gasoline/Ethanol Blends With Nominal Ethanol Concentrations Up To 85 Percent (E0 – E85), UL 87A.

6.3.2 System level fluid compatibility

6.3.2.1 The casting impregnation material, applied as intended to a casting, shall comply with the Long Term Exposure Test, Section 24. The casting shall not show indications of porosity leakage at any point during or after this test.

6.4 Internal parts – fluid compatibility

6.4.1 Nonmetallic parts located internally to a fluid confining part, degradation of which would not directly result in leakage, is not required to comply with Nonmetallic materials, 6.2. The part shall be tested in accordance with 6.4.2.

6.4.2 Internal nonmetallic parts shall be tested during the Long Term Exposure Test, Section 24. During this test, the part shall not degrade to the extent that visible particles can be observed in the fluid.

6.5 Insulating Materials

6.5.1 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current-Arc Resistance to Ignition (HAI), Comparative Tracking Index (CTI) values indicated in Table 6.2. A material is in direct support of an uninsulated live part when:

a) is in direct physical contact with the uninsulated live part; and

b) It serves to physically support and maintain the relative position of the uninsulated live part An insulating material is considered to be in direct support of an uninsulated live part when the material acts to maintain the relative position of the uninsulated live part when the part is not retained in position when the part is rotated in any direction. An encapsulant is not considered direct support unless there is no other primary means to hold the live part in position.

Exception No. 1: With respect to RTI temperatures of insulating materials, see footnote a) of Table 6.2.

Exception No. 2: A generic material provided in the thickness indicated in Table 6.3 shall comply with this requirement without additional evaluation.

Table 6.2
Minimum material characteristics for the direct support of uninsulated live parts

Flame Class	RTI Electrical	Maximum Performance Level Category (PLC)		
		HWI[b, c]	HAI[d, e]	CTI[f, g, h]
HB	a	2	1	3
V-2, VTM-2	a	2	2	3
V-1, VTM-1	a	3	2	3
V-0, VTM-0	a	4	3	3

[a] The electrical Relative Thermal Index (RTI) value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used. The RTI shall not be exceeded during the Temperature Test, Section 26. Where an insulating material forms part of an insulation system that complies with the Standard for Systems of Insulating Materials – General, UL 1446, is described as a major insulating ground/interwinding/encapsulant component in the system, and the insulation system forms part of the valve construction, the material may be used at temperatures appropriate for that rated class system.

[b] The Hot Wire Ignition (HWI) value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a HWI value, the material is evaluated as in footnote c.

[c] A material without an HWI Performance Level Category (PLC) value or with a HWI PLC value greater (worse) than the value required by this table shall be subjected to the end-product Abnormal Overload Test or the Glow-Wire End-Product Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or for AC coil constructions to the Burn Out Test, Section 39.

[d] The High Current Arc Resistance to Ignition (HAI) value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a HAI value, the material is evaluated as in footnote e. For constructions where there are no arcing parts or no mechanically secured electrical connections subjected to movement (for example electrical connections are potted or encapsulated), HAI is not applicable.

[e] A material without an HAI PLC value or with an HAI PLC value greater (worse) than the value required by this table shall be subjected to the End-Product Arc Resistance Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[f] The Comparative Tracking Index (CTI) PLC value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used. When the thickness of an insulating material is less than the minimum specified thickness corresponding to a CTI value, the material is evaluated as having the same CTI value found for the greater thickness. The CTI value applies to insulating materials used in pollution degree 3 environments for voltages of 600 V or less. For equipment where pollution degree 1 or 2 is maintained, an insulating material shall have a CTI PLC of 4 or less. For constructions where creepage distances between uninsulated live parts of opposite polarity or between uninsulated live parts and grounded or dead metal parts are greater than 12.7 mm, CTI is not applicable.

[g] A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by Table 6.2 shall have a proof tracking index of 175 when used in pollution degree 3 environment or a proof tracking index of 100 when used in pollution degree 1 or 2 environment as determined by the end-product Proof Tracking Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[h] CTI requirements are not applicable if the over surface spacing between uninsulated live parts (e.g., spade terminals) at opposite polarity or uninsulated live parts and grounded or accessible dead metal are separated with an over-surface electrical spacing (creepage) of at least 1/2-in (12.7 mm).

Table 6.3
Generic materials for direct support of uninsulated live parts

Generic Material	Thickness,		RTI, °C
	Inch	(mm)	
Diallyl Phthalate	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Melamine	0.028	(0.71)	130
Melamine-Phenolic	0.028	(0.71)	130
Phenolic	0.028	(0.71)	150
Unfilled Nylon	0.028	(0.71)	105
Unfilled Polycarbonate	0.028	(0.71)	105
Urea Formaldehyde	0.028	(0.71)	100
Ceramic, Porcelain, and Slate	No limit		No limit
Beryllium Oxide	No limit		No limit
NOTE – Each material shall be used within its minimum thickness and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test, Section 23.			

6.5.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated current-carrying parts of other than low-voltage nonsafety circuits.

6.5.3 Glass covering an observation opening in the fluid containing body shall be subjected to the Sight Glass Impact, Section 44 and Sight Glass Temperature Shock, Section 45 requirements.

6.6 Blending options

6.6.1 Valves intended for use with dispensing equipment that provides for a variable blending option, at gasoline/ethanol blends with nominal ethanol concentrations above 25 percent, shall be subjected to the Blend Cycling Test, Section 42.

6.6.2 Valves intended for use with dispensing equipment that provides for a fixed blending option, as gasoline/ethanol blends with nominal ethanol concentrations above 25 percent, shall be evaluated in accordance with (a) or (b):

a) If intended to be located after the blending option such that the valve is only subjected to the final blended fuel, then the Blending Cycling Test is not required.

b) If intended to be located at or before the blending option such that it is subjected to a different gasoline/ethanol blend levels, the valve shall be subjected to the Blending Cycling Test, Section 42.

6.6.3 Valves intended for use with dispensing equipment that provides for a variable or fixed blending of gasoline/ethanol blends with nominal ethanol concentrations below 25 percent are considered acceptable without further evaluation for the blending option.

7 Fluid Connections

7.1 An opening threaded for connection of pipe shall be in accordance with the Standard for Pipe Threads General Purpose (Inch), ANSI/ASME B1.20.1 or the Standard for Dryseal Pipe Threads (Inch), ANSI/ASME B1.20.3. See also 49.1(h).

Exception: Valves intended for use in installations where pipe fittings incorporate other than NPT type threads shall be permitted to be provided with pipe threads complying with a national pipe thread standard compatible with those fittings. The pipe thread type shall be identified in accordance with 49.12.

7.2 Flanged pipe connections shall be in accordance with the Standard for Classes 25, 125 and 250 Cast Iron Pipe Flanges and Flanged Fittings, ASME B16.1 or the Standard for Pipe Flanges and Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard, ANSI/ASME B16.5.

7.3 A valve intended for connection to pipe larger than 3-inch nominal size shall be provided with flanged pipe connections in accordance with 7.2.

7.4 Tube fitting connections shall be in accordance with Standard for Automotive Tube Fittings, SAE J512; Cast Copper Alloy Fittings for Flared Copper Tubes, ANSI/ASME B16.26; Standard for Refrigeration Tube Fittings – General Specifications, SAE J513; and Pneumatic Fluid Power-Connections-Ports and Stud Ends, ISO 16030.

7.5 Solder joint connections shall be in accordance with the Standard for Cast Copper Alloy Solder Joint Pressure Fittings, ASME/ANSI B16.18 or Wrought Copper and Copper Alloy Solder Joint Pressure Fittings, ASME/ANSI B16.22.

7.6 Weld joint connections shall be in accordance with the Standard for Factory-Made Wrought Steel Buttwelding Fittings, ASME/ANSI B16.9 or Forged Steel Fittings, Socket-Welding and Threaded, ASME/ANSI B16.11.

8 Seals and Stuff Boxes

8.1 A manually operated stem shall not back out of the valve nor shall threads of a stem enter a stuffing box recess when the stem is rotated or reciprocated, even though an adjustable packing nut or other takeup is disengaged.

Exception: A stem such as that provided for a fuel-gas pilot adjusting screw, not complying with these requirements, may be used if provided with a cap requiring the use of a tool to gain access to the stem.

8.2 If packing is used to reduce the risk of leakage around a valve stem, and if it is necessary for the user to adjust or renew the packing during intended usage or as wear occurs, a stuffing box conforming to the following shall be used:

a) The stuffing box shall be provided with a removable gland or follower, and shall be provided with a packing nut or other means for adjustment.

b) The stuffing box gland shall be made of corrosion-resistant material.

c) The stuffing box shall be fully packed prior to shipment of the valve.

8.3 A stuffing box for an automatically operated valve shall be constructed to reduce the risk of binding of the valve stem.

8.4 An adjustable stuffing box used to seal an automatically actuated stem of a safety valve shall be constructed so that any adjustment of the packing takeup will not bind the stem sufficiently to interfere with automatic functioning of the valve. A gland shall be spring-loaded.

8.5 The physical characteristics of a takeup spring shall be such that it will advance the gland through not less than one-half its possible travel from its initial setting with the spring compressed. At the advanced position of the gland, a takeup spring shall not require further adjustment to prevent leakage from the stuffing box when tested in accordance with these requirements.

9 Springs

9.1 A spring shall be protected against abrasion and shall be guided or arranged to reduce the risk of binding, buckling, or other interference with its free movement.

10 Diaphragms

10.1 The assembly of a diaphragm type valve shall be such that the valve operates as intended as a result of diaphragm movement.

10.2 A metal part coming in contact with a diaphragm shall have no sharp edges, burrs, projections, and the like, that may chafe or abrade the diaphragm.

10.3 A valve in which a flexible diaphragm, bellows, or similar construction constitutes the only fluid seal, shall have the atmospheric side of the diaphragm or bellows enclosed in a casing constructed to limit external leakage in the event of a diaphragm or bellows rupture, or shall have provisions for connection of a vent pipe or tubing intended to be routed to the outdoors or other acceptable location.

11 Operating Mechanisms

11.1 If threaded fasteners secure moving parts, they shall be upset, locked, or otherwise prevented from loosening when tested in accordance with these requirements.

11.2 Operation of a manually actuated mechanism of a valve shall not subject parts to distortion or damage to the extent that their intended function is impaired.

11.3 Moving parts shall be separated from conductors by barriers or by its physical location so that such an operating part is not obstructed by stowed wiring.

11.4 A valve using an electronic control circuit shall be investigated under conditions of actual service to determine compliance with applicable requirements.

12 Current-Carrying Parts

12.1 A current-carrying part shall be silver, copper, copper alloy, or other metal that has been determined to be acceptable for such use.

12.2 An uninsulated live part, including a terminal or contact assembly, shall be secured to its supporting surface by methods other than friction between surfaces so that it will be prevented from turning or shifting in position.

12.3 A lock washer may be used to prevent turning of a terminal or connection stud.

13 Enclosures

13.1 General

13.1.1 The mechanism of a valve shall be protected by an enclosure to reduce the risk of damage to or interference with operating parts. Electrical parts, other than Class 2 terminals in nonsafety circuits, shall be located or enclosed so that protection against unintentional contact or shorting of live parts will be provided if such contact or shorting may result in a risk of fire, electric shock, or injury to persons.

13.1.2 Class 2 terminals for a safety-control circuit shall comply with the requirements in 13.1.1 if shorting or grounding of the terminals may result in a risk of fire, electric shock, or injury to persons, or cause improper operation of a safety control.

13.1.3 The enclosure shall provide room for the distribution of wires and cables required for the intended wiring of the valve. See 14.4.1.

13.1.4 The enclosure and any part of the enclosure such as a cover, or the like, shall be provided with means for securing it in place.

13.1.5 Automotive fuel valves are not required to comply with these enclosure requirements.

13.1.6 Glass used for an observation window not more than 4 inches (102 mm) in any dimension and not less than 1/16 in. (1.60 mm) thick or glass used for an observation window having no dimension greater than 12 inches (305 mm) and not less than 1/8 in. (3.2 mm) thick need not be subject to additional evaluation. Glass used to cover a larger opening shall comply with the Crushing resistance test and Resistance to Impact (normal only) test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

13.1.7 A nonmetallic enclosure or enclosure part, including coil retainers, shall comply with 13.3 as appropriate. Coil retainers of enclosed valves where the coil retainer is exposed to the same degree as the enclosures shall be additionally subjected to the Coil Retainer Impact and Coil Retainer Mechanical Strength Tests specified in the Standard for Electrically Operated Valves, UL 429.

13.2 Metallic enclosures

13.2.1 The thickness of a metal enclosure shall not be less than that specified in Table 13.1, Table 13.2, and Table 13.3.

13.2.2 A part such as a dial or nameplate that constitutes part of the enclosure, shall be of metal or other material as specified for the basic enclosure.

Table 13.1
Thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)	inch	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d,e]	(0.51)	0.023[d,e]	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026[d,e]	(0.66)	0.029[d,e]	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)

Table 13.1 Continued on Next Page

Table 13.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)	inch	(mm)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has the same outside dimensions as the enclosure surface and which has torsional rigidity to resist the bending moments which is capable of being applied via the enclosure surface when it is deflected. Construction that is determined to have equivalent reinforcing is allowed to be accomplished by constructions that produce a structure which is as rigid as one built with a frame of angles or channels. Constructions determined to be without supporting frame include:

1) Single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure are allowed to have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

[d] Sheet metal for an enclosure intended for outdoor (rainproof, raintight or watertight) use shall comply with 13.6.1 – 13.6.5.

[e] At points where a wiring system is to be connected, the thickness shall not be less than 0.032 inch (0.81 mm) if uncoated and not less than 0.034 inch (0.86 mm) if zinc coated.

Table 13.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d,e]	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.7)	9.5	(24.1)		
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029[e]	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.2)		
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036[e]	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)		

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has the same outside dimensions as the enclosure surface and which has torsional rigidity to resist the bending moments which are capable of being applied via the enclosure surface when it is deflected. Construction that is determined to have equivalent reinforcing is allowed to be accomplished by constructions that produce a structure which is as rigid as one built with a frame of angles or channels. Constructions considered to be without supporting frame include:

1) Single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame (for example, with spring clips).

Table 13.2 Continued on Next Page

Table 13.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]					
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Minimum thickness,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (rainproof, raintight or watertight) shall not be less than 0.029 inch (0.74 mm) thick.

[e] At points where a wiring system is to be connected, the thickness shall not be less than 0.045 inch (1.14 mm).

Table 13.3
Cast-metal enclosures of malleable iron and die-cast or permanent mold cast aluminum, brass, bronze, or zinc

Use or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less and having no dimension greater than 6 inches (152 mm)[a,b,c]	1/16	(1.6)	1/8	(3.2)
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32	(2.4)	1/8	(3.2)
At a conduit hole	1/4	(6.4)	1/4	(6.4)

[a] The area limitation for metal 1/16 inch thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

[b] Die-cast metal may be minimum 0.035 inch (0.89 mm) thick if:

1) The enclosure is not intended to be used as a splice box and

2) The voltage rating of the complete device is such that the potential between any two conductors does not exceed 250 volts AC or DC.

[c] Die-cast metal may be minimum 0.028 inch (0.71 mm) thick for an enclosure housing only low-voltage circuits.

13.2.3 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that affords protection to the conductors equivalent to that provided by a standard conduit bushing and that has an internal diameter as indicated in Table 13.4.

Table 13.4
Throat diameter of conduit stop

Trade size of conduit,		Minimum diameter,[a]		Maximum diameter,	
inch	(mm O.D.)	inch	(mm)	inches	(mm)
1/2	(21.3)	0.56	(14.2)	0.62	(15.8)
3/4	(26.7)	0.74	(18.8)	0.82	(20.9)
1	(33.4)	0.94	(23.9)	1.05	(26.7)

[a] A smaller diameter may be provided in a construction as described in 14.2.2 if the throat diameter of the conduit stop is of a sufficient size to accommodate the conductors without damage and the conductors will not be pulled through the opening during installation of the device.

13.3 Polymeric enclosures

13.3.1 A polymeric electrical enclosure or a polymeric part (such as a plug or other closure) that is relied upon to complete and maintain the integrity of an electrical enclosure shall comply with the Flammability – 127 mm (5 Inch) Flame Test, Crushing Resistance Test, Resistance to Impact Test (both normal and cold), and the Mold Stress-Relief Distortion Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and also with the additional requirements specified in this standard. Polymeric parts may be tested separately or may be tested as part of the overall electrical enclosure.

Exception No. 1: Polymeric enclosures enclosing Class 2 circuits only, need not comply with the flammability – 127 mm (5 Inch) flame rating, Crush Resistance Test, Resistance to Impact Test, maximum use temperature properties and the Mold Stress-Relief Distortion Test.

Exception No. 2: A polymeric plug or other closure made of a material classed in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and that serves to complete and maintain the integrity of an electrical enclosure is acceptable if the closure is:

a) Not more than 1.2 square inches (775 mm^2) in area and is:

1) Rated 5VA, 5VB, V-0, V-1, or V-2; or

2) Rated HB and complies with the Flammability – 127 mm (5 Inch) Flame Test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) More than 1.2 square inches (775 mm^2) in area and is:

1) Rated 5VA and complies with the Resistance to Impact Test requirements (both normal and cold) in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or;

2) Rated 5VB, V-0, V-1, V-2 or HB and complies with the Flammability – 127 mm (5 Inch) Flame Test, the Resistance to Impact Test (both normal and cold) and the Crushing Resistance Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

13.3.2 In addition to the requirements in 13.3.1 polymeric materials used for outdoor use type applications as defined in the Standard for Enclosures for Electrical Equipment, UL 50, such as Types 3, 3R, 4, and 4X enclosures or polymeric materials used for closures, fastenings, or hinges for these enclosures, shall comply with the Ultraviolet Light Exposure Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

13.3.3 In addition to the requirements in 13.3.1, polymeric materials used for Types 6 and 6P enclosures or polymeric materials used for closures, fastenings, or hinges for these enclosures, shall comply with the Ultraviolet Light Exposure Test and the Water Exposure and Immersion Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

13.4 Enclosure conduit connection

13.4.1 A conduit hub or nipple that is molded into a polymeric enclosure or attached to the enclosure of a valve by swaging, staking, or similar means shall withstand, without pulling apart or turning, a direct pull of 200 pounds (890 N), a bending moment of 600 pound-inches (67.8 N·m), and a torque of 600 pound-inches, each applied for 5 minutes.

Exception: If the enclosure has only one conduit connection point and is intended to be an end of line device, the bending moment shall be 150 pound-inches (17.0 N-m), and the torque shall be 200 pound-inches (22.6 N-m)

13.4.2 For the pullout test in 13.4.1, the valve is to be supported by rigid conduit in the intended manner and is to support a weight of 200 pounds (90.7 kg).

13.4.3 For the bending and torsion tests in 13.4.1, the valve is to be rigidly supported by means other than the conduit fittings. In the bending test, the force is to be applied to the conduit at right angles to its axis, and the lever arm is to be measured from the wall of the enclosure in which the hub or stud is located to the point of application of the bending force. In the torsion test, the force is to be applied to the conduit in a direction tending to tighten the connection, and the lever arm is to be measured from the center of the conduit.

13.4.4 With reference to 13.4.1, the bending test, a 9 feet – 10-7/64 inch minimum (3.0 meter) length of conduit of the intended size shall be installed:

a) In a hub or an opening if provided as part of the enclosure; or

b) If a hub or opening is not provided, in the center of the largest unreinforced surface intended for the connection of conduit.

13.4.5 The enclosure shall be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The test shall be terminated once the deflection of the conduit end exceeds 10 inches (255 mm). If a weight is necessary to cause the conduit end to deflect, the test shall be terminated once the deflection of the conduit end exceeds 10 inches (255 mm) or once a bending moment of 600 pound-inches (67.8 N·m) is achieved. For the SI system of units, the magnitude of the weight shall be determined from the equation:

$$W = (0.1M - 0.5CL) / L$$

in which,

W and C are measured in kilograms;

M is measured in Newton-meters; and

L is measured in meters.

For the inch-pound units, the magnitude of the weight shall be determined from the equation:

$$W = (M - 0.5CL) / L$$

in which,

W is the weight, in pounds, to be hung at the end of the conduit;

L is the length of the conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended;

C is the weight of the conduit, in pounds; and

M is the bending moment required, in inch-pounds.

13.5 Openings

13.5.1 An opening shall not be provided in an enclosure that houses a fuse or any portion of a circuit breaker other than the operating handle, unless the construction affords containment of electrical fault disturbances equivalent to that provided by an enclosure complying with the requirements in 13.1.1–13.3.3.

13.5.2 The following requirements apply to openings:

a) An opening shall not be provided in a compartment or part of an enclosure that contains field-wiring splices in a line-voltage circuit.

b) No openings shall be located in the mounting surface of an enclosure.

Exception: The following openings may be located in the mounting surface of an enclosure:

1) A mounting opening.

2) A maximum of four openings provided for the escape of air or paint during a painting process. The maximum dimension of such an opening shall not exceed 1/8 inch (3.2 mm).

3) A maximum of four unused holes provided for mounting of internal components. The maximum dimension of such an opening shall not exceed 3/16 inch (4.8 mm).

c) If the bottom surface is not the mounting surface, an opening may be provided in the bottom surface of an enclosure if the opening does not permit materials to fall directly out from the interior of the unit. See Figure 13.1 for an example of an acceptable construction.

d) The shortest distance between an opening and the bottom of an enclosure or a wall-mounting surface shall be at least one-quarter of the enclosure height or depth, respectively, or 1 inch (25.4 mm), whichever is less.

e) There shall not be emission of flame or molten material, or manifestation of risk of fire, during normal or abnormal tests on the control.

f) Unless the construction of a device provided with forced ventilation is such that there is no direct path between live parts and the outlet opening, burnout tests as described in Section 39 shall be conducted to determine that there is no emission of flame or molten material through the opening.

g) Air from an opening, either forced or otherwise, shall not be directed:

1) Into a duct or into a concealed space in a building or

2) Against the mounting surface.

h) There shall not be more than four holes for mounting an enclosure having a maximum dimension of 18 inches (457 mm); six holes for an enclosure with a maximum dimension of more than 18 inches, but less than 48 inches (1.2 m); eight holes for an enclosure with a maximum dimension of 48 inches or more. Four of the holes for mounting an enclosure with a maximum dimension of 12 inches (305 mm) may be keyhole slots having the configuration illustrated in Figure 13.2. The dimensions shown in Figure 13.2 may vary if the area is equivalent. Four of the holes for mounting a larger enclosure may be keyhole slots, the dimensions of which are not specified, and which shall be evaluated with regard to the enclosure dimensions and configuration.

Figure 13.1

Bottom surface openings of enclosures

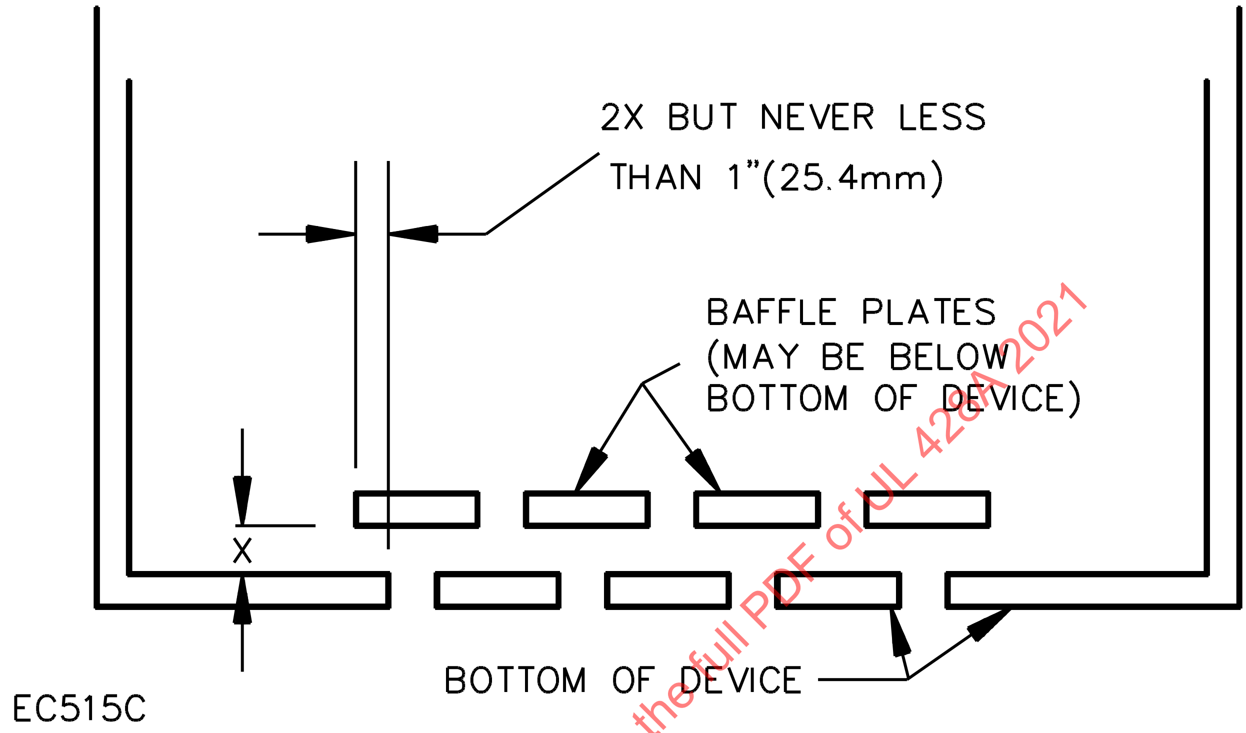
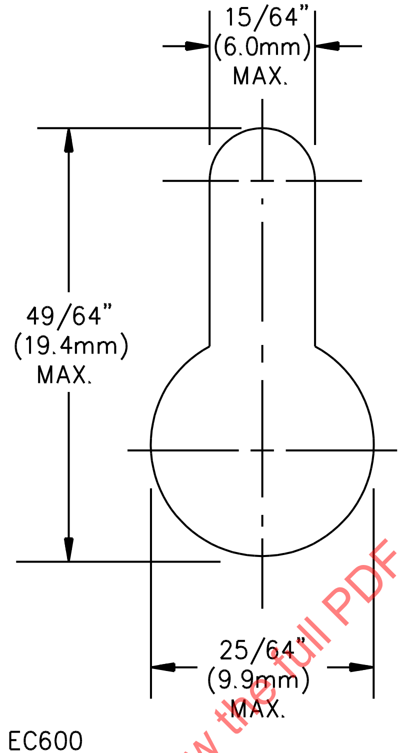


Figure 13.2

Keyhole slot



13.6 Accessibility of live parts

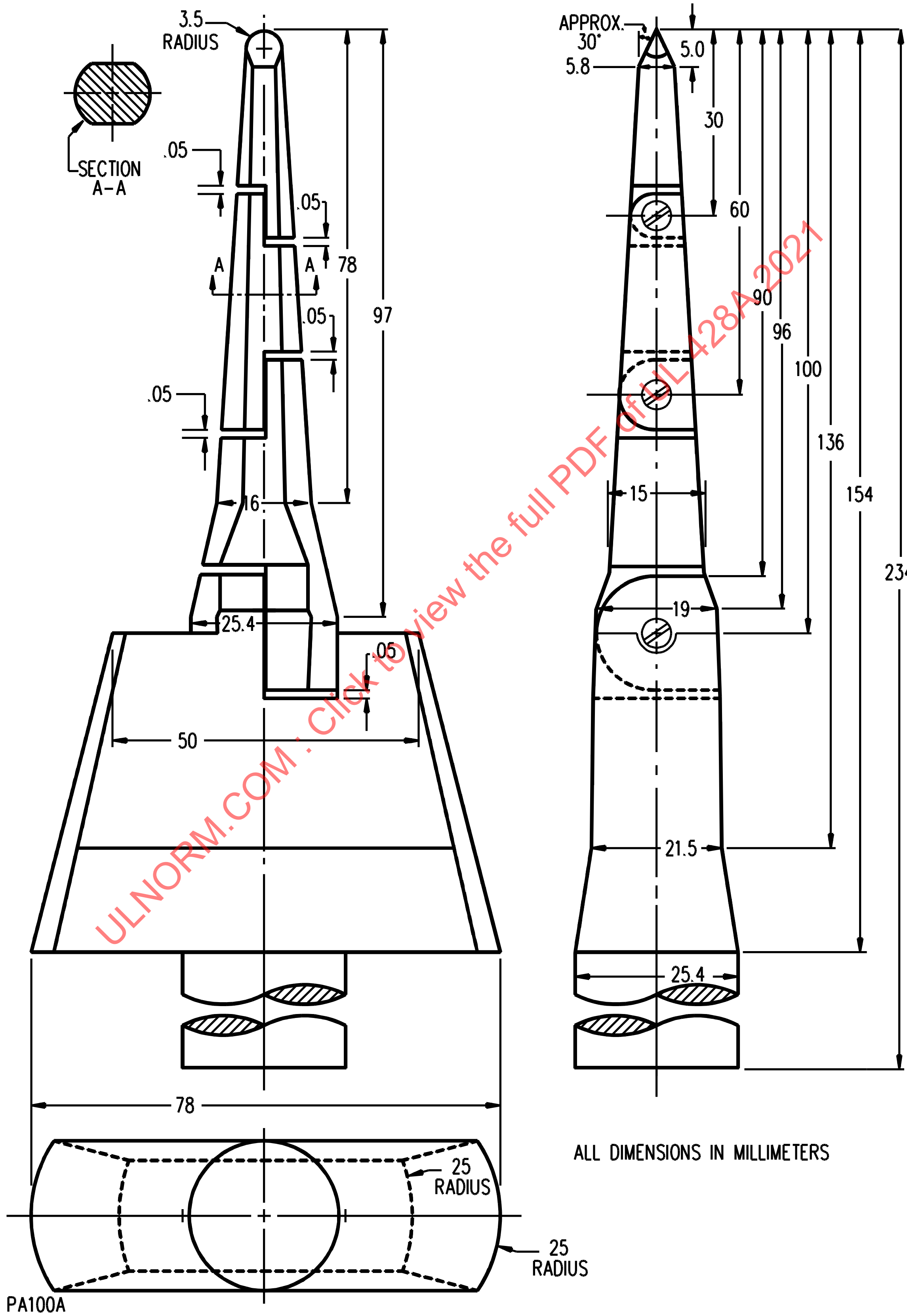
13.6.1 Electrical parts of valves shall be located or enclosed to reduce the risk of unintentional contact with an uninsulated live part. See 13.6.2 – 13.6.4. For the purpose of these requirements, film-coated wire is considered to be an uninsulated live part.

Exception: An enclosure is not required for a device intended for assembly as part of another device.

13.6.2 An opening in an enclosure of a valve is acceptable if an accessibility probe as illustrated in Figure 13.3, when inserted into the opening, cannot be made to touch any part that involves the risk of electric shock to the end-user or service personnel. However, in no case shall the opening be large enough to permit the entrance of a 1-inch (25.4-mm) diameter rod.

Figure 13.3

Accessibility probe



13.6.3 With regard to the application of the requirement in 13.6.2, the accessibility probe shall be articulated into any configuration and shall be rotated or angled to any position before, during, or after insertion into the opening, and the penetration shall be to any depth allowed by the opening size, including minimal depth combined with maximum articulation.

13.6.4 If any part of the enclosure must be opened or removed as part of normal operation, regular adjustment, or regular or required maintenance (set point adjustment, timer or time of day clock adjustment, battery replacement, and the like) with or without the use of tools, or can be opened or removed without the use of tools, the accessibility probe is to be applied without the part in place.

13.6.5 The smaller dimension (width) of an opening in an enclosure around a dial, adjusting knob, lever, handle, pointer, or the like shall not be more than 1/8 inch (3.2 mm) for any setting or position of the dial, knob, and the like.

13.6.6 A plate or plug for an unused conduit opening or other hole in the enclosure shall not be less than:

a) 0.014 inch (0.36 mm) thick for steel or 0.019 inch (0.48 mm) thick for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimension and

b) 0.027 inch (0.69 mm) thick for steel or 0.032 inch (0.81 mm) thick for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimension.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

13.7 Screens and expanded metal

13.7.1 The wires of a screen shall not be less than 16 AWG (1.3 mm^2) if the screen openings are 1/2 square inch (3.23 cm^2) or less in area, and not less than 12 AWG (3.3 mm^2) for larger screen openings.

13.7.2 Except as noted in 13.7.3, perforated sheet steel and sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) in average thickness [0.045 inch (1.14 mm) if zinc coated] if the mesh openings or perforations are 1/2 square inch (3.23 cm^2) or less in area, and not less than 0.080 inch (2.03 mm) in average thickness [0.084 inch (2.13 mm) if zinc coated] for larger openings.

13.7.3 For a small device in which the indentation of a guard or enclosure will not alter the clearance between uninsulated, movable, current-carrying parts and grounded metal so as to adversely affect performance or reduce electrical spacings below the minimum values specified in Table 21.1, 0.020-inch (0.51-mm) thick expanded metal mesh [0.023 inch (0.58 mm) if zinc coated] may be used if:

a) The exposed mesh on any one side or surface of the device so protected has an area of not more than 72 square inches (464.5 cm^2) and has no dimension greater than 12 inches (305 mm) or

b) The width of an opening so protected is not greater than 3-1/2 inches (88.9 mm).

13.8 Rainproof, raintight, and watertight enclosures

13.8.1 An enclosure for a valve intended to be used in wet locations and to be designated "Rainproof" shall be constructed to prevent the entrance of a beating rain at a level higher than the lowest live part within the enclosure. The enclosure shall be provided with external means for mounting, except that internal means for mounting may be employed if constructed to prevent water from entering the enclosure. Hinges and other attachments shall be resistant to corrosion. Metals shall not be used in combinations that result in galvanic action that can impair the function of any part of the device.

13.8.2 An enclosure for a valve intended to be used in wet locations and to be designated "Raintight" shall comply with the requirements in 13.8.1, except that it shall be constructed to prevent the entrance of water in a beating rain.

13.8.3 To determine if an enclosure complies with 13.8.1 or 13.8.2, the complete valve shall be subjected to the Rain Test, Section 42.

13.8.4 An opening for conduit in a raintight enclosure, other than in the bottom of the enclosure, shall be threaded.

13.8.5 An opening for conduit in a rainproof enclosure shall be threaded unless located wholly below the lowest terminal lug or other live part within the enclosure. There shall be provision for drainage of the enclosure if a knockout or unthreaded hole is provided other than in the bottom.

13.8.6 An enclosure for a valve intended to be used in wet locations and to be designated "Watertight" shall be constructed to prevent the entrance of water. The enclosure shall be provided with external means for mounting, except that internal means for mounting may be used if constructed to prevent water from entering the enclosure. Hinges and other attachments shall be resistant to corrosion. Metals shall not be used in combinations that result in galvanic action that can impair the function of any part of the device.

13.8.7 To determine if an enclosure complies with 13.8.5 and 13.8.6, the complete valve shall be subjected to the Hosedown Test, Section 43.

13.9 Corrosion protection

13.9.1 A rainproof, raintight, or watertight enclosure shall be protected against corrosion with one of the following coatings, or by other metallic or nonmetallic coatings that have been determined to provide equivalent protection.

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in the Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot-test requirements in this ASTM specification. The weight of zinc coating may be determined by any recognized method; however, in case of question the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 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 44. An annealed coating shall also comply with 13.9.4.

c) A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 44.

d) A cadmium coating not less than 0.00075 inch (0.01905 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 inch (0.0127 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 44. The paint shall be an organic epoxy or alkyd-resin type, or other outdoor paint. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.

13.9.2 With reference to 13.9.1, other finishes, including paints, metallic finishes, and combinations of the two, may be used if comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) complying with 13.9.1(a) indicate they provide equivalent protection. Among the factors that are to be taken into consideration when evaluating the coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, and ultraviolet light and water.

13.9.2.1 Organic coatings provided for corrosion protection shall comply with the requirements in the Standard for Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment, UL 1332.

13.9.3 Samples having coatings containing organic material are to be tested in the as-received condition and also after having been exposed to the high temperature phase of the Temperature Test, Section 26.

13.9.4 An annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted shall be painted in the bent or formed area if the bending or forming process damages the zinc coating, except that such areas on the inside surface of an enclosure that water does not enter during the Rain Test, Section 42, need not be painted.

13.9.5 If 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 requirements in 13.9.4.

13.9.6 A nonmetallic cabinet and an enclosure intended for outdoor use are to be evaluated on the basis of the effect of exposure to ultraviolet light and water, in addition to the factors described in 13.1.7.

13.9.7 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material used to make an enclosure rainproof or raintight shall comply with the requirements in 13.9.8 or 13.9.9, whichever is applicable.

13.9.8 A gasket of rubber or neoprene, or composition gasket utilizing an elastomeric material, shall be subjected to the Tensile Strength Test as described in the Standard for Gaskets and Seals, UL 157. The gasket may be used if there is no visible evidence of deterioration such as softening, hardening, or cracking after flexing.

13.9.9 A gasket of thermoplastic material, or a composition thereof, may be used after consideration of the effects of heat aging, distortion under conditions of use, and the means of securing the gasket to the cover or enclosure.

13.10 Safety valves

13.10.1 The enclosure of a safety valve shall not interfere with the operation of the valve. Any openings in the enclosure shall be located and sized so that they cannot be used as a means for blocking the valve in the open position.

13.10.2 Class 2 electrical parts of a safety valve, except one intended for use only when located within an enclosure, shall be enclosed if grounding, opening, or shorting of the electrical circuit may result in failure of the valve to shut off automatically.

14 Field Wiring Connections

14.1 General

14.1.1 For the purpose of these requirements, and particularly where wiring terminals or leads are mentioned, wiring connections are considered to be those made to the valve when the valve is installed.

14.1.2 A terminal box or wiring compartment shall be located so that wire connections therein may be inspected without disturbing either high-voltage or safety-circuit wiring.

14.1.3 A valve, other than one intended only for use as an automotive fuel valve, shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the rating of the valve.

14.1.4 For power-circuit connections, a valve shall have provision for the connection of a wiring system that is in accordance with the National Electrical Code, NFPA 70.

14.1.5 A valve that is intended for use with either a specific fitting or a fitting that accommodates only one type of wiring system shall be supplied with such a fitting and is marked as indicated in 49.1(p).

14.2 Leads

14.2.1 A coil lead or the like intended to be spliced in the field to a branch circuit conductor in accordance with the National Electrical Code, NFPA 70, shall not be smaller than 18 AWG (0.82 mm^2). The insulation, if rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick.

14.2.2 A coil lead shall have a minimum length of 18 inches (457 mm) as measured from the periphery of the coil to its termination.

Exception No. 1: If splicing is intended to be accomplished within the valve enclosure, a minimum length of 6 inches (153 mm) shall be provided.

Exception No. 2: A valve intended only for use as an automotive fuel valve need not comply with this requirement.

14.2.3 A lead intended for connection of a neutral or grounded supply conductor shall be finished white or gray, and shall be distinguishable from the other leads. No other lead shall be so identified.

14.2.4 A lead intended for the connection of an equipment-grounding conductor shall not be smaller than the largest current-carrying conductor and shall have a free length of 6 inches (153 mm) or more. The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green or green with one or more yellow stripes. No other lead visible to the installer in a field wiring terminal compartment shall be so identified.

14.2.5 Leads (pigtails) for field connections shall be provided with strain relief to prevent mechanical stress from being transmitted to terminals, splices, or interior wiring. Each lead shall withstand for 1 minute a pull of 10 pounds (44.5 N).

14.2.6 A valve intended for use only within other equipment, an automotive fuel valve, or a low-voltage valve for connection only to nonsafety control circuits may be provided with leads entering the enclosure through an acceptable insulating bushing, or with leads in accordance with 14.2.9.

14.2.7 A bushing of rubber or rubber-like material provided in accordance with 14.2.6 shall be 1/8 inch (3.2 mm) or more in thickness along the inside edge of the opening, except that it may be minimum 1/16 inch (1.6 mm) thick [with a minus tolerance of 1/64 inch (0.4 mm)] if the metal around the hole is eyeletted or similarly treated to produce smooth edges. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, projections, and the like, which might damage the bushing.

14.2.8 A bushing of rubber or rubber-like material shall be located so that it will not be exposed to oil, grease, oily vapors, or similar substances that may have a deleterious effect on the material of the bushing, unless the bushing complies with the applicable requirements in 6.2, Nonmetallic materials.

14.2.9 An insulating bushing is not required on valves of the type described in 14.2.6 that are provided with leads of flexible cord not smaller than Type P-1, or insulated conductors acceptable for the service and having not less than 3/64 inch (1.2 mm) thick insulation. The surface against which such leads may bear shall be rounded.

14.3 Field Wiring Terminals

14.3.1 A wiring terminal shall be provided with a soldering lug or pressure terminal connector fastened in place by a bolt or screw, except that a wire-binding screw may be used at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs, corners, or the equivalent are provided to hold the wire in place.

14.3.2 A wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by means such as two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; or by a connecting strap or clip fitted into an adjacent part.

14.3.3 A field-wiring pressure wire connector provided with electrically operated valves shall comply with one of the following, as applicable:

a) The performance requirements in the Standard for Wire Connectors, UL 486A-486B; or

b) The performance requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

14.3.4 A wire-binding screw at a field-wiring terminal shall not be smaller than 8 AWG (4.2 mm diameter). The screw shall thread into metal.

Exception: A 6 AWG (3.5 mm diameter) screw may be used for the connection of one 14 AWG (2.1 mm^2), one 16 AWG (1.3 mm^2), or one 18 AWG (0.82 mm^2) conductor.

14.3.5 It should be noted that according to the National Electrical Code, NFPA No. 70, 14 AWG (2.1 mm^2) is the smallest conductor that the installer may use for branch circuit wiring and thus is the smallest conductor that may be anticipated at a terminal for the connection of a power supply wire.

14.3.6 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG (2.1 mm^2). In either case there shall not be less than two full threads in the metal, unless a lesser number of threads results in a connection in which the threads will not strip with normal tightening torque in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

14.3.7 A terminal plate formed from stock having the minimum required thickness may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

14.3.8 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size specified in 14.1.3 but no smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

14.3.9 A terminal intended for connection of a neutral or grounded supply conductor shall be of a white metal or plated with white metal and shall be readily distinguishable from other terminals. The terminal may be identified in an equivalent manner, such as on an attached wiring diagram.

14.3.10 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head, either hexagonal or slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G," "GR," "GND," "Ground," "Grounding," or the like, or by marking on a wiring diagram provided on the valve. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during intended servicing of the valve.

14.3.11 A quick connect terminal shall be used with 22 – 10 AWG conductors. A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch (2.8-, 3.2-, 4.8-, 5.2-, and 6.3-mm) wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to such areas as crimp pullout, engagement-disengagement forces of the connector and tab, and temperature rises in accordance with UL 310. A quick connect terminal may consist of either a connector (Female QC) or a production tab (Male QC).

14.3.12 A quick connect tab shall comply with the Tab Pull Test of the Standard for Terminal Blocks, UL 1059, and the construction requirements in accordance with the Standard for Electrical Quick-Connect Terminals, UL 310.

14.4 Wiring space

14.4.1 If it is intended that field-wiring connections be made within the valve enclosure, room shall be provided for making such connections.

14.4.2 To determine the acceptability of the wiring space, the valve is to be wired as it would be in service. A reasonable amount of slack is to be left in each conductor within the enclosure, and not more than average care is to be exercised in stowing this slack into the enclosure. Consideration is then to be given to the location of the conduit opening relative to parts operating at temperatures in excess of the permissible temperature limit of the field installed wiring and splices, moving parts that might abrade insulation or be fouled by field installed wiring to impair their intended operation, or sharp stationary parts over which wires may be routed or against which slack may bestowed. These considerations apply whether connections are to be made at terminals or by splices to pigtail leads.

15 Internal Wiring

15.1 The internal wiring of a valve shall consist of wires (including conductors covered with insulating tubing) acceptable for the atmosphere, temperature, and voltage to which the wiring is to be subjected. High voltage conductor insulation shall be equivalent to that of Type T or TW circuits.

15.2 These requirements are not intended to exclude the use of printed wiring material or an acceptably supported bare conductor.

15.3 Where the use of a short length of suitably insulated conductor is not feasible (for example, a short coil lead), electrical insulating tubing may be used. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners. The wall thickness at any point for the smallest sizes of polyvinyl chloride tubing shall be not less than 0.017 inch (0.43 mm). For insulating tubing of other types, the thickness shall not be less than that providing mechanical strength, dielectric properties, heat and moisture-resistant characteristics, and the like, at least equal to those of 0.017 inch (0.43 mm) thick polyvinyl chloride tubing.

15.4 The internal wiring and connections between parts of a valve shall be protected or enclosed.

15.5 A rubber-insulated conductor shall not be subjected to exposure to oil, grease, oily vapor, or other substances having a deleterious effect on rubber.

15.6 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, that may cause abrasion of the insulation on conductors.

15.7 Holes in sheet metal walls through which insulated wires pass shall be provided with smoothly rounded bushings or shall have smooth, rounded surfaces upon which the wires may bear, to reduce the risk of abrasion of the insulation.

15.8 Splices and connections shall be mechanically secure and shall maintain electrical contact without strain on connections and terminals. Soldered connections shall be mechanically secure before being soldered.

Exception: Connections to printed-wiring boards need not be mechanically secure prior to soldering, if the soldering is done by a machine process in which the soldering time and solder temperature are automatically controlled.

15.9 A splice shall be provided with insulation at least equivalent to that required for the wires involved.

16 Grounding

16.1 A valve, except one intended for use only in low-voltage circuits, shall have provision for grounding all noncurrent-carrying metal parts that are exposed or are likely to be touched by a person during intended operation or adjustment of the valve, and that are likely to become energized as a result of an electrical fault.

16.2 If a valve is furnished with an enclosure to provide for connection of one of the wiring systems covered by the National Electrical Code, ANSI/NFPA 70, all exposed dead metal parts shall be electrically bonded to an equipment grounding terminal or lead located within the enclosure. If connection to the wiring system is not intended to be accomplished within the valve enclosure, and all exposed dead metal parts requiring grounding are electrically bonded to the enclosure, a knockout or threaded opening in a metal enclosure may be provided. See 14.2.2 regarding lead lengths.

16.3 The equipment grounding terminal or lead grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. The grounding point shall be located so that the grounding means will not be required to be removed during normal servicing. See 14.2.4 and 14.3.10.

16.4 A single point reference ground may be employed in a low-voltage circuit. The enclosure, frame, or panel, including bolted joints, may carry the current of a low-voltage circuit. In neither of these instances shall a current be carried through the field equipment grounding means, the metallic raceway or other power supply grounding means, or the earth ground.

16.5 The grounded-circuit conductor shall not be grounded at or in conjunction with equipment covered by this standard.

17 Bonding

17.1 If the valve is marked as specified in 49.6, it shall be provided with a wire connector securely mounted to the outside of the housing acceptable for the connection of a minimum 8 AWG (8.4 mm^2) solid copper wire.

18 Protection of Users and Service Personnel

18.1 These requirements apply to live parts in other than low-voltage circuits, and to moving parts that may cause a risk of injury to persons.

18.2 Live parts shall be located and enclosures and covers arranged to reduce the risk of electric shock while removing or replacing a cover.

18.3 An uninsulated live part shall be located, guarded, or enclosed so as to reduce the likelihood of contact by persons with nearby live or moving parts that may cause a risk of injury to persons while relamping, changing fuses, adjusting controls, lubricating motors, or during other maintenance operations.

18.4 An uninsulated live part or a moving part that may cause a risk of injury to persons shall be located, guarded or enclosed to reduce the risk of unintentional contact by service personnel adjusting or resetting controls, and the like, or performing service functions which may have to be performed while the equipment is energized.

18.5 An electrical component that may require examination, adjustment, servicing, or maintenance while it is energized shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting the service person to the risk of electric shock or to contact with adjacent moving parts that may cause a risk of injury to persons. Access to the components in the valve assembly shall not be impeded in the direction of access by other components or by wiring.

18.6 Parts of valves subjected to contact during normal operation, adjustment, and user servicing, shall be free of sharp corners and edges.

19 Transformers, Coils and Motors

19.1 A Class 2 circuit shall be supplied by an isolating source that complies with the requirements in the Standard for Class 2 Power Units, UL 1310, or the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

19.2 A coil winding containing porous materials shall be varnished-dipped, impregnated, or the equivalent, to resist the absorption of moisture.

19.3 When the temperature of the coil exceeds the Class 105 (A) insulation limits in Table 26.1, the insulation system shall additionally comply with the Standard for Systems of Insulating Materials – General, UL 1446.

19.4 A motor employed as part of a motor-operated valve shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

19.5 Each motor shall be capable of delivering its maximum normal load without introducing risk of fire, electric shock, or injury to persons. The motor winding shall resist the absorption of moisture as noted in 19.2.

19.6 Each motor shall incorporate one of the following forms of locked rotor protection:

a) Thermal protection complying with the applicable requirements in the Standard for Thermally Protected Motors, UL 1004-3;

b) Impedance protection complying with the applicable requirements in the Standard for Impedance Protected Motors, UL 1004-2; or

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

20 Switches

20.1 A switching device intended to control external loads shall be tested in accordance with the Standard for Special Use Switches, UL 1054 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

Exception: Not applicable to non-safety switch circuits supplied from a Class 2 source.

20.2 A switch provided as part of a safety valve shall be considered as a safety switch unless the valve marking indicates that the switch is not intended for use as a safety switch.

20.3 A safety switch shall be capable of 100,000 cycles of operation at rated load.

20.4 A nonsafety switch shall be capable of 6000 cycles of operation at rated load.

21 Spacings

21.1 General

21.1.1 Live screwheads or nuts on the underside of a support shall be countersunk not less than 1/8 inch (3.2 mm) in the clear, and then covered with a waterproof, insulating, sealing compound that will not melt at a temperature 15°C (27°F) higher than the intended operating temperature of the valve, and at not less than 65°C (149°F) in any case; except that if such parts are staked, upset, or otherwise prevented from loosening, they need not be recessed, and they may be insulated from the mounting surface by material other than sealing compound or by the provision of spacings through air and over surface in accordance with these requirements.

21.1.2 The spacing at wiring terminals is to be measured with appropriate wires in place and connected to the terminals as in actual service.

21.1.3 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirement in 21.2.1, and shall be evaluated on the basis of the highest voltage involved.

21.1.4 As an alternative approach to the spacing requirements specified in 21.2 and 21.3, and other than as noted in 22.2 and 22.3, clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as amended in Section 22.

21.2 High-voltage circuits

21.2.1 Except as noted in 21.2.3, 21.2.9 and Section 22, the spacing of high-voltage parts in a valve shall not be less than those indicated in Table 21.1. Greater spacing may be required if the enclosure, because of its size, shape, or the material used, is not sufficiently rigid to maintain the minimum spacing requirements.

Table 21.1
Minimum spacings

Location		General						Maximum rating of 2000 volt-amperes, 300 volts			
		A						B[a]		C	
		0 – 150 volts,		151 – 300 volts,		301 – 600 volts,		General purpose valves 0 – 300 volts,		Safety valves 0 – 300 volts,	
		inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated high or low-voltage parts, an uninsulated grounded dead metal part other than the enclosure, or an exposed dead metal part which is isolated (insulated)	Through air or oil	1/8[b,c,d]	(3.2[b,c,d])	1/4[c,d]	(6.4[c,d])	3/8[c,d]	(9.5[c,d])	1/16[b]	(1.6[b])	1/8[b,c,d]	(3.2[b,c,d])
	Over surface	1/4[d]	(6.4[d])	3/8[d]	(9.5[d])	1/2[d]	(12.7[d])	1/16[b]	(1.6[b])	1/4[d]	(6.4[d])
Between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or metal-clad cable	Shortest distance	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/4	(6.4)	1/4	(6.4)

NOTES

1 The volt-ampere equivalent of a horsepower rating is to be taken as the product of the voltage and the full-load current.

2 The spacings at an individual component part are to be evaluated on the basis of the total volt-ampere consumption of the equipment which it controls.

3 The volt-ampere limitation includes the maximum volt-ampere consumption of the valve assembly plus the volt-ampere consumption of the equipment to be controlled at any one time.

[a] If reduced spacings indicated in column B are used, all electrical parts of the device are to be subjected to the regular production-control dielectric voltage-withstand test. The applied test potential is to be in accordance with these requirements – with an additional 20-percent voltage applied for a time of 1 second rather than 1 minute.

[b] The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded dead metal part shall not be less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greater than that indicated.

[c] In a safety valve and in a valve including components used in a safety-control circuit, the spacing between wiring terminals, regardless of polarity, and between a wiring terminal and a dead metal part (including the enclosure) which may be grounded when the device is installed, shall not be less than 1/4 inch (6.4 mm) of a short circuit between the parts may result in risk of fire or electric shock when the valve or a controlled device is operated.

Table 21.1 Continued on Next Page

Table 21.1 Continued

Location	General						Maximum rating of 2000 volt-amperes, 300 volts			
	A						B[a]		C	
	0 – 150 volts,		151 – 300 volts,		301 – 600 volts,		General purpose valves 0 – 300 volts,		Safety valves 0 – 300 volts,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)

[d] In a safety valve and in a valve including components used in a safety-control circuit, the spacings between uninsulated live parts of the same polarity, except at contacts, shall not be less than 1/32 inch (0.8 mm) through air and not less than 1/16 inch (1.6 mm) over the surface of insulating material, if a short circuit between the parts may result in risk of fire or electric shock when the valve or a controlled device is operated. The construction of the parts shall maintain these spacings permanently. Otherwise, the spacings in such a valve shall comply with the requirements in Table 21.1.

[e] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce the spacings between the metal piece and uninsulated live parts.

21.2.2 If more than one circuit is included in one enclosure, the spacing from one circuit to another, and the spacing from any one circuit to the enclosure or other uninsulated dead metal part excluding its mounting surface, are to be based on the maximum voltage and total volt-ampere rating of the overall assembly and not on the individual circuit rating. The inherent spacings within an individual component such as a relay (including spacings from a live part to the mounting surface other than the enclosure) are to be evaluated on the basis of the volt-amperes consumed and controlled by the individual components.

21.2.3 The spacings in a component device (such as a snap switch), supplied as part of a valve assembly, other than in a safety-control circuit, shall not be less than the minimum spacings required for the class of device in question, or not less than the spacings indicated in Table 21.1, whichever are smaller. In a wiring device which is part of a safety-control circuit or a safety valve, spacings shall comply with the requirement in footnote d to Table 21.1.

21.2.4 Unless made of a material conforming to 21.2.7, a barrier or liner shall be used in conjunction with at least 1/32 inch (0.8 mm) air space.

21.2.5 Mica material not less than 0.013 inch (0.33 mm) thick may be used in lieu of the through-air spacing required in Table 21.1, if the mica is tightly held in a fixed position by the parts between which the spacing is required.

21.2.6 Film-coated wire is considered to be the same as an uninsulated live part in determining compliance of a device with the spacing requirements in this standard.

21.2.7 When insulating material is used as a barrier to comply with over surface and through air spacing requirements, the insulating material used shall comply with at least one of the following criteria:

a) Be a generic insulating material provided in the thickness indicated in Table 21.2 when the insulating material does not physically support or maintain the relative position of the uninsulated parts involved; or

b) Comply with at least one of the following:

1) Comply with the direct support requirements in Section 6 at the use thickness;

2) Be one of the materials called out in Table 21.2 at a thickness not less than 0.013 inch (0.33 mm) thick plus one-half required clearance spacings when the insulating material is provided in lieu of required clearance distance only; or

3) At the use thickness, capable of withstanding the 5000 V ac Dielectric Strength Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: Materials with a dielectric strength rating of at least 5 kV at the use thickness require no further evaluation.

Exception No. 2: When the barrier is provided in lieu of clearance distance only, is not within 1/32 inch (0.8 mm) of uninsulated live parts, and does not physically support or maintain the relative position of uninsulated parts involved, the insulating material is only required to comply with the RTI and HAI values in Table 6.2.

5) Insulating Tape as follows:

i) Complies with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510, and used in sufficient layers equivalent to a 5kV dielectric rating.

ii) Suitable operating temperature rating.

iii) When tape overlaps on itself or is adhered to an adjacent surface to form a sealed joint, the amount of overlap shall be at least 1/16 in. (1.6 mm).

iv) When the overlap described in (iii) is less than 1/16 in. (1.6 mm) the construction complies with the clamped joint test in Section 46, Clamped Insulating Joints in Lieu of Spacings.

Table 21.2
Generic materials suitable as a barrier

Generic material	Minimum thickness,		RTI, °C
	Inch	(mm)	
Aramid Paper	0.010	(0.25)	105
Cambric	0.028	(0.71)	105
Electrical Grade Paper	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Mica	0.006	(0.15)	105
Mylar (PETP)	0.007	(0.18)	105
RTV	0.028	(0.71)	105
Silicone	0.028	(0.71)	105
Treated Cloth	0.028	(0.71)	105
Vulcanized Fiber	0.028	(0.71)	105
NOTE – Each material shall have at least the minimum thickness specified and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test.			

21.2.8 Spacing distances may be reduced to a minimum of 0.028 in, (0.71 mm) between printed wiring board traces operating at opposite polarity to each other on printed wiring boards when the printed wiring board is provided with conformal coating complying with the requirements in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E. The printed wiring board material and the measured through air and over surface spacings between traces shall be appropriate for the conformal coating being used.

21.2.9 For coil constructions where the cross-over lead insulation and insulation under coil terminals and magnet wire splices is provided in order to comply with over surface and through air spacing requirements and does not comply with the requirements in 21.2.7, the construction is considered to comply with spacing requirements when there is no indication of breakdown in the system as a result of the Increased Potential Test, Section 38.

21.2.10 For other than providing isolation between different circuits including ground or in a safety circuit, spacings between traces of different potential on a printed wiring board are not required to comply with the spacing requirements of this Standard when:

a) The printed wiring board has a flammability rating of V-0;

b) The printed wiring board base material has a minimum Comparative Tracking Index (CTI) of 100 volts; and

c) The equipment complies with the Printed Wiring Board Abnormal Operation Test, Section 48.

21.3 Low-voltage circuits – and low-voltage safety-control circuits

21.3.1 In a low voltage circuit, a safety valve and in a valve including components employed in a safety-control circuit, the spacings of low-voltage parts shall be as indicated in 21.3.2 – 21.3.4, if a short circuit between the parts involved may prevent the valve or controlled device from closing as intended.

21.3.2 The spacing between an uninsulated live part and the wall of a metal enclosure, including fittings for the connection of conduit or cable, shall not be less than 1/8 inch (3.2 mm). A greater spacing may be required if, because of its size, shape, or the material used, the enclosure is not sufficiently rigid to maintain the required spacing.

21.3.3 The spacing between wiring terminals, regardless of polarity, and between a wiring terminal and a dead metal part (including the enclosure) that may be grounded when the valve is installed, shall not be less than 1/4 inch (6.4 mm).

21.3.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the valve is installed shall not be less than 1/32 inch (0.8 mm), if the construction of the parts is such that the spacings will be maintained.

21.4 Other than safety-control circuits

21.4.1 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 of circuits classified as Class 2.

22 Alternate Spacing – Clearances and Creepage Distances

22.1 As indicated in 21.1.4, an alternative approach to the spacing requirements specified in 21.2 and 21.3 may be used to evaluate clearances and creepage distances as described in 22.2 – 22.4.

22.2 Clearance between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in Table 21.1. The clearance shall be determined by physical measurement.

22.3 The clearance and creepage distance at field-wiring terminals shall be in accordance with the requirements in 21.1 – 21.4.

Exception: If the design of the field-wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field-wiring terminal may be evaluated in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

22.4 When conducting an evaluation in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

a) For clearance:

1) When in a safety valve or in a valve including components employed in a safety-control circuit, a short circuit between the parts involved may prevent the valve or controlled device from operating as intended, the assembly shall be evaluated for Overvoltage Category III. Other valves covered under this standard shall be evaluated for Overvoltage Category II;

2) The phase-to-ground rated system voltage used in the determination of clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product when no isolating transformer is provided. The measured clearance distance used in the evaluation of isolated secondary circuitry shall be interpolated when the secondary voltage occurs between voltages in the supply voltage column;

3) To determine equivalence with current through-air spacing requirements, an impulse test potential having a value as determined in UL 840 shall be applied.

b) For creepage:

1) Any printed-wiring board, which complies with the requirements in the Standard for Printed-Wiring Boards, UL 796, provides a Comparative Tracking Index (CTI) of 100, and when it complies with the requirements for direct support in UL 796, it provides a CTI of 175;

2) Unless specified elsewhere in this standard, equipment shall be evaluated for Pollution Degree 3;

3) Printed-wiring boards are evaluated as Pollution Degree 2 when adjacent conductive material is covered by any coating, such as a solder mask, which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

4) Printed-wiring boards shall be evaluated as Pollution Degree 1 under one of the following conditions:

i) A coating, which complies with the requirements for conformal coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

ii) At a specific printed-wiring board location by application of at least a 0.028 inch (0.71 mm) thick layer of silicone rubber or through potting, without air bubbles, in epoxy or potting material.

23 Separation of Circuits

23.1 General

23.1.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits (internal wiring) shall be separated by barriers or shall be segregated; and shall, in any case, be separated by barriers or segregated from uninsulated live parts connected to different circuits or opposite polarity parts of the same circuit.

23.1.2 Segregation of insulated conductors as required in 23.1.1 may be accomplished by clamping, routing, or equivalent means that maintains separation of the conductors from insulated or uninsulated live parts of a different circuit.

23.1.3 Field-installation conductors of any circuit shall be segregated or separated by barriers from:

a) Field-installation and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit.

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting may result in the risk of fire, electric shock, or injury to persons, except that a construction in which field-installed conductors may make contact with wiring terminals may be used, if Type T, TW, or equivalent conductors are or are intended to be installed when wired in accordance with the National Electrical Code, NFPA 70.

23.1.4 Segregation of field-installation conductors from other field-installation conductors and from uninsulated live parts of the valve connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live parts) so that there is no intermingling of the conductors or parts of different circuits. If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the valve and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 23.1.3, that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated. To determine if a device complies with the requirements in 23.1.3, it is to be wired as it would be in service. A reasonable amount of slack is to be left in each conductor within the enclosure and no more than average care is to be exercised in stowing this slack into the wiring compartment.

23.2 Barriers

23.2.1 A barrier used to provide separation between the wiring of different circuits or between operating parts and field installation conductors shall be of metal or of insulating material and shall be held in place.

23.2.2 A metal barrier shall have a thickness at least as great as that required by Table 13.1 or Table 13.2 based on the size of the barrier. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick, or shall be thicker if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall not be more than 1/16 inch (1.6 mm) wide.

23.2.3 Openings in a barrier for the passage of conductors shall not be larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires. See also 15.7 for additional requirements.

PERFORMANCE

24 General

24.1 Except as otherwise indicated, representative commercial sample(s) of a valve are to be subjected to the applicable tests described herein. The order of tests, as far as applicable, is to be as indicated in Sections 24 – 42 with the exception of the specific test sequence shown in 24.6. In addition, except as noted in 24.2 or 24.3, the various tests are to be conducted at rated frequency and at the voltage indicated in Table 24.1. Additional samples of internal parts, such as diaphragms, seats, and the like, may be required for separate tests.

24.2 If a valve is rated at 50 hertz only, or 50/60 hertz, the input, temperature, overvoltage, undervoltage, and burnout tests may be conducted, with the concurrence of those concerned, at a frequency of 60 hertz and at a test voltage calculated as specified in 24.4.

Table 24.1
Test voltages

Test	Voltage range[a,b,c]				
	110 – 120	220 – 240	257 – 277	440 – 480	550 – 600
All tests except operation and dielectric voltage-withstand	120	240	277	480	600
Operation	–	–	–	–	–
Overvoltage, AC or DC	132	264	305	528	660
Undervoltage, AC or DC	102	204	235	408	510
Dielectric voltage-withstand	As described in Section 35				

[a] If a 60-hertz rated coil has a voltage rating that does not fall within any of the indicated voltage ranges, it shall be tested at its rated voltage.

[b] If coils rated for 60 hertz are supplied for various voltage ratings within a specified range (for example, 110, 115, or 117 volts), and if a coil is available for the maximum voltage rating of that range (120 volts), tests may be conducted on representative coils based on the marked voltage ratings of the coils selected for testing. If a coil is not available for the maximum voltage rating of that range, tests shall be conducted on all coils at the test potential indicated in this table.

[c] If a coil is direct current (DC) or 50 hertz rated, the test voltage shall be based on the rated voltage. See 24.2 and 24.3.

24.3 If a valve is rated at 50/60 hertz, and the test voltage calculated in accordance with 24.4 is less than or equal to the 60-hertz test voltage specified in Table 24.1, the input, temperature, overvoltage, undervoltage, and burnout tests are to be conducted at the higher voltage.

24.4 With reference to 24.2, the test voltage is to be based on increasing the current through the valve coil in accordance with the ratio of the impedance at the two frequencies for which the valve is rated. The test voltage is to be calculated from the following formula:

$$V_T = \frac{1.2\ V_R\ V_M\ I_M}{\sqrt{(V_M\ I_M)^2 + 0.44\ P_M^{\ 2}}}$$

in which:

V_T *is the test voltage;*

V_R is the rated voltage at 50 hertz;

V_M is the rated voltage at 60 hertz, or 1.091 V_R if the valve has a frequency rating of 50 hertz only;

I_M is the input current measured at V_M at 60 hertz; and

P_M is the input power measured at V_M and 60 hertz.

24.5 All tests shall be performed using the test fluids specified for that test. No substitution of test fluids in allowed. When the test indicates that CE25a, CE40a or CE85a are to be used, the test fluid shall be prepared as described in Supplement SB.

24.6 The following test sequence outlines the order in which tests shall be performed. Tests included in this standard, but not included in the test sequence, can be performed in any order in accordance with 24.1. The tests in the given sequence are to be performed on samples that were subjected to the Long Term Exposure Test, Section 27. One sample of the valve is required for each applicable test fluid, and that sample shall then be subjected to the sequence.

a) Long Term Exposure Test, Section 27;

b) External Leakage Test, Section 30;

c) Operation Test, Section 28;

d) Endurance Test, Section 32;

e) External Leakage Test, Section 30;

f) Operation Test, Section 28; and

g) Hydrostatic Strength Test, Section 34.

24.7 To reduce the effects of seal dry out due to removal of the test fluid after specific tests, the tests in the given sequence in 24.6, shall be started within 4 hours of removal of the previous test fluid. If necessary to coordinate testing, the sample may be left filled with the most recent test fluid at room temperature until the next test is initiated. If the previous test used an aerostatic or hydrostatic source, the sample shall be filled with kerosene.

24.8 A valve that must be mounted in a definite position in order to function as intended is to be tested in that position if directions for mounting in the correct position are given on the valve or in an instruction sheet supplied with the valve.

24.9 Class 2 Valves should be tested in accordance with UL 429, Table 24.3.

25 Input Test

25.1 The input to a valve shall not exceed the marked rating of the valve by more than 10 percent when it is operated under the conditions of normal use and with the valve connected to a supply circuit as indicated in Table 24.1. Input measurements are recorded within 10 seconds of initial energization at an ambient temperature of 21 – 32°C (70 – 90°F).

26 Temperature Test

26.1 An electric valve, when tested under the conditions described below, shall not attain a temperature at any point sufficiently high to constitute a risk of fire or to damage any materials employed in the device, nor show temperature rises at specific points greater than those indicated in Table 26.1.

26.2 All values for temperature rises specified in Table 26.1 apply to a valve intended for use in ambient temperatures normally prevailing in occupiable spaces, which usually are not higher than 25°C (77°F) but may be as high as 40°C (104°F) occasionally and for brief periods. Tests of a valve for service with such ambient temperatures may be conducted and with any ambient temperature in the range of 10 – 40°C (50 – 104°F). If a valve is intended specifically for use in a prevailing ambient temperature more than 25°C, the test is to be conducted at this higher ambient temperature, and the allowable temperature rises specified in the table are to be reduced by the amount of the difference between that higher ambient temperature and 25°C.

26.3 The temperature rise attained by the motor of a motor-operated valve, when stalled, and while connected to a supply circuit as indicated in Table 24.1, shall not exceed the limits specified in Table 26.1, if stalling the motor is part of the normal operation. If stalling the motor is not part of the normal operation, the limits specified in Table 26.1 do not apply; but the motor, when stalled or otherwise operated with a blocked valve stem, shall not show any manifestation of a risk of fire.

26.4 The temperature rise attained on an electric valve for use with a fluid at a temperature exceeding 25° C (77° F) shall not exceed the limits specified in Table 26.1, with and without the hot fluid flowing through the valve. In the case of a normally open valve, the valve is to be energized with the hot fluid on only one side of the valve, and the valve also is to be tested with the hot fluid flowing and the valve de-energized if the maximum fluid temperature rating is greater than the insulation class rating. A valve that is rated for handling a fluid at a temperature of 25°C (77°F) or less , or when the maximum ambient and fluid temperatures are identical, is to be tested at the specified ambient temperature with no flow of fluid through the valve.

Table 26.1
Maximum temperature rises

Items	°C	(°F)
1. Terminals[a]	50	(90)
2. Points on or within a wiring compartment on which any conductors may contact [a] to be connected to the valve may rest or on wires intended for supply connection[a]	35	(63)
3. Laminated contacts	50	(90)
4. Solid contacts[b]	65	(117)
5. Wire, code[c]		
Types FF, RF, RUW	35	(63)
Types FFH, RFH, RH, RHW, THW, THWN	50	(90)
Types T, TF, TFF, TW	35	(63)
Type TA	65	(117)
6. Appliance wiring material		
75°C rating	50	(90)
80°C rating	55	(99)
90°C rating	65	(117)
105°C rating	80	(144)
200°C rating	175	(315)
250°C rating	225	(405)
7. Other types of insulated wires[d]		
8. Flexible cord		
Types S, SJ, SJO, SJT, SO, ST	35	(63)

Table 26.1 Continued on Next Page

Table 26.1 Continued

Items	°C	(°F)
9. Class A insulation systems on coil windings of motors[e]		
A. In open motors		
Thermocouple method	65	(117)
Resistance method	75	(135)
B. In totally enclosed motors		
Thermocouple method	70	(126)
Resistance method	80	(144)
10. Class 105 insulation systems on coils other than motor coils		
Thermocouple method	65	(117)
Resistance method	85	(153)
11. Class 130 insulation systems on coils other than motors		
Thermocouple method	85	(153)
Resistance method	95	(171)
12. Class 155 insulation systems on coils other than motor coils		
Thermocouple method	95	(171)
Resistance method	115	(207)
13. Class 180 insulation systems on coils other than motor coils		
Thermocouple method	115	(207)
Resistance method	135	(243)
14. Class 200 insulation systems on coils other than motor coils		
Thermocouple method	135	(275)
Resistance method	150	(302)
15. Class 220 insulation systems on coils other than motor coils		
Thermocouple method	150	(302)
Resistance method	170	(338)
16. Class 240 insulation systems on coils other than motor coils		
Thermocouple method	170	(338)
Resistance method	190	(374)
17. Varnished-cloth insulation	60	(108)
18. Phenolic composition used as electrical insulation or as a part whose failure would result in unsafe operation[c]	125	(225)
19. Fiber used as electrical insulation	65	(117)
20. Material used as electrical insulation[k]	l	l
21. Class 2 transformer enclosure	60	(108)
22. Power transformer enclosure	65	(117)
23. Sealing compounds	see footnote f	
24. Capacitors	see footnote g	
25. Polymeric fluid confining parts	see footnote h	
26. Semiconductors	see footnote j	
NOTE – The inclusion of a temperature limit for a material in this table is not indicative of the acceptability of the material if it does not otherwise conform to these requirements.		

Table 26.1 Continued on Next Page

Table 26.1 Continued

Items	°C	(°F)
[a] The temperature rise observed is permitted to exceed the values specified, if the valve is marked in accordance with 49.8 and 49.9. In no case shall the wiring attain a temperature higher than 90°C (194°F).		
[b] Contacts of silver or a silver alloy in a valve which is constructed to function where a high ambient temperature prevails may be used without any additional tests if they do not attain a temperature higher than 100°C (212°F) when the valve is tested at the ambient temperature in question. If the contacts attain a temperature higher than 100°C (212°F) but not higher than 150°C (302°F), they shall comply with the requirements for use at tests the higher ambient temperature in question, when subjected to overload and endurance.		
[c] The limitation on phenolic composition and on rubber and thermoplastic insulation does not apply to compounds that have been investigated and determined to comply with the requirements for higher temperatures.		
[d] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, NFPA 70; and the maximum temperature rise in any case shall not be more than the temperature limit of the wire in question minus 25°C (77°F).		
[e] For a synchronous clock motor, the maximum temperature rise is the same as that specified for insulation systems on "coils other than motor coils".		
[f] The maximum temperature, of a sealing compound is 25°C (77°F) less than the melting point temperature of the compound.		
[g] For a capacitor, the maximum temperature rise is the marked temperature limit of the capacitor minus an assumed ambient (room) temperature of 25°C (77°F).		
[h] The temperature rise shall not exceed the maximum rated Mechanical Impact Relative Thermal Index (RTI Mech) as determined by the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B minus an assumed ambient (room) temperature of 25°C (77°F).		
[j] The maximum temperature rise on the case is the maximum case temperature for the applied power dissipation recommended by the semiconductor manufacturer minus an assumed ambient of 25°C (77°F).		
[k] See Table 6.2.		
[l] The maximum temperature rise of the material shall not exceed the temperature limit of the material minus an assumed ambient temperature of 25 °C (77 °F).		

26.5 In lieu of the procedures described in 26.4, a normally closed, piloted-diaphragm type valve for use solely on heating appliances may be tested (the main valve being closed):

a) In rated ambient with fluid (air) flowing through the piloted valve and

b) In room ambient with no air flow.

26.6 In conducting the temperature test on a valve intended for use at room temperature and for handling fluids at room temperature, 1-foot (0.3-m) sections of pipe of the required size are to be fitted in the inlet and outlet openings of the valve to be tested. The pipe is to be arranged as a framework so that the valve will be mounted or suspended away from other heat-conducting bodies. In addition, openings for the connection of metal-clad cable or rigid conduit are to be provided with at least 1-foot lengths of conduit or metal-clad cable through which leads of the valve are to be carried. If a valve is provided with a junction box in which supply connections to the valve are to be made, wires not smaller than 18 AWG (0.82 mm^2) are to be connected to the valve and the temperature rise attained by such leads is not to exceed that allowed for Type R wire. The ends of the conduit or pipe need not be plugged. Galvanized pipe is to be used for water and steam valves; black pipe is to be used for other valves, except that copper tubing may be used if the design of the valve so indicates.

26.7 If a valve is rated for use in an ambient temperature exceeding 25° C (77° F), the test assembly described in 26.6 is to be placed in an enclosure in which the specified ambient temperature is maintained during the temperature test.

26.8 If a valve is rated for handling a fluid at a temperature exceeding the ambient temperature for which the valve is intended, the valve is to be connected into a piping system conveying the test fluid at the specified temperature. The test fluid is to be the fluid the valve is intended to handle or a similar fluid having a specific heat approximating that of the intended fluid. If a valve is intended for use with more than one fluid, the test is to be conducted with the fluid (or a similar fluid) determined to represent maximum temperature conditions. Otherwise the test arrangement is to be as described in 26.6 and 26.7.

26.9 Except as noted in 26.10, the valve is to be energized and allowed to remain energized until equilibrium temperatures are attained.

26.10 A valve intended for intermittent operation is to be energized and de-energized at its rated duty cycle until equilibrium temperatures are attained. See 45.1(o).

26.11 A modulating valve is to be kept floating also between its maximum and minimum position until equilibrium temperatures are attained.

26.12 A valve constructed for rapid repeated operation is to be also energized and de-energized repeatedly at the maximum intended rate of operation until equilibrium temperatures are attained.

26.13 If a valve includes switching devices or other auxiliary circuits, all such circuits are to carry maximum rated current during the temperature test.

26.14 The ambient or room air temperature is to be measured by a thermocouple not larger than 24 AWG (0.21 mm^2), or a thermometer shielded from direct radiation and located so as to indicate actual air temperature in the vicinity of the valve.

26.15 Except at coils, temperature readings are to be obtained by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change. The preferred method of measuring temperatures on coils is the thermocouple method; but temperature measurements by either the thermocouple or change-in-resistance method is permitted. Temperature measurements by either method is not to be employed for a temperature measurement at any point where supplementary heat insulation is employed. When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is standard practice to use thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of indicating instrument; and such equipment is to be used whenever temperature measurements by thermocouples are required.

27 Long Term Exposure Test

27.1 General

27.1.1 The test outlined in 27.2 – 27.4 is to be performed on one or two samples of the valve. If the product is rated for use with gasoline or a gasoline/ethanol blend with a nominal ethanol concentration of up to 25 percent (E0 – E25), then the test shall be performed using the CE25a test fluid on one sample. If the product is rated for use with gasoline or a gasoline/ethanol blends with a nominal ethanol concentration of up to 40 percent (E0 – E40), then the test shall be performed using both the CE25a and CE40a test fluids. If the product is rated for use with a gasoline/ethanol blend with a nominal ethanol concentration of up to 85 percent, then the test shall be performed using both the CE25a and CE85a test fluids with one fluid per sample. See Supplement SB for the test fluids.

27.2 Samples

27.2.1 A sample of a complete valve is to be tested. All inlet and outlet openings of the samples shall be sealed in accordance with 27.2.3.

27.2.2 If platings or coatings are used internal to the device, additional samples may be used. See 27.4.2.

27.2.3 Closures shall be provided to seal off inlet and outlet openings of all samples in accordance with 27.2.1. These closures shall be fabricated of materials as specified in 27.2.4. The closures shall be provided with a 1/4 inch NPT opening for connection to the test apparatus. All closures shall be installed by the manufacturer and provided with a torque rating. There will be no other adjustment to connections for the duration of the test.

27.2.4 Material combinations at the product and closure interface will be as specified by the manufacturer. All closures for valves rated for gasoline/ethanol blends with nominal ethanol concentrations up to 25 or 40 percent shall be fabricated of suitable materials. All closures for valves rated for gasoline/ethanol blends with nominal ethanol concentrations above 25 percent shall be fabricated of the materials representing permitted material to which the device may be connected; such as aluminum closures representing aluminum tubing. Table 6.2 shall be used to determine the worst case material interactions based on the materials specified by the manufacturer. Materials specified by the manufacturer but not included in Table 6.2 shall be tested as necessary to represent worst case conditions.

27.2.5 Any o-rings, gaskets, or other sealing materials, shall be provided and installed by the manufacturer. These dynamic sealing devices shall be the same as those that will be used in the final product installation. Static seals shall be representative of the seals being used in the final product installation. If the sealing device or material is not considered part of the component under test, but will be provided in an end product at the time of installation, a representative seal shall be provided for the test.

27.3 Method

27.3.1 The sample is to be exposed to the applicable test fluid in accordance with 27.1.1. The test fluids shall be prepared using the instructions in Supplement SB.

27.3.2 A quick connect device is connected to the 1/4 inch NPT connection at the inlet, and is used to fill the samples with the applicable test fluids. A source of pressure may be used to assist in filling or draining the samples, however, the pressure shall not exceed the rated pressure of the valve under test. Once the samples are filled to exclude all air, they are closed off and sealed. The samples are then placed in the test chamber.

27.3.3 The chamber temperature is increased to 60 ± 2°C (140 ± 4°F). When the chamber reaches this temperature, the exposure period begins. The samples are exposed to the applicable test fluid at 60 ± 2°C for approximately 168 hours. At the end of this duration, the exposure period is halted and the chamber is allowed to cool. The samples are subjected to a 50 psi (347 kPa) pressure for one minute. The fluid is then drained from the samples and observed in accordance with 27.4.2. After this observation, the fluid is discarded. The samples are then immediately refilled with new test fluid and the chamber temperature is allowed to increase to 60 ± 2°C again. The total duration of the test shall equal 1008 hours of exposure at 60 ± 2°C.

27.3.4 At the end of the total exposure duration, the test fluid is left in the samples and the samples are removed from the chamber. The samples are then subjected to the test sequence as outlined in 24.6 and in accordance with 24.7. Prior to the initiation of the test sequence, the Long Term Exposure test fluid is to be drained and discarded.

27.3.5 If the device contains any parts or surfaces that are plated or coated, if the device uses casting impregnation materials to eliminate porosity leakage, or if the device contains internal nonmetallic parts, the plating, coating, impregnation, or internal parts are tested both during and after this exposure. See 27.4.2 and 27.4.4.

27.4 Results

27.4.1 There shall be no leakage during this test. If leakage is observed at any point during the test, the test is to be stopped.

27.4.2 For platings or coatings, there shall be no softening of the plating or coating material. Compliance is checked by observance of the drained test fluid. There shall be no evidence of visible flaking or material. In addition, there shall be no substantial discoloration of the test fluid when observing the drained fluid. Discoloration is an indication of chemical attack on the plating or coating internal to the device. In order to determine that the base metal is not exposed, visual inspections shall be made. If the visual inspection requires examination of internal surfaces, the samples shall be cut open to determine compliance. If this is necessary, additional samples can be used to determine compliance with this requirement, such that the remaining test sequence will not be disturbed by cutting open samples. However, both the samples to be cut open and the samples to be used for the test sequence are required to complete the Long Term Exposure Test.

27.4.3 For casting impregnation materials, the sample shall not show evidence of porosity leakage during or after the fluid exposure duration.

27.4.4 For internal nonmetallic parts, there shall be no visible evidence of this material in the drained test fluid.

28 Operation Test

28.1 A valve shall withstand a continuous voltage 10 percent above its rated voltage and shall operate as intended at that voltage, at rated voltage, and at 85 percent of rated voltage. For a valve having a voltage rating within one of the ranges given in Table 24.1, the test voltage specified in that table is to be employed.

28.2 A valve tested in accordance with 28.1 shall handle a fluid for which the valve is intended at the maximum operating pressure differential. The test is to be repeated at the minimum operating pressure differential if the valve is so rated.

28.3 A valve rated for use in ambient temperatures greater than 25°C (77°F) or for handling a fluid at temperatures greater than 25°C, or both, is to be tested in accordance with 28.1 and 28.2, at the maximum temperatures specified by the manufacturer.

28.4 A valve rated for an ambient or fluid temperature less than 25° C (77° F) is to be tested in accordance with 28.1 and 28.2 at the minimum temperature specified.

28.5 For the operation at 110 percent of rated voltage, the valve is to be subjected to that increased voltage until equilibrium temperature is reached and then tested immediately for operation at that voltage and then at rated voltage.

28.6 For the operation at 85 percent of rated voltage, the valve is to be subjected to the rated voltage until equilibrium temperature is reached and then tested immediately for operation at 85 percent of rated voltage.

28.7 A valve intended for intermittent operation is to be operated at its rated duty cycle.

28.8 When a valve is constructed with more than one orifice size, the test is to be conducted on the orifice that has the highest force value determined by multiplying the MOPD by the orifice area.

29 Torque Test

29.1 All valves

29.1.1 Joints in a valve shall not leak, nor shall there be evidence of loosening of joints, distortion, external leakage, or other damage resulting from the stresses imposed on pipe-threaded sections due to the turning effects exerted by assembling to piping or tubing.

29.1.2 Torque tests shall be conducted under ambient temperature conditions maintained within the range of 10 – 40°C (50 – 104°F).

29.1.3 The sample valve used in this test is to be rigidly anchored or otherwise supported by a tool which fits snugly about the body of the valve, or to a section of the shank shaped for a wrench, if such section is provided, adjacent to the end into which the pipe is to be connected. A section of unused Schedule 80 pipe (as specified in the Specifications for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless, ASTM A53/A53M) of sufficient length for wrench engagement is to be connected to the female pipe threaded section of the body, the male threads having first been lubricated with SAE No. 10 machine oil (as specified in the Standard for Engine Oil Viscosity Classification, SAE J300). Each pipe section is then to be tightened to the applicable torque specified in Table 29.1.

Table 29.1
Torque requirements for pipe connections

Pipe size	Torque,	
Nominal inches	lb-in	(N·m)
1/8	170	(19.2)
1/4	220	(24.2)
3/8	280	(31.6)
1/2	375	(42.4)
3/4	560	(63.3)
1	750	(84.8)
1-1/14	875	(98.9)
1-1/12	940	(106)
2	1190	(134)
2-1/2	1310	(148)
3	1310	(148)

29.1.4 After the torque force has been applied to each connected pipe, the test sample is to be subjected to the External Leakage Test, Section 30. If leakage is noted at the threaded joint between the pipe and the valve body, the joint is to be remade using a pipe joint sealing compound and the sample is to be retested for external leakage.

29.1.5 Upon removal of the pipe from the test sample, the assembly is to be examined for loosening of body joints.

29.2 Safety valves

29.2.1 A safety valve shall not suffer deformation sufficient to cause seat leakage in excess of that permitted by these requirements when tested in accordance with 29.1.1 – 29.1.3.

29.2.2 Following the test described in 29.1.3, a safety valve is to be checked for seat leakage in accordance with Section 31.

30 External Leakage Test

30.1 A valve shall be tested for external leakage as specified in the torque, endurance, and burnout tests.

30.2 A valve shall not leak externally when tested hydrostatically at a pressure of one and one-half times the maximum rated pressure but not less than 1/2 psig (3.5 kPa) with the valve in the open position and the outlet closed.

30.3 The inlet of the valve is to be connected to a hydrostatic source capable of supplying the specified test pressure. The outlet of the valve is to be sealed. Any bypass or other openings not essential to the operation of the valve during this test are to be sealed unless this discharge in the main fluid stream before the outlet of the valve. The test fluid is to be admitted and maintained at the specified test pressure. In the case of diaphragm elements which, in intended usage, are subjected to pressure on both sides of the diaphragm, the test pressure is to be applied to both sides of the diaphragm slowly and without shock.

31 Seat Leakage Test

31.1 A valve is to be tested for seat leakage before and after the Endurance Test, Section 30. A seat leakage test for valves intended for handling the fuels anticipated by these requirements shall be made with water.

31.2 Seat leakage tests are to be conducted at the minimum and maximum ambient and fluid temperature ratings applicable to the intended use and as designated by the manufacturer. One test is to be conducted on each sample within the ambient and fluid temperature range of 10 – 40°C (50 – 104°F). For the minimum test conditions, the test ambient and fluid temperature are to be at the lower of the rated fluid and ambient temperature. For the maximum test conditions, the test ambient and fluid temperature are to be at the higher of the rated fluid and ambient temperature.

31.3 A valve shall not leak past the seat when the test liquid at any pressure of not more than one and one-half times maximum operating pressure differential is imposed for a period of 24 hours. This test shall be applied with the valve in its correct normal position of installation.

31.4 To demonstrate compliance with the requirements in 31.3, the inlet of the test valve is to be connected to a suitable hydraulic system. The valve is to be in the closed position assumed as the result of normal operation. The pressure is to be maintained at the inlet to the valve at one and one-half times maximum operating pressure differential and the test repeated at a pressure of 1/4 psig (1.7 kPa).

32 Endurance Test

32.1 A valve intended for use with the fuels anticipated by these requirements, shall be subjected to 100,000 cycles of open and close action at the maximum rated operating pressure differential. At the end of the 100,000 cycles, the valve shall operate as intended and shall not leak externally.

32.2 The endurance test is to be conducted at a rate not faster than six operations per minute. However, a rate greater than six operations per minute may be used if requested by the manufacturer.

32.3 A valve is to be tested with kerosene as the test fluid. This test is to be performed after the Long Term Exposure Test, Section 27, in accordance with 24.6.

32.4 The appropriate tests for external leakage and seat leakage are to be conducted before and after the endurance test in accordance with the test sequence shown in 24.6.

33 Vibration Test – Safety Valves

33.1 A safety valve intended for use on mobile equipment shall be subjected also to a vibration test as described in 33.2. While the valve is vibrating, a safety valve shall comply with the requirements for seat leakage and operation.

33.2 Tests to demonstrate conformance with 33.1 are to be conducted following the endurance test. The valve is to be attached to the platform of a vibrating machine. Connections to the inlet and outlet of the valve are to be made with tubing. The test fluid is to be applied to the inlet of the valve at the specified pressure. With the valve in the closed position, it is to be vibrated for a period of 8 hours at 1000 cycles per minute with a displacement of 0.15 inch (3.8 mm). The Seat Leakage and operating tests are then to be conducted while the valve is being vibrated at any convenient ambient and fluid temperature between 10 and 40°C (50 and 104°F).

34 Hydrostatic Strength Test

34.1 All parts of a valve, except a diaphragm, that are subjected to pressure during intended operation shall be tested hydrostatically to determine that the strength of the parts is sufficient to withstand, without rupture, a pressure equivalent to five times the maximum rated pressure of the valve.

34.2 Prior to the beginning of this test, a valve is to comply with the requirements for the Torque Test, Section 29.

34.3 The valve is to be tested by connecting the inlet to a hydraulic system. With the outlet of the valve sealed and the valve in the open position, the pressure is to be raised slowly to the required test pressure and held for a period of 1 minute. In the case of a diaphragm valve, the test pressure is to be applied on both sides of the diaphragm slowly and without shock to avoid excessively stressing the diaphragm.

34.4 External leakage observed during this test is acceptable provided the test pressure can be maintained for the entire test duration, and if, following the hydrostatic test, the valve complies with the requirements for external leakage specified in Section 30.

35 Dielectric Voltage-Withstand Test

35.1 An electrically operated valve shall withstand for 1 minute without breakdown the application of a voltage potential as specified in 35.2:

a) Between uninsulated high-voltage live parts and grounded or exposed metal parts or the enclosure with the contacts open and closed;

b) Between high-voltage terminals of opposite polarity with the contacts closed; and

c) Between uninsulated metal parts of one high-voltage circuit and such parts of another high-voltage circuit, or low-voltage circuit.

35.2 With respect to 35.1, the test potential shall be the following values for alternating-current:

a) 500 volts – For equipment rated not more than 30 volts;

b) 1000 volts plus twice the rated voltage of the equipment – For equipment rated 51 – 600 volts;

c) A 50 Hz source may be used in lieu of a 60 Hz source;

d) The test may be conducted with a direct current potential when the test voltage is 1.414 times the stated alternating current potential value.

35.3 A Class 2 transformer, included in a valve shall withstand, without breakdown, for a period of 1 minute, the application of an alternating potential of twice the maximum rated primary voltage plus 1000 volts, at rated frequency, between primary and secondary windings and between the primary winding and the core or enclosure.

35.4 A power transformer included in a valve shall withstand, without breakdown, for a period of 1 minute, the application of an alternating potential of twice the maximum rated primary or secondary voltage plus 1000 volts, at rated frequency, between primary and secondary windings; and shall withstand under the same conditions the application of an alternating potential of twice the rated voltage of each winding plus 1000 volts, at rated frequency, between each winding and the core or enclosure.

35.5 If a barrier or liner is used to insulate an exposed dead metal part, the valve shall be capable of withstanding a dielectric voltage-withstand test as indicated in 35.1 between uninsulated live parts and the exposed dead metal part.

35.6 To determine compliance with the requirements in 35.1 – 35.5, a valve is to be tested in the heated condition as attained during the temperature test by means of a transformer having a 500 volt-ampere capacity, the output voltage of which can be varied. The voltage waveform of the transformer should closely approximate a sine wave. Starting at zero, the applied potential is to be raised gradually until the required test value is reached, and is to be held at that value for 1 minute.

36 Increased Potential Test

36.1 A coil assembly that complies with 21.2.8 is to be subjected to the tests described in 36.2 – 32.4. There shall not be breakdown of the coil insulation during this test as indicated by de-energization of the coil or coil-burnout.

36.2 Three separate samples of the coil and frame assembly are to be subjected to this test. After constant temperatures have been reached as a result of the conditioning specified in 36.3, each coil is to be removed from the chamber and the terminals are to be connected to an alternating current source of twice the test potential (voltage) specified in Table 24.1 at a frequency of 400 hertz or less.

36.3 An oven shall be used to condition the test samples before conducting the increased potential portion of the tests described in 36.2. The maximum temperature rating of the insulation class is to be used for the oven conditioning as indicated in Table 36.1.

36.4 The increased test potential specified in 36.2 is to be obtained by starting at one quarter or less of the test value specified in Table 24.1 and increasing to twice the value in not more than 15 seconds. After being held for 7200 electrical cycles or for 60 seconds, whichever is less, the potential is to be reduced within 5 seconds to one quarter or less of the test value specified in Table 24.1 and the circuit is to be opened.

Table 36.1
Oven conditioning temperatures

Insulation class	Conditioning temperature, °C	(°F)
105 (A)	110	(230)
130 (B)	120	(248)
155 (F)	140	(284)
180 (H)	160	(320)
200 (N)	175	(347)
220 (R)	195	(383)
240 (S)	215	(419)

37 Burnout Test

37.1 One sample with AC rms rated coil shall be subjected to this test. When the valve body is polymeric then three separate samples shall be tested. A coil sourced by the output of a half or full wave rectified AC input is not subjected to this test.

37.2 There shall not be damage to the enclosure, emission of flame or molten metal, or risk of electric shock of an AC rms voltage operated valve when the valve mechanism has been blocked in the position assumed when the valve is de-energized and the valve then energized continuously for valve rated for continuous duty or at its rated duty cycle for intermittent duty cycle rated valves at rated frequency and at the voltage indicated in Table 24.1, with the valve grounded.

37.3 The circuit to which the valve is to be connected for test is to be protected by fuses rated at least ten times the current input rating of the valve. Opening of the fuses may occur and the valve need not be operative following the test.

37.4 All exposed dead metal parts shall be grounded through a 3A fuse having a voltage rated equal to or greater than the maximum circuit voltage. The fuse shall not open during the test.

37.5 The coil is to be covered with a single layer of cheesecloth. The cheesecloth shall be bleached cheesecloth running approximately 34 g/m^2 with a thread count in the range of 10 – 13 by 9 – 12 threads/cm.

37.6 Immediately following the Burnout Test the samples are conditioned in an oven at the maximum temperature permitted based on the class rating of the insulation system employed by the valve, see Table 36.1 for reference temperatures, for a minimum of four hours. The samples are then removed and within two minutes of removal from the conditioning oven are subjected to the Dielectric Voltage-Withstand Test, Section 35.

Exception: Dielectric Voltage-Withstand Test, Section 37, may be conducted immediately following burnout test while in the hot condition without additional oven conditioning provided the coil did not open or otherwise cease to operate or the dielectric test was able to be conducted within 30 seconds of the coil winding opening.

37.7 Valves employing a polymeric valve body (except air valves) shall be subjected to the External Leakage Test, Section 30. The External Leakage Test is to be conducted before and after the Burnout Test and is to comply with the requirements in Section 30.

38 Breakdown of Component Test

38.1 There shall be no emission of flame or molten metal nor ignition of cheese cloth loosely placed over the seams and ventilation openings where provided or totally around the device when capacitors, diodes, or other solid state components are short- or open-circuited.

Exception: The test is not required for the following:

a) When circuit analysis indicates that no other component or portion of the circuit will be seriously overloaded as a result of the assumed open circuiting or short circuiting of another component,

b) For components in Class 2 circuits, or

c) For components complying with requirements applicable to the component.

The cheesecloth shall be bleached cheesecloth running approximately 34 g/m^2 with a thread count in the range of 10 – 13 by 9 – 12 threads/cm.

38.2 The breakdown of the component shall be simulated after the device is fully energized and in operation. The equipment under test shall be operated in this manner until ultimate conditions are achieved. Ultimate conditions are defined as when either the equipment under test ceases to function or attains thermal stabilization.

38.3 Components shall be evaluated one at a time. As sufficient number of samples shall be tested in order to address each component selected for this test and its failure mode. Only one test is necessary for each component and its particular failure mode. More than one failure mode can be selected for any component.

38.4 For an open type device, a wire mesh cage that is 1.5 times the size of the device may be provided to simulate the intended enclosure.

38.5 The outer enclosure or wire mesh cage (if any) and any grounded or exposed dead-metal part are to be connected through a 30-ampere fuse to the supply circuit pole least likely to arc to ground. The 30-ampere fuse shall not open.

39 Rain Test

39.1 An enclosure for a valve intended for use in wet locations and designated Rainproof or Raintight is to be subjected to a rain exposure to determine compliance with the requirements for these designations.

39.2 The complete valve is to be mounted with conduit connections as in intended service, and a water spray adjusted to be approximately the equivalent of a beating rain is then to be applied to it from the top and sides for 1 hour.

39.3 The test sample is to be examined to determine that no electrical parts are wetted and that there is no accumulation of water within the enclosures of electrical parts prior to rain exposure.

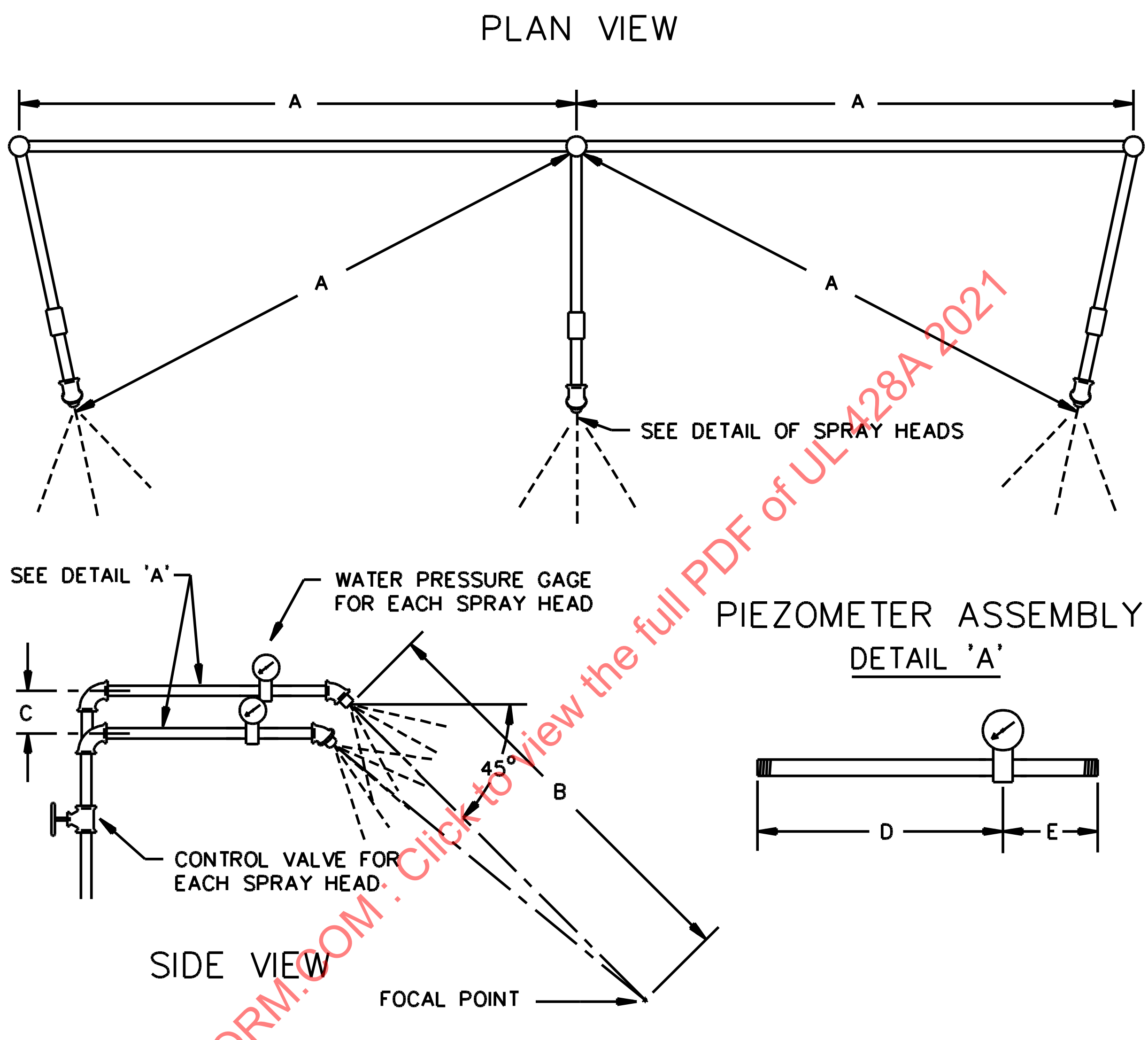
39.4 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 39.1. Spray heads are to be constructed in accordance with Figure 39.2. The water pressure for all tests is to be maintained at 5 psig (34.5 kPa) at each spray head. The test sample is to be brought into the focal area of the three spray heads and the spray is to be directed toward it at an angle of 45 degrees to the vertical.

39.5 An enclosure for a valve designated Rainproof shall prevent the entrance of water at a level higher than the lowest live part within the enclosure.

39.6 An enclosure for a valve designated Raintight shall prevent the entrance of any water.

Figure 39.1

Rain-test spray piping



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

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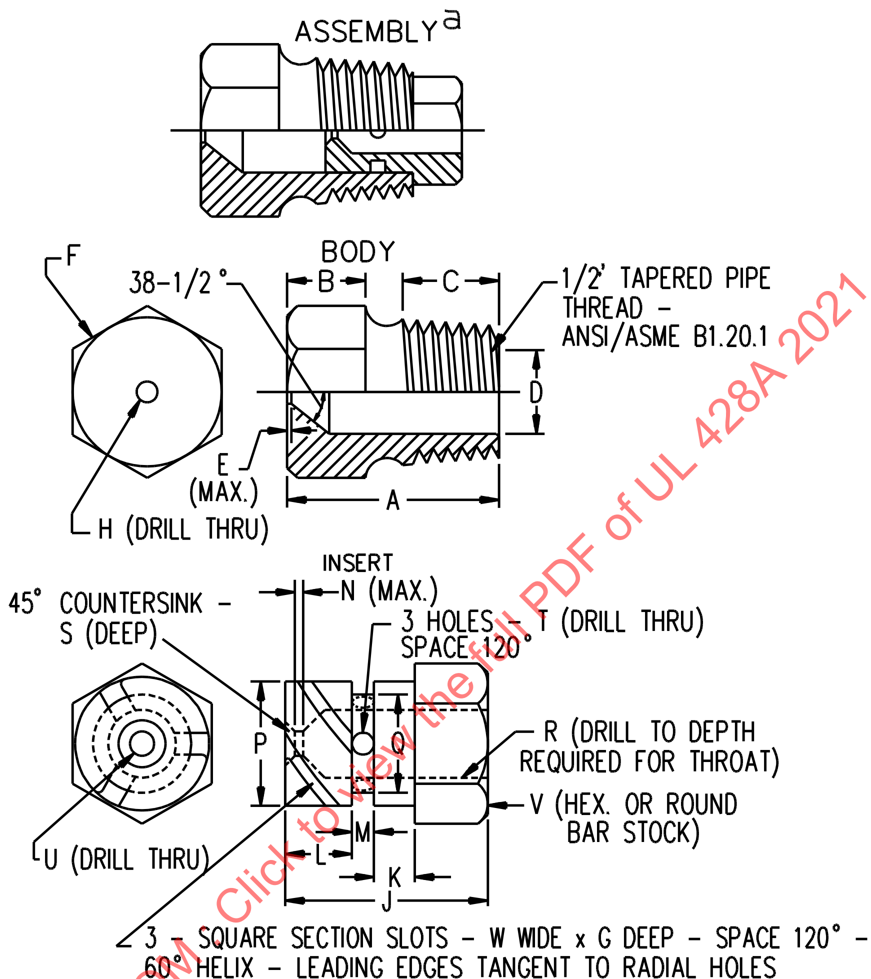
Figure 39.2

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