UL 429

ISBN 0-7629-0352-X

Electrically Operated Valves

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Electrically Operated Valves, UL 429

Fifth Edition, Dated March 23, 1999

Revisions: This Standard contains revisions through and including June 9, 2003.

Summary of Topics

These revisions are being isssued to revise the external leakage requirements, delete a paragraph that references another standard since this information is redundant, and to revise a term to be consistent with the terminology used in the National Electrical Code.

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new and revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated February 26, 2003. The bulletin(s) is now obsolete and may be discarded.

The revisions dated June 9, 2003 include a reprinted title page (page1) for this Standard.

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

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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

A change in an effective date is indicated by a note following the affected item, and giving both the previous effective date and the new date the requirement becomes effective.

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

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

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

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MARCH 23, 1999
(Title Page Reprinted: June 9, 2003)

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UL 429

Standard for Electrically Operated Valves

First Edition – January, 1955
Second Edition – May, 1973
Third Edition – March, 1982
Fourth Edition – August, 1994

Fifth Edition

March 23, 1999

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

The Department of Defense (DoD) has adopted UL 429 on August 10, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

ISBN 0-7629-0352-X

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FOREWORD

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

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

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

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated general purpose and safety valves rated 600 volts or less and intended for the control of fluids, such as air, gases, oils, refrigerants, steam, water, and the like. Electrically operated valves, other than automotive fuel valves, covered by these requirements are intended to be used in other than hazardous locations as defined by the National Electrical Code, NFPA 70.

1.2 These requirements also cover electrically operated valves intended to be factory installed on or in certain appliances as operating or safety controls.

1.3 These requirements do not cover general purpose valves that are not intended to be used with a flammable or hazardous fluid and are intended only for connection to a low voltage circuit of limited power supplied by a primary battery or a separate external Class 2 transformer. However, if a high-voltage transformer with a low-voltage secondary is incorporated as an integral part of a valve, the assembly is covered by these requirements.

1.4 These requirements do not cover valves for use in hydraulic fluid power systems.

1.5 These requirements do not cover valves covered by the requirements in the Standard for Automatic Valves for Gas Appliances, IAS/AGA Z21.21.

1.6 Deleted December 28, 2001

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. See Appendix A for a list of standards covering components used in the valves covered by this standard.

2.1.1 revised December 6, 2000

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

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

b) Is superseded by a requirement in this standard.

2.1.2 revised December 6, 2000

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

2.1.3 revised December 6, 2000

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

2.1.4 revised December 6, 2000

2.2 Units of measurement

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

2.2.1 revised December 6, 2000

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.

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 ELECTRICAL CIRCUITS –

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

1) An inherently limited Class 2 transformer;

2) A combination of a transformer and an overcurrent-protective device that complies with the applicable requirements for a Class 2 transformer that is not inherently limited;

3) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that complies with the applicable performance requirements for an inherently limited Class 2 transformer;

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

5) 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) 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.

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c) 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 ANSI/UL 913-1997.

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

3.4 FLAMMABLE FLUID – A gas or liquid considered to be flammable or combustible, such as acetylene, petroleum base hydraulic oil, fuel oil, gasoline, kerosene, or similar petroleum product, liquefied petroleum gas (LP-Gas), manufactured or natural fuel gas, anhydrous ammonia, or hydrogen.

3.5 GENERAL PURPOSE VALVE – Either a normally open or normally closed valve intended to control the flow of a fluid, but not depended upon to act as a safety valve.

3.6 HAZARDOUS FLUID – A gas or liquid considered to be highly corrosive or toxic, for example, a strong acid or alkali, ammonia, or perchlorethylene.

3.7 HYDRAULIC FLUID POWER SYSTEM – A system that transmits and controls power by use of a pressurized hydraulic fluid within an enclosed circuit.

3.8 INTERLOCK – A switch or control intended to verify the physical state of a required condition (that is, supervise the closing of a safety valve) and to furnish that verification to a safety-control circuit by means of a switch contact closure.

3.9 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.

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

3.11 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.

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

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

3.14 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.

3.15 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 37, does not permit water to enter the enclosure.

CONSTRUCTION

4 General

4.1 Except as indicated in 4.2 – 4.4, switch contacts, a resistance heating element, or a part that may arc or glow in a valve intended to control a flammable gas shall not be located in the main gas stream or in a compartment that may contain gas in the event of rupture of a bellows or diaphragm.

4.2 Electrical parts, including switch contacts and resistance elements, may be located in a gas-containing compartment of a valve intended for use only in an intrinsically safe circuit.

4.3 A coil may be located in a gas-containing compartment of a valve rated at not more than 125 volts, if:

a) The coil assembly (coil and leads) is potted in a coil compartment so that only one side of the potted coil assembly is exposed to the gas.

b) The valve complies with the requirements in the Burnout Test, Section 35.

c) The potting material complies with the requirements in 6.1.1.

4.4 Electrical parts may be located in a pilot or control gas stream apart from the main gas stream if the valve has been determined to comply with the requirements for an explosion test. During the test, ignition of a flammable gas-air mixture in the control or pilot-gas compartment shall not cause ignition of a similar mixture in the main gas stream.

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 may be hand-removable if:

a) The valve is intended for use with nonflammable or nonhazardous fluids only,

b) Leakage becomes apparent to the user before such part is completely disengaged, and

c) The part can be retightened with the valve under rated pressure so as to prevent further leakage.

Otherwise, such parts 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 Valves intended for oxygen service shall be free of oil, grease, and other foreign substances that are not compatible with oxygen. Thread sealing compounds and lubricants shall be compatible with oxygen.

5.1.8 The valve assembly shall withstand the stresses and vibration of intended operation, as determined by compliance with the Endurance Test, Section 30.

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).

6 Materials

6.1 All valves

6.1.1 A part in contact with the fluid to be handled shall be resistant to the action of the fluid.

6.1.2 Zinc, copper, and copper base alloys such as brass are subject to rapid destructive action by ammonia in the presence of water and shall not be used in contact with ammonia.

6.1.3 Iron and steel parts, except bearings, thermal elements, laminated relay cores, and the like, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, sherardizing, plating, or other means that have been determined to be equivalent.

6.1.4 The requirement in 6.1.3 applies to enclosing cases whether of sheet steel or cast iron, to current-carrying parts, and to other parts upon which intended mechanical operation may depend. It does not apply to small minor parts of iron or steel, such as washers, screws, bolts, and the like, that are not current-carrying, if malfunction of such unprotected parts does not introduce a risk of injury to persons.

6.1.5 A support for current-carrying parts shall be made of noncombustible, moisture-resistant insulating material that has been determined to be acceptable for the support of current-carrying parts. The support shall be constructed so that, considering the material used, it will withstand the most severe conditions likely to be met in service, including the influence of the arc formed by the operation of contacts.

6.1.6 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.

6.1.7 The acceptability of a nonmetallic body or enclosure material shall be determined for each application. Among the factors to be taken into consideration when judging the acceptability of a nonmetallic material are:

a) The mechanical strength,

b) Resistance to impact, and

c) Resistance to distortion and creeping at temperatures to which the material may be subjected under all conditions of intended usage.

All these factors are to be considered with respect to aging.

6.2 General purpose valves for flammable and hazardous fluids, and safety valves

6.2.1 A fluid-confining or operating part of a valve, if malfunction of such a part will allow leakage or introduce a risk of injury to persons, shall have the strength and durability for intended service of the parts and the assembly.

6.2.2 With reference to the requirements in 6.2.1, a material (except a valve disc or soft seat, an epoxy seal, a seal ring, a diaphragm, or a gasket) shall have a melting point (solidus temperature) of not less than 510°C (950°F) and a tensile strength of not less than 10,000 psi (69 MPa) at 204°C (400°F).

6.2.3 A brazing material used for joining fluid-confining parts of a valve for LP-Gas shall have a melting point (solidus temperature) of not less than 538°C (1000°F). Brazing involving copper or copper base alloys shall not be used on valves intended for use with ammonia.

6.2.4 A synthetic rubber part in contact with one of the fluids indicated in Table 6.1 shall not show excessive volume change or loss of weight, when considered on the basis of its intended function, following immersion for 70 hours in the specified test liquid. See the Immersion-Volume Change Test, Section 40, and the Immersion-Extraction Test, Section 41. The immersion-extraction test is not to be conducted with Reference Fuel A or IRM Oil No. 903.

6.2.4 revised March 23, 1999

Table 6.1
Test fluid for synthetic rubber materials

Table 6.1 revised March 23, 1999

Fluid handled	Test liquid
Anhydrous ammonia	Liquid anhydrous ammonia
Manufactured and natural fuel gases	IRM Oil No. 903 (ASTM D471)
LP-Gas	n-Hexane
Fuel oils	IRM Oil No. 903 (ASTM D471)
Gasoline	A and C Reference Fuels (ASTM D471)
Hydraulic oils	IRM Oil No. 903 (ASTM D471)
Caustic, corrosive, toxic	Fluid handled

6.2.5 With reference to the requirements in 6.2.4, the change in volume shall not be more than 25 percent swelling (40 percent in Reference Fuel C) or 1 percent shrinkage, and the weight loss (extraction) shall not be more than 10 percent. If the limits for volume change or weight loss are exceeded, a complete valve assembly is to be filled with the appropriate test liquid for 70 hours and then shall comply with the requirements for the External Leakage Test, Section 28, the Seat Leakage Test, Section 29, and the Hydrostatic Strength Test, Section 32.

6.2.6 A part made of synthetic rubber is not to crack or show visible evidence of deterioration following exposure as specified in the accelerated air-oven aging test in the Standard for Gaskets and Seals, UL 157. The maximum service temperature used to determine the conditioning time and temperature for the oven aging is determined to be 60°C (140°F) unless the product is designated for use at a higher temperature.

Effective date for 6.2.6 changed from September 25, 2000 to December 28, 2000

6.2.7 Any other part shall be resistant to atmospheric corrosion and attack by the fluid it may normally contact in service if the corrosion of such part may cause external leakage, or prevent a safety valve from functioning as a safety shutoff.

6.2.8 If atmospheric corrosion of a ferrous part will interfere with the intended function of a valve, the part shall be of a corrosion-resistant material or be provided with a corrosion-resistant protective coating.

6.2.9 A protective coating for nonelectrical parts shall be:

a) A uniform zinc coating having an average thickness of not less than 0.0002 inch (0.0051 mm) with a minimum thickness at any location of 0.00015 inch (0.0038 mm) or

b) A coating, other than zinc, that provides protection against corrosion at least equivalent to sheet steel having a zinc coating on each surface as specified in (a).

6.2.10 The thickness of a protective coating of zinc on a fabricated part, or on samples of zinc-coated sheet steel, to be used in comparative testing of a protective coating as described in 6.2.9(b) is to be determined as described in the Metallic Coating Thickness Test, Section 38.

6.2.11 Comparative tests for determinations of equivalency of a protective coating as described in 6.2.9(b) are to consist of simultaneous exposure to the Salt Spray Test, Section 39, of samples of other than zinc-coated parts together with samples of zinc-coated sheet steel having the minimum coating of zinc specified in 6.2.9(a).

6.2.12 Materials that may have their protective coating damaged or the effectiveness reduced by the manufacturing process are to be tested after being subjected to such process.

6.2.13 Samples having coatings involving 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 25.

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 B1.20.1-1983 (R1992) or the Standard for Dryseal Pipe Threads (Inch), ANSI B1.20.3-1976 (R1998). See also 44.1(h).

7.2 A valve assembly intended for attachment to pipe larger than 3-inch nominal size shall be provided with standard flanged pipe connections.

7.3 If warping of a casting can affect the tightness of fluid-confining joints or the necessary fit of parts, the casting shall be stress-relieved to reduce the risk of warping.

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 All valves

10.1.1 The assembly of a diaphragm type valve shall be such that positive motion of the valve will follow as a result of diaphragm movement.

10.1.2 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.

10.2 Flammable and hazardous fluid valves

10.2.1 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. See 28.8.

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 low-voltage 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 Low-voltage 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 The thickness of a metal enclosure shall not be less than that specified in Tables 13.1, 13.2, and 13.3.

13.1.6 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.

13.1.7 Glass covering an observation opening shall be secured in place so that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches (101.6 mm) in any dimension shall not be less than 1/16 inch (1.6 mm) thick. Glass for a larger opening, but not more than 144 square inches (929 cm^2) in area and having no dimension greater than 12 inches (304.8 mm), shall not be less than 1/8 inch (3.2 mm) thick.

13.1.8 A nonmetallic enclosure or enclosure part shall have mechanical strength and durability and be formed to protect operating parts against damage, and to resist the abuses likely to be encountered during installation and intended use and service. The enclosure or enclosure part shall reduce the risk of fire, electric shock, and injury to persons.

13.1.9 Among the factors to be taken into consideration when evaluating the acceptability of a nonmetallic enclosure are:

a) The mechanical strength;

b) Resistance to impact;

c) Combustibility and resistance to ignition from electrical sources;

d) Dielectric strength, insulation resistance, and resistance to arc tracking; and

e) Resistance to distortion and creeping at temperatures to which the material may be subjected under all conditions of intended usage.

All these factors are to be considered with respect to aging.

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
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 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.

13.1.10 If threads for the connection of a conduit are not tapped all the way through a hole in an enclosure wall, or if a construction that has been investigated and determined to be equivalent is used, there shall not be less than three threads in the metal and the construction of the control shall be such that a conduit bushing can be attached as intended.

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]					
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Minimum thickness,	
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).

[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 or raintight) 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

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.

13.1.11 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.

13.1.12 In an enclosure threaded for support by rigid conduit, at least five full threads shall be provided for engaging the conduit.

13.1.13 A conduit hub or nipple 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.

13.1.14 For the pullout test in 13.1.13, 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).

13.1.15 For the bending and torsion tests in 13.1.13, 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.

13.1.16 With reference to 13.1.13, distortion of the enclosure may occur and the test may be discontinued when noticeable enclosure distortion occurs.

13.2 Openings

13.2.1 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 – 13.1.12.

13.2.2 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, such as transformer burnout and burnout of a relay with blocked armature.

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 in addition to those mentioned in (e) 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

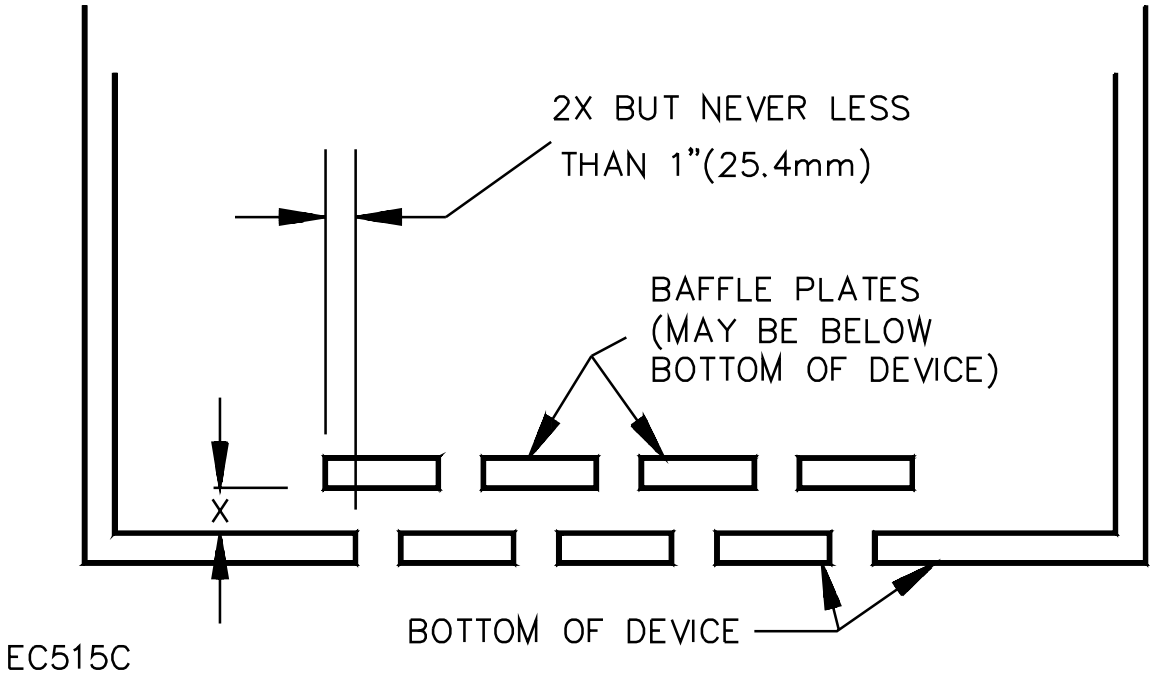
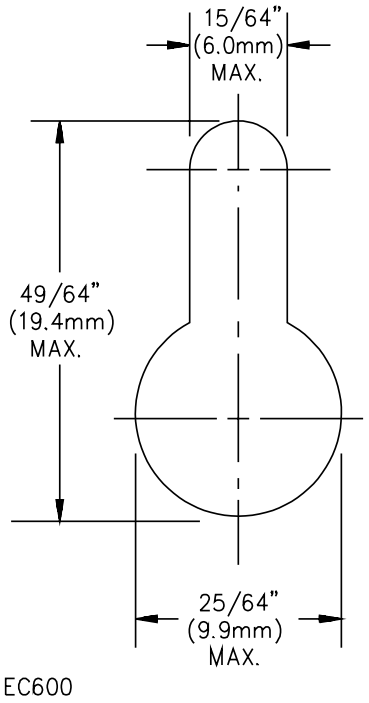


Figure 13.2
Keyhole slot



13.3 Accessibility of live parts

13.3.1 Electrical parts of valves shall be located or enclosed to reduce the risk of unintentional contact with an uninsulated live part. See 13.3.2 – 13.3.4. For the purpose of these requirements, film-coated wire is considered to be an uninsulated live part.

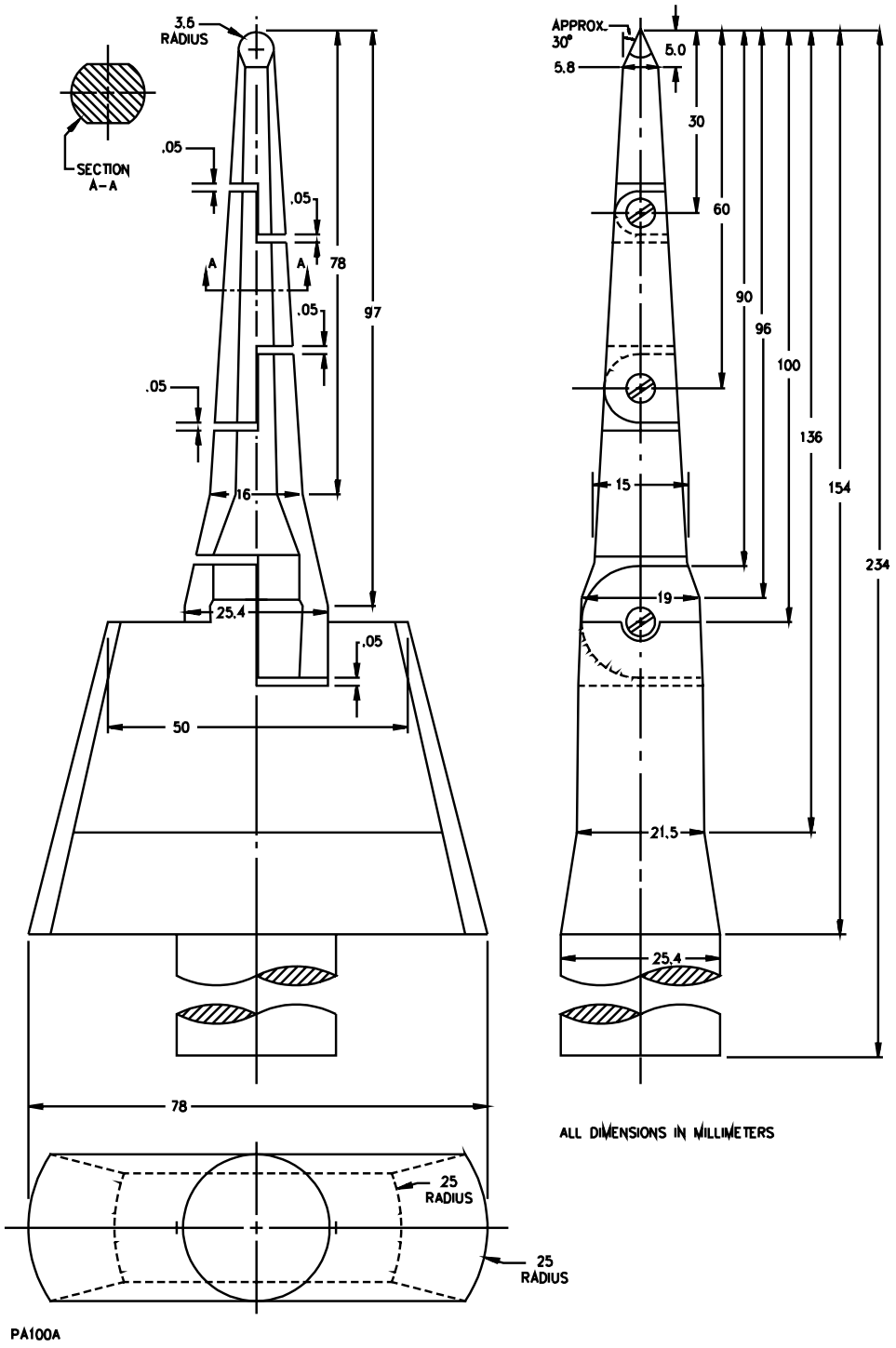
Exception: An enclosure is not required for a device intended for assembly as part of another device.

13.3.2 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.

13.3.3 With regard to the application of the requirement in 13.3.2, 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.

13.3.4 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.

Figure 13.3
Accessibility probe



13.3.5 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.

13.3.6 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.

13.4 Screens and expanded metal

13.4.1 The wires of a screen shall not be less than No. 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 No. 12 AWG (3.3 mm^2) for larger screen openings.

13.4.2 Except as noted in 13.4.3, 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.

13.4.3 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).

13.5 Rainproof, raintight, and watertight enclosures

13.5.1 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.

13.5.2 An enclosure for a valve intended to be used in wet locations and to be designated ″Raintight″ shall comply with the requirements in 13.5.1, except that it shall be constructed to prevent the entrance of water in a beating rain.

13.5.3 To determine if an enclosure complies with 13.5.1 or 13.5.2, the complete valve shall be subjected to the Rain Test, Section 36.

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

13.5.5 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.

13.5.6 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.

13.5.7 To determine if an enclosure complies with 13.5.5 and 13.5.6, the complete valve shall be subjected to the Hosedown Test, Section 37.

13.6 Corrosion protection

13.6.1 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 Sheet Steel, Zinc Coated (Galvanized), or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-98, 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 of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81 (1995).

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 38. An annealed coating shall also comply with 13.6.4.

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 38.

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 38. 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.

13.6.1 revised March 23, 1999

13.6.2 With reference to 13.6.1, 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 13.6.1(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.

13.6.3 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 25.

13.6.4 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 36, need not be painted.

13.6.5 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 13.6.4.

13.6.6 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 13.1.9.

13.6.7 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 13.6.8 or 13.6.9, whichever is applicable.

13.6.8 A gasket of rubber or neoprene, or composition gasket utilizing an elastomeric material, shall be tested as specified in 6.2.6. The gasket may be used if there is no visible evidence of deterioration such as softening, hardening, or cracking after flexing.

13.6.9 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.

13.7 Safety valves

13.7.1 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.

13.7.2 Low-voltage 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, ANSI/NFPA 70-1999, 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, ANSI/NFPA 70-1999.

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.

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, ANSI/NFPA 70-1999, shall not be smaller than No. 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.

14.2.3 revised June 9, 2003

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 6.2.4 – 6.2.6.

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 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 No. 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 wire-binding screw at a field-wiring terminal shall not be smaller than No. 8 (4.2 mm diameter). The screw shall thread into metal.

Exception: A No. 6 (3.5 mm diameter) screw may be used for the connection of one No. 14 AWG (2.1 mm^2), one No. 16 AWG (1.3 mm^2), or one No. 18 AWG (0.82 mm^2) conductor.

14.3.4 It should be noted that according to the National Electrical Code, ANSI/NFPA No. 70-1999, No. 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.

14.3.5 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 No. 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 No. 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 and Soldering Lugs for Use With Copper Conductors, UL 486A.

14.3.6 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.

14.3.7 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 No. 14 AWG (2.1 mm^2), under the head of the screw or the washer.

14.3.8 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.

14.3.9 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.

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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 70-1999, 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 14.3.9.

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 44.6, it shall be provided with a wire connector securely mounted to the outside of the housing acceptable for the connection of a minimum No. 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 and Coils

19.1 A transformer intended to furnish power to a low-voltage circuit shall be of the isolated secondary type, and shall comply with the Standard for Specialty Transformers, UL 506.

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

20 Switches

20.1 A switching device intended to control external loads shall be tested in accordance with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873.

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.

21.2 High-voltage circuits

21.2.1 Except as noted in 21.2.3 and 21.2.4, the spacings of high-voltage parts in a valve shall not be less than those indicated in Table 21.1. Greater spacings may be required if the enclosure, because of its size, shape, or the material used, is not sufficiently rigid to maintain the minimum spacings.

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 An insulating lining or barrier of vulcanized fiber or similar materials employed where spacings would otherwise be insufficient shall be not less than 0.028 inch (0.71 mm) thick and shall be so located or of such material that it will not be impaired by arcing; except that vulcanized fiber not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the required through-air spacing.

Exception: Cross-over lead insulation and insulation under coil terminals, including through air space, is not required to comply with these requirements when there is no indication of breakdown in the system as a result of the Increased Potential Test, Section 34.

21.2.5 Insulating material having a thickness less than that specified in 21.2.4 may be used if it has equivalent mechanical and electrical properties.

21.2.6 Unless made of a material conforming to 6.1.5, a barrier or liner shall be used in conjunction with at least 1/32 inch (0.8 mm) air space.

21.2.7 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.

21.2.8 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.

21.3 Low-voltage circuits – safety-control circuits

21.3.1 In 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 operating 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.

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.

4 Spacings and the thickness of insulation within a coil winding may be less than what is specified, if dielectric voltage-withstand tests at the factory are made (between the coil windings and grounded dead metal parts) on all production of coil windings employed in the device in question. In addition, the coil is required to be capable of withstanding (not a routine factory test) the application of the test potential between coil-end leads after breaking the inner-layer coil lead where it enters the inner layer, or an equivalent opposite-polarity test. The applied test potential is to be in accordance with these requirements – with an additional 20-percent voltage applied in the case of the routine factory test if the test time is 1 second instead of 1 minute.

[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.

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, inch (mm)	151 – 300 volts, inch (mm)	301 – 600 volts, inch (mm)	General purpose valves 0 – 300 volts, inch (mm)	Safety valves 0 – 300 volts, inch (mm)

[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.

[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.

21.3.3 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 low voltage.

22 Separation of Circuits

22.1 General

22.1.1 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.

22.1.2 Segregation of insulated conductors as required in 22.1.1 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.

22.1.3 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, ANSI/NFPA 70-1999.

22.1.4 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 22.1.3, 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 22.1.3, 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.

22.2 Barriers

22.2.1 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.

22.2.2 A metal barrier shall have a thickness at least as great as that required by Table 13.1 or 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.

22.2.3 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

23 General

23.1 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 – 41 and, except as noted in 23.2 or 23.3, the various tests are to be conducted at rated frequency and at the voltage indicated in Table 23.1. Additional samples of internal parts, such as diaphragms, seats, and the like, may be required for separate tests.

23.2 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 23.4.

Table 23.1
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 33				

[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 23.2 and 23.3.

23.3 If a valve is rated at 50/60 hertz, and the test voltage calculated in accordance with 23.4 is less than or equal to the 60-hertz test voltage specified in Table 23.1, the input, temperature, overvoltage, undervoltage, and burnout tests are to be conducted at the higher voltage.

23.4 With reference to 23.2, 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.

23.5 A valve is to be investigated for a specific fluid or fluids and for the service conditions for which it is to be recommended, such as ambient and fluid temperature and fluid pressure.

23.6 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.

23.7 In addition to the following tests, a valve shall be tested, as appropriate, in accordance with the requirements of 4.4, 6.2.4 – 6.2.6, 6.2.9, and 20.1 – 20.3.

24 Power Input and Output Test

24.1 Except as noted in 24.2, the power 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 23.1.

24.2 A valve that incorporates a transformer or a combination of transformer and fixed impedance or other device as the source of supply of a low-voltage circuit as described in 3.4 and that is intended for connections to external low-voltage open wiring shall be subjected to an output test with the primary energized at full rated voltage, as indicated in Table 23.1. Under any noncapacitive conditions of loading (from no load to the short circuiting of any or all secondary low-voltage installation wiring terminals) and without disturbing internal connections, the secondary output current shall not be greater than what is permitted for a standard Class 2 transformer.

25 Temperature Test

25.1 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 25.1.

25.2 All values for temperature rises specified in Table 25.1 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 (without correction) 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.

25.3 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 23.1, shall not exceed the limits specified in Table 25.1, 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 25.1 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.

25.4 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 25.1, with or without the hot fluid flowing through the valve, except that 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 with the valve de-energized. A valve that is rated for handling a fluid at a temperature of 25°C (77°F) or less is to be tested at the specified ambient temperature with no flow of fluid through the valve.

Table 25.1
Maximum temperature rises

Items	°C	(°F)
1. Terminals[a]	50	90
2. Points on or within a terminal box or compartment on which conductors 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
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

Table 25.1 Continued on Next Page

Table 25.1 Continued

Items	°C	(°F)
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. Varnished-cloth insulation	60	108
15. Phenolic composition used as electrical insulation or as a part whose failure would result in unsafe operation[c]	125	225
16. Fiber used as electrical insulation	65	117
17. Class 2 transformer enclosure	60	108
18. Power transformer enclosure	65	117
19. Sealing compounds	see footnote f	see footnote f
20. Capacitors	see footnote g	see footnote g

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.

[a] The temperature rise observed on the terminals and at points within a terminal box may exceed the values specified, if the valve is marked in accordance with 44.11 and 44.12. The wiring shall not 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, ANSI/NFPA 70-1999; 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 Class 105 insulation systems on coils other than motor coils.

[f] The maximum temperature, corrected to a 25°C assumed ambient temperature, of a sealing compound is 15°C (27°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.

25.5 In lieu of the procedures described in 25.4, 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.

25.6 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 No. 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.

25.7 If a valve is rated for use in an ambient temperature exceeding 25°C (77°F), the test assembly described in 25.6 is to be placed in an enclosure in which the specified ambient temperature is maintained during the temperature test.

25.8 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 25.6 and 25.7.

25.9 Except as noted in 25.10, the valve is to be energized and allowed to remain energized until equilibrium temperatures are attained.

25.10 A valve intended for intermittent operation is to be energized and de-energized at its rated duty cycle until equilibrium temperatures are attained. See 44.1(o).

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

25.12 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.

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

25.14 The ambient or room air temperature is to be measured by a thermocouple not larger than No. 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.

25.15 Except at coils, temperature readings are to be obtained by means of thermocouples consisting of wires not larger than No. 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 No. 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.

26 Operation Test

26.1 All valves

26.1.1 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 23.1, the test voltage specified in that table is to be employed.

26.1.2 A valve is to be tested in accordance with 26.1.1 when handling a fluid for which the valve is intended and with the maximum operating pressure differential on the valve seat. The test is to be repeated at the minimum operating pressure differential if the valve is so rated.

26.1.3 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 also to be tested in accordance with 26.1.1 and 26.1.2, at the maximum temperatures specified by the manufacturer.

26.1.4 A valve rated for use in an ambient temperature less than 25°C (77°F) is also to be tested in accordance with 26.1.1 and 26.1.2 at the minimum temperature specified by the manufacturer.

26.1.5 For the operation at increased 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 at rated voltage.

26.1.6 For the operation at minimum voltage, the valve is to be subjected to the rated voltage until equilibrium temperature is reached and then tested immediately for operation at the minimum voltage.

26.2 Safety valves

26.2.1 A safety valve intended for use with a fuel oil as identified and described in the Standard Specifications for Fuel Oils ASTM D396-98, shall be capable of closing when in the low-ambient temperature and while handling the fluid for which it is intended when the fluid is maintained at the low temperature and the viscosity indicated in Table 26.1.

26.2.2 If a maximum closing time is to be specified for a safety valve, the time so specified is to be as determined under the temperature-pressure conditions, within the ratings for the valve, causing the slowest closing. For this determination, the temperature and pressure are not to exceed the rating for the valve; the ambient temperature and the fluid temperature are to be not less than specified in Table 26.1; and the pressure on the valve disc is to be not less than the minimum rated pressure that is to be 3 inches (76.2 mm) of water for gas valves rated at not more than 1/2 psig (3.5 kPa).

Table 26.1
Temperatures and viscosities for test

Kind of valve	Ambient and fluid temperature	Viscosity, S.S.U.
Oil valves for Nos. 1, 2, 4, and 5 fuel oils and liquids of like viscosity	0°C (32°F)	For: No. 1 oil – 50 No. 2 oil – 100 No. 4 oil – 1,500 No. 5 oil – 15, 000
Oil valves for Nos. 5 and 6 fuel oils and liquids of like viscosity for use on burners and similar applications provided with means to permit liquid flow beyond valve only while liquid is heated to a predetermined temperature.	Minimum temperature specified for testing purposes by manufacturer, but not more than 45°C (113°F)	Viscosity of the fuel corresponding to fluid temperature specified, but not more than 15,000 and not less than 5,000.

NOTES

1 Viscosities selected above for test purposes are predicated on fuel oils having viscosities as indicated below:

a) No. 5 oil – 40 S. Saybolt Furol at 122°F (50°C)

b) No. 6 oil – 300 S. Saybolt Furol at 122°F (50°C)

2 A viscosity of more than 15,000 S.S.U. is considered to be in excess of the maximum viscosity allowing pumping.

3 A viscosity of 5000 S.S.U. is considered to be the average viscosity practical for pumping.

4 A safety valve to be used on an oil-fired heating appliance is required to open under the minimum operating temperature conditions specified for the burner when the burner equipment is energized at undervoltage conditions. The maximum viscosity at which the valve is designed to open should be specified for test purposes by the manufacturer of the valve. A valve so tested and determined to open at a viscosity of not less than 5000 S.S.U. is to be qualified with respect to performance for use on any oil burner listed for Nos. 5 and 6 fuel oils.

27 Torque Test

27.1 All valves

27.1.1 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.

27.1.2 Torque tests shall be conducted under ambient temperature conditions maintained within the range of 15 – 35°C (59 – 95°F).

27.1.3 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 Welded and Seamless Steel Pipe, ANSI/ASTM A53-98) 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 Engine Oil Viscosity Classification, ANSI/SAE J300 APRIL 97). Each pipe section is then to be tightened to the applicable torque specified in Table 27.1.

Table 27.1
Torque requirements for pipe connections

Pipe size, ANSI B1.20.1-83 (R1992), Nominal inches	Torque, lb-in	Torque, (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

27.1.4 After the torque force has been applied to each connected pipe, the test sample is to be subjected to the External Leakage Test, Section 28. 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.

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

27.2 Safety valves

27.2.1 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 27.1.1– 27.1.3.

27.2.2 Following the test described in 27.1.3, a safety valve is to be checked for seat leakage in accordance with 29.4 or 29.6, whichever is applicable.

28 External Leakage Test

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

28.1 revised June 9, 2003

28.2 Except as indicated in 28.3 and 28.3.1, a valve shall not leak externally at a rate in excess of 200 cubic centimeters per hour (cm^3/hr) when tested with air or nitrogen gas 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.

28.2 revised June 9, 2003

28.3 A general purpose valve for inert gas shall not leak externally at a rate in excess of 1.5 cubic feet per hour (42,500 cm^3/hr) when tested at maximum rated pressure.

28.3 revised June 9, 2003

28.3.1 A general purpose air valve that is subjected to an external leakage test following a torque, endurance or burnout test shall not leak externally in excess of value measured during the as-received test condition, as a consequence of conducting the Torque, Endurance or Burnout Test. The External Leakage Test is to be conducted at maximum rated pressure. No other external leakage limits are specified for general purpose air valves.

28.3.1 added June 9, 2003

28.4 The inlet of the valve is to be connected to a system capable of supplying clean air or other test medium at 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 gas pressure on both sides of the diaphragm, the test pressure is to be applied to both sides of the diaphragm slowly and without shock.

28.5 Leakage is to be measured by a flow meter capable of indicating accurately for the test fluid employed, a flow rate of 200 cm^3/hr (50,000 cm^3/hr for the tests described in 28.3 and 28.8). A valve rated for pressures of 50 psig (345 kPa) or more is acceptable if, when the fluid-containing parts of the valve are submerged in water to a depth of approximately 1 inch (25.4 mm), while under the test pressure, no bubble indicating leakage is observed within 10 seconds after the parts are submerged.

28.6 Leakage of test fluid through a diaphragm-type gas valve, when pressure is applied to one side of the diaphragm only, shall not exceed that specified in 29.6 for seat leakage, when the valve is tested with a pressure of one and one-half times maximum rated pressure but not less than 1/2 psig (3.5 kPa).

28.6 revised June 9, 2003

28.7 To demonstrate compliance with the requirements in 28.6, the escapement orifice, bypass connection, and other openings are to be closed in such a manner that pressure can be applied to one side of the diaphragm only. The method of test outlined in 29.7 and 29.8 is to be used, except that the outlet tubing is to be attached so as to collect any leakage from the valve outlet and the bleed connection.

28.8 To comply with the requirements of 10.2.1, a valve shall not allow leakage under conditions of ruptured diaphragm or bellows, from an unthreaded vent opening, or around any pins, stems, or linkage passing through the housing in excess of the following rate when the valve is tested to its maximum rated pressure:

a) One cubic foot (28,300 cm^3) per hour of a 0.64 specific gravity gas or 0.8 cubic foot (22,640 cm^3) per hour of air or nitrogen for a valve for use only with fuel gases having specific gravities less than 1.0;

b) One-half cubic foot (14,150 cm^3) per hour of a 1.53 specific gravity gas or 0.62 cubic foot (17,550 cm^3) per hour of air or nitrogen for a valve for use with liquefied petroleum gases;

c) One thousand cubic centimeters per hour of water for a valve for use with flammable or combustible liquids, such as gasoline, kerosene, and Nos. 1 and 2 fuel oil; or

d) Two thousand cubic centimeters per hour of the lightest grade of fuel oil heavier than No. 2 for which a valve is to be used.

29 Seat Leakage Test

29.1 A safety 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 gases shall be made with air or inert gas and for other valves with water or the least viscous liquid the valve is intended to handle.

29.2 Seat leakage tests are to be conducted at the 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 15 – 35°C (59 – 95°F).

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29.3 A safety valve rated for use in an ambient temperature less than 0°C (32°F) is also to be tested for seat leakage at the minimum ambient temperature specified by the manufacturer. The test fluid is to be maintained at the ambient temperature designated for the test.

29.4 A safety valve for liquids 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.

29.5 To demonstrate compliance with the requirements in 29.4, 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).

29.6 A safety valve for gases shall not leak past the seat in excess of the values specified in Table 29.1 when tested with air or inert gas at a pressure of 1/4 psig (1.7 kPa) and also at a pressure of one and one-half times maximum operating pressure differential, but not less than 1/2 psig (3.5 kPa). This test shall be applied with the valve installed in its intended position.

Table 29.1
Maximum allowable leakage

Type of gas	Maximum allowable leakage [cubic centimeters per hour at standard atmospheric conditions of 60°F (15.6°C) and a barometric pressure of 30 inches (760 mm) of mercury]
Air, common refrigerants, and nontoxic nonhazardous gases	5400
Hydrogen, natural, manufactured, and mixed gas, liquefied petroleum gas (propane, butane, or a mixture of the two) and acetylene	Port diameter 1 inch (25.4 mm) or less – 235
	Port diameter over 1 inch (25.4 mm) – 235 per inch (25.4 mm) of port diameter
Toxic and hazardous gases other than the foregoing	None

29.7 In order to comply with the requirements in 29.6, the inlet of the test valve is to be connected to a system capable of supplying clean air or other test gas at the test pressures. A tight connection is to be made to the valve outlet, terminating in suitable tubing. The open end of this outlet tube is to be located within an inverted graduated cylinder which is calibrated in cubic centimeters. The inverted cylinder is to be closed by a water seal. The apparatus is to be adjusted so that the end of the outlet tube is located approximately 1/2 inch (12.7 mm) above the water level within the inverted graduated cylinder, and so that the water within and exterior to the graduated cylinder is at the same level. With these adjustments made, the water level within the graduated cylinder is to be recorded.

29.8 With the valve in the closed position assumed as the result of intended operation the test fluid is to be applied to the valve inlet at the specified test pressure for a test period of not less than 2 minutes. During this time the vertical position of the graduated cylinder is to be adjusted, if necessary, to maintain the same water level within and exterior to it. At the end of the test period, and with the water within and exterior to the graduated cylinder at the same level, the level of water within the graduated cylinder is again to be recorded. From the change of volume within the graduated cylinder, the leakage rate is to be calculated according to the following formula:

$$R = V \times \frac{60}{m}\left[\frac{290}{(273+t)} \times \frac{P}{760}\right]$$

in which:

R is the leakage rate in cubic centimeters per hour,

V is the increase in volume within graduated cylinder during test,

m is the time of test in minutes,

t is the ambient temperature during test in degrees C, and

P is the barometric pressure during test in millimeters of mercury.

29.9 As an alternate method, leakage may be measured by a flow meter, capable of indicating accurately for the test fluid employed the maximum flow rates permitted, installed on the inlet side of the valve under test, or by any other method capable of providing the desired results. Valves intended for use with unspecified toxic or hazardous gases may be tested while submerged in water to a depth of approximately 1 inch (25.4 mm). After elimination of any trapped air, there shall be no evidence of bubble leakage over a 5-minute test period.

30 Endurance Test

30.1 A general purpose valve for use with other than flammable or hazardous fluids shall perform as intended for 6000 cycles of operation when handling a fluid for which the valve is intended at the rated temperature and with a rated operating pressure differential on the valve seat. The valve shall not stick, nor become inoperative. Required corrosion protection shall not be impaired.

30.2 A general purpose valve for flammable and hazardous fluids shall comply with the requirements of 30.1 and also shall perform as intended for 94,000 additional cycles or until it ceases to function, whichever occurs first. The test shall be made with the valve handling a fluid for which the valve is intended at the rated temperature and with a rated operating pressure differential on the valve seat.

30.3 An automatically closing manual-reset safety valve shall perform as intended for 6000 cycles of operation when handling a fluid for which the valve is intended at the rated temperature and with the rated maximum operating pressure differential on the valve seat. All other safety valves shall perform as intended for 100,000 cycles of operation when handling a fluid for which the valve is intended at the rated temperature and with the rated maximum operating pressure differential on the valve seat. There shall be no sticking of the valve, nor shall the valve become inoperative. Required corrosion protection shall not be impaired.

30.4 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. When a safety valve for fuel oil is tested, a strainer having a straining element with screen openings not smaller than those of a 50-mesh screen is to be installed in the supply line near the inlet to the valve.

30.5 The fluid to be handled by a valve during an endurance test is indicated below:

a) A valve for air or gases including oxygen is to be tested with air or nitrogen.

b) A valve for gasoline or liquid butane or propane is to be tested with mineral spirits or a product having a comparable specific gravity.[a]

c) A valve for fuel oil not heavier than No. 2 is to be tested with No. 1 oil (ASTM D396-98, Specifications for Fuel Oils).

d) A valve for Nos. 4 and 5 fuel oil is to be tested with No. 4 oil (ASTM D396-98).

e) A valve for No. 6 fuel oil is to be tested with No. 6 oil (ASTM D396-98).

f) A valve for steam is to be tested as general purpose valves only and with saturated steam.

g) A valve for water or aqueous solution is to be tested with water.

h) A valve for other fluids is to be tested with the intended fluid where practical.

[a]APCO 467 manufactured by APCO Oil Company has composition and specific gravity characteristics suitable for this test.

30.6 If a valve is intended to handle fluids at temperatures greater than room temperature, the test fluid is to be maintained at the maximum rated temperature during the endurance test. However, the test temperature is not to exceed the flash point of the test fluid.

30.7 If a valve is intended to handle more than one fluid, the endurance test is to be conducted with the fluid imposing the most severe service.

30.8 If a valve is rated for use in an ambient temperature other than 25°C (77°F), the test assembly is to be placed in an enclosure in which the rated ambient temperature is maintained during the test.

30.9 An endurance test on a valve rated for use within a specified range of ambient temperatures (for example, minus 40– 52°C), is to be conducted with the valve subjected to one-half the required number of cycles at each temperature extreme.

30.10 The appropriate tests for external leakage and seat leakage are to be conducted before and after the endurance test. |

30.10 revised June 9, 2003 |

30.11 If external or seat leakage becomes apparent to a degree exceeding the requirements for those factors, the test may be interrupted and the degree of leakage confirmed prior to continuation or termination of the test.

31 Vibration Test – Safety Valves

31.1 A safety valve intended for use on mobile equipment shall be subjected also to a vibration test as described in 31.2. While the valve is vibrating, a safety valve shall comply with the requirements for seat leakage and operation.

31.2 Tests to demonstrate conformance with 31.1 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 prescribed tests are then to be conducted while the valve is being vibrated.

32 Hydrostatic Strength Test

32.1 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.

32.2 Prior to the beginning of this test, a valve is to comply with the requirements for the Torque Test, Section 27.

32.3 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.

32.4 External leakage observed during this test is acceptable if, following the hydrostatic test, the valve complies with the requirements for external leakage specified in 28.2.

33 Dielectric Voltage-Withstand Test

33.1 High-voltage portions of an electric valve shall withstand for 1 minute without breakdown the application of a 60-hertz alternating potential of 1000 volts plus twice maximum rated voltage of the circuits involved:

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.

33.2 A valve employing a low-voltage circuit shall withstand for 1 minute without breakdown the application of a 60-hertz alternating potential of 500 volts applied between uninsulated low-voltage live parts of opposite polarity (with contacts, if any, closed), and between uninsulated low-voltage live parts and the enclosure and grounded dead metal parts.

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33.3 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.

33.4 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.

33.5 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 33.1 between uninsulated live parts and the exposed dead metal part.

33.6 The insulation on a flexible pigtail lead for a high-voltage circuit or for a low-voltage safety-control circuit where failure may cause risk of fire, electric shock, or injury to persons shall withstand for 1 minute without breakdown, when dry, an alternating potential of 1000 volts plus twice maximum rated voltage; and after exposure to moist air, such a lead shall withstand without breakdown an alternating potential of rated voltage plus 500 volts.

33.7 A lead that is to be tested dry is to be conditioned for 24 hours in a desiccator with dry calcium chloride; and a lead that is to be tested after exposure to moist air is to be conditioned for 24 hours in air having a relative humidity of 85 ±5 percent at a temperature of 32 ±2°C (89 ±3 °F).

33.8 To determine if a lead complies with the requirement of 33.6, the straight conductor is to be used as one electrode and a 1-inch (25.4-mm) wide metal foil wrap, suitably located away from the ends of the sample, is to be the other electrode at each of three different positions or on three separate test samples.

33.9 To determine compliance with the requirements in 33.1 – 33.6, 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.

34 Increased Potential Test

34.1 A coil assembly that complies with the Exception to 21.2.4 is to be subjected to the tests described in 34.2 – 34.4. There shall not be breakdown of the coil insulation during this test as indicated by de-energization of the coil or coil-burnout.

34.2 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 34.3, 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 23.1 at a frequency of 400 hertz or less.

34.3 An oven shall be used to condition the test samples before conducting the increased potential portion of the tests described in 34.2. The maximum temperature rating of the insulation class is to be used for the oven conditioning as indicated in Table 34.1.

34.4 The increased test potential specified in 34.2 is to be obtained by starting at one quarter or less of the test value specified in Table 23.1 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 23.1 and the circuit is to be opened.

Table 34.1
Oven conditioning temperatures

Insulation class	Conditioning temperature, °C	(°F)
105	110	230
130	120	248
155	140	284
180	160	320

35 Burnout Test

35.1 There shall not be damage to the enclosure, emission of flame or molten metal, or damage to a coil winding located in a flammable gas-confining compartment of a valve when the valve mechanism has been blocked in the position assumed when the valve is de-energized and the valve then energized continuously at rated frequency and at the voltage indicated in Table 23.1, with the valve grounded.

35.2 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.

35.3 If the valve body is nonmetallic, three samples are to be tested. The external leakage test is to be conducted before and after the burnout test and is to comply with the requirements in Section 28.

35.3 revised June 9, 2003

35.4 Except for a valve having a coil winding located in a flammable gas-containing compartment, or a valve having openings in the bottom of an electrical enclosure, a valve which has been subjected to an endurance test of 100,000 cycles and determined to perform as required in 30.2 or 30.3 need not be subjected to the burnout test.

36 Rain Test

36.1 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.

36.2 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.

36.3 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.

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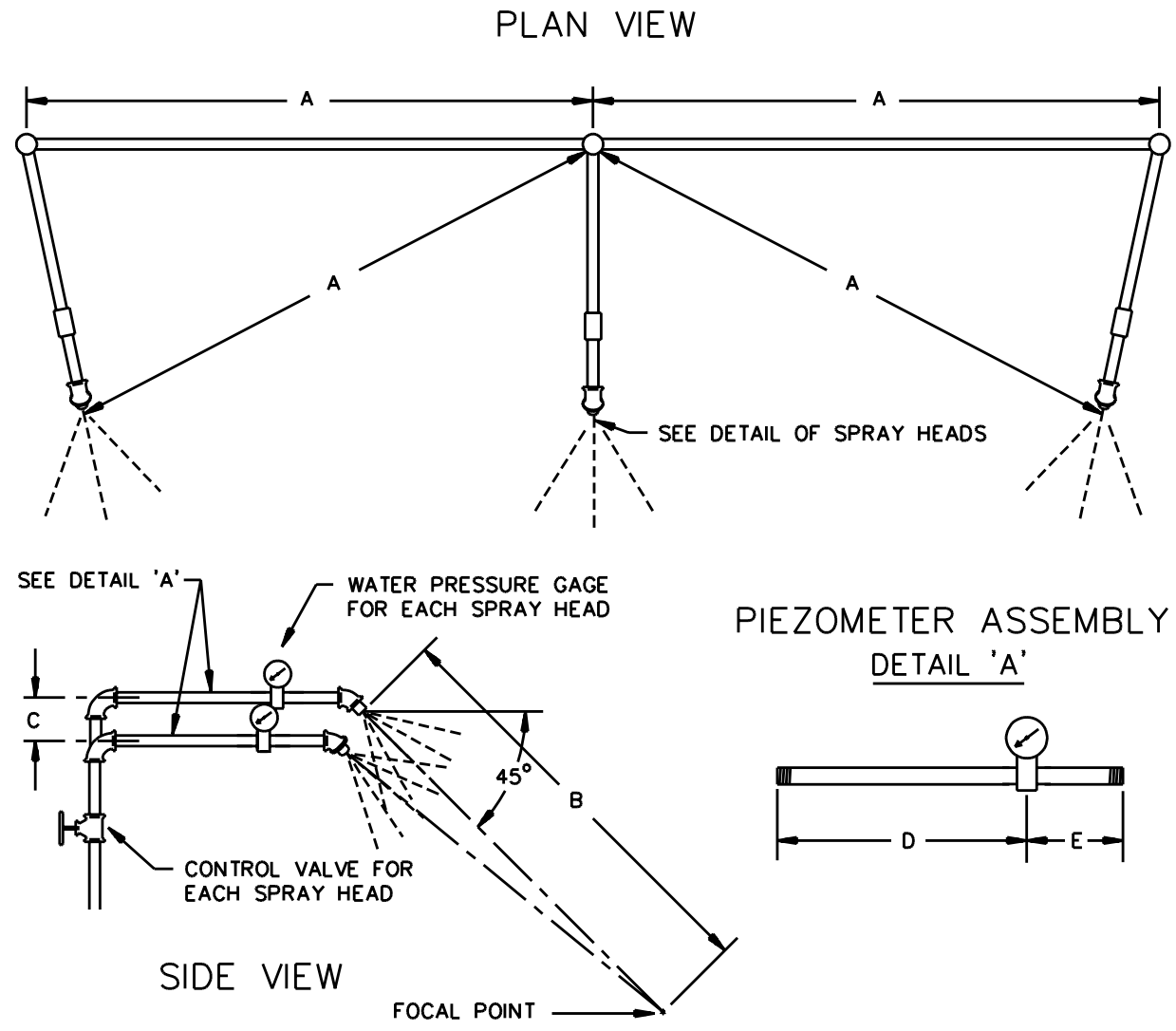
36.4 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 36.1. Spray heads are to be constructed in accordance with Figure 36.2. The water pressure for all tests is to be maintained at 5 psig (34.5 kPa) at each spray head. The test sample is to 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.

36.5 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.

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

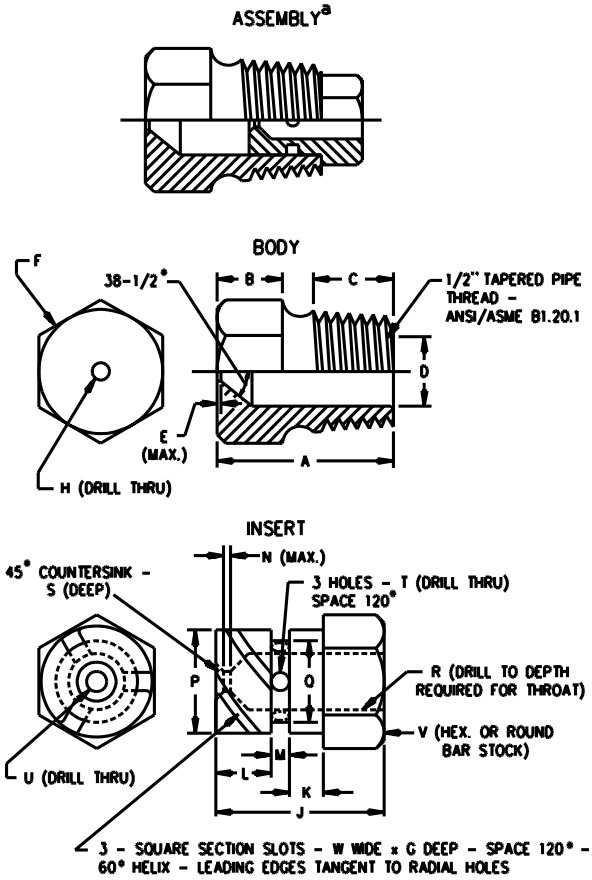
Figure 36.1
Rain-test spray piping



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

RT101E

Figure 36.2
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

37 Hosedown Test

37.1 An enclosure for a valve intended to be watertight (see 3.16) is to be subjected to the test specified in 37.2. No water shall enter the electrical enclosure.

37.2 A solid stream of water from a hose having a 1 inch (25.4 mm) diameter nozzle and a flow rate of at least 65 gallons per minute (246 l/m) is to be directed for 5 minutes over the entire surface of the enclosure from a distance of 10 – 12 feet (3.05 – 3.67 m).

38 Metallic Coating Thickness Test

38.1 The method of determining the thickness of a zinc or cadmium coating is described in 38.2 – 38.9.

38.2 The solution used for the test is to be made from distilled water and is to contain 200 grams per liter of American Chemical Society (ACS) reagent grade chromic acid (CrO_3) and 50 grams per liter of ACS reagent grade concentrated sulfuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of ACS reagent grade concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

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

38.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at an ambient temperature of 70 – 90°F (21 – 32°C).

38.5 Each sample is to be cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed using solvents. Samples are then to be rinsed in water and dried with clean cheesecloth. Care is to be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

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

38.7 The stopcock is to be opened and the time measured, in seconds, until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

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

38.9 To calculate the thickness of the coating being tested, select from Table 38.1 the thickness factor appropriate for the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as described in 38.7.

Table 38.1
Coating thickness factors

Temperature,		0.00001 inch (0.00025 mm) per second	
°F	(°C)	Cadmium platings	Zinc platings
70	21.1	1.331	0.980
71	21.7	1.340	0.990
72	22.2	1.352	1.000
73	22.8	1.362	1.010
74	23.3	1.372	1.015
75	23.9	1.383	1.025
76	24.4	1.395	1.033
77	25.0	1.405	1.042
78	25.6	1.416	1.050
79	26.1	1.427	1.060
80	26.7	1.438	1.070
81	27.2	1.450	1.080
82	27.8	1.460	1.085
83	28.3	1.470	1.095
84	28.9	1.480	1.100
85	29.4	1.490	1.110
86	30.0	1.501	1.120
87	30.6	1.513	1.130
88	31.1	1.524	1.141
89	31.7	1.534	1.150
90	32.2	1.546	1.160

39 Salt Spray Test

39.1 The Salt Spray Test referred to in 6.2.11 is to be conducted using the methods and apparatus described in the Standard Method of Salt Spray (Fog) Testing, ANSI/ASTM B117-97.

39.2 Comparative testing of corrosion resistant coatings is to be conducted on at least two samples of coated parts representative of all such parts used in an assembly and on at least two comparison samples of zinc-coated sheet steel conforming with the requirements in 6.2.9 or 13.6.5, whichever is applicable. Edges of samples that expose base material as the result of cutting to accommodate the test arrangement are to be covered with moisture-resistant tape or compound.

39.3 Samples are to be cleaned with soap and water, rinsed (metallic coatings are to be rinsed with alcohol), and dried before being placed in the corrosive media.

39.4 The apparatus for salt spray (fog) testing is to consist of:

a) A fog chamber,

b) A salt solution reservoir,

c) A supply of conditioned compressed air,

d) One dispersion tower constructed in accordance with ASTM B117-97 for producing a salt fog,

e) Specimen supports,

f) Provision for heating the chamber, and

g) Necessary means of control.

39.5 The dispersion tower for producing the salt fog is to be located in the center of the chamber and supplied with humidified air at a pressure of 17 – 19 psig (117 – 131 kPa) so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

39.6 The salt solution is to consist of 5 percent by weight of common salt (sodium chloride) in distilled water, and the pH value of the collected solution is to be between 6.5 and 7.2 with a specific gravity of 1.0255 – 1.0400 at 25°C (77°F). The temperature of the chamber is to be maintained at 35 ±1°C (95 ±2°F) throughout the test period.

39.7 The test specimens are to be suspended so that the principal surface being tested is at an angle of 15 degrees from the vertical.

39.8 Drops of solution that accumulate on the ceiling or cover of the chamber are to be diverted from dropping on the specimens, and drops of solution that fall from the specimens are not to be recirculated, but are to be removed by a drain located at the bottom of the apparatus.

39.9 Specimens are to be examined periodically during the tests for the appearance or progress of corrosion. The test chamber is to be operated throughout each day, except for the short time required for examination of the specimens on working days, and incidental maintenance. The specimens are not to be cleaned during the test.

39.10 These tests are to be continued until the coating under investigation or the zinc coating on the comparison specimens has deteriorated to the point that significant amounts of corrosion products are formed on the underlying steel or other material.

40 Immersion-Volume Change Test

40.1 The volume change test referred to in 6.2.4 shall comply with the volume change test described in the Standard for Gaskets and Seals, UL 157.

41 Immersion-Extraction Test

41.1 The immersion-extraction test referred to in 6.2.4 is to be conducted and shall comply with the Extraction Test described in the Standard for Gaskets and Seals, UL 157.

41.2 Deleted June 9, 2003

MANUFACTURING AND PRODUCTION TESTS

42 General

42.1 The manufacturer shall provide regular production control, inspection, and tests. The program shall include at least the following:

a) Seat leakage test on each safety valve at a pressure not less than the rated maximum operating pressure differential. A valve intended for use with liquids may be tested using either aerostatic or hydrostatic pressure.

b) External leakage test on each safety valve, and on each valve for use with flammable or hazardous fluids, at a pressure not less than the maximum rated pressure.

c) Operational test on each safety valve at maximum pressure differential designated for the valve.

d) Dielectric voltage-withstand test on each valve if required to comply with footnote a to Table 21.1.

42.1 revised December 28, 2001

42.2 Each valve intended for oxygen service shall be cleaned and free of oil, grease, or other foreign substances. See 5.1.7.

ELECTRICAL RATINGS

43 Details

43.1 An electric valve shall be rated in volts; and, as appropriate for the intended use, also in amperes, amperes resistive (or resistance only or noninductive), volt-amperes or watts, or any combination thereof. The rating shall indicate whether the valve is intended for use with DC or AC and, if for AC, the number of phases, and, if necessary, the frequency; except that a valve obviously intended for single-phase use only need not be marked with the phase rating.

43.2 A valve that incorporates a switch for the control of external loads shall indicate the rating of such a switching device in accordance with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873.

MARKINGS

44 Details

44.1 The following information shall appear on each valve, unless indicated otherwise.

a) The manufacturer's or private labeler's name or identifying symbol.

b) A distinctive catalog number or the equivalent.

c) The electrical rating. See 43.1 and 43.2.

d) The maximum rated pressure or the maximum operating pressure differential, if lower than the rated pressure, or both.

e) The type of valve, only if it is a safety valve as defined by these requirements. A safety valve may be identified using the term ″Safety Shutoff″ or the equivalent such as ″Safety,″ ″Shutoff,″ or ″Positive Shutoff.″ See 45.2.

f) The kind and the maximum temperature of fluid or fluids for which the valve is intended. See 44.3.

g) Any required reference to operating handles. See 5.2.7.

h) Any limitations for mounting, including use of dryseal pipe threads. See 7.1, 23.6, and 44.2.

i) The designation of wiring terminals or the provision of a wiring diagram to indicate the connections unless the correct wiring connections are plainly evident. See 14.3.9.

j) Any required statement concerning use of 75 or 90°C (167 or 194°F) supply connections. See 44.11 and 44.12.

k) Any elevated ambient temperature rating in excess of 25°C (77°F) and any low ambient temperature rating of less than 0°C (32°F). See 44.3.

l) Any applicable cautionary or warning statement required in 44.1 and 44.2.

m) Any marking required to identify a switch not intended for use as a safety switch. See 20.4.

n) The direction of flow. See 44.3.

o) The duty cycle, if intended for intermittent operation.

44.2 The markings required by 44.1 (e) and (h) and by 44.5 are not required if the catalog designation marked on the product identifies each kind of valve and the service for which it is intended, and any mounting limitations are included on an instruction sheet provided with each valve or on a printed tag wired to the assembly.

44.3 The markings required by 44.1 (f), (k), and (n) may be either:

a) Included as part of the valve marking or on a tag attached to the valve,

b) Shown on the smallest carton in which the valve is packaged, or

c) Included in installation instructions provided with each valve.

44.4 A valve that has been investigated for automotive use only shall be marked to so indicate.

44.5 A valve having an enclosure that has been investigated for use in wet locations shall be marked ″Rainproof Enclosure,″ ″Raintight Enclosure,″ or ″Watertight Enclosure,″ as appropriate. See 44.2.

44.6 A valve intended for use in the water circulating system of a swimming pool and similar applications shall be marked, ″Swimming Pool Valve″ or the equivalent.

44.7 A safety valve intended for use on a gas- or oil-fired heating appliance shall be marked with its maximum closing time if in excess of 1 second and if the valve is other than a direct acting solenoid type.

44.8 A valve that has been cleaned for oxygen service shall be marked to so indicate.

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44.9 All markings shall be legible and reasonably permanent. Except as noted in 44.13, markings shall be located so that they will be visible after installation of the valve. Markings shall be visible during the phase of installation, use, or inspection for which they are intended to apply. Markings of a cautionary nature or reflecting some special use or restriction shall be at least as prominent as the general or informational (for example, ratings) marking. The marking required by 44.8 may be included on a printed tag wired to the valve.

44.10 A low-voltage (0 – 30 volts) valve that is intended only to be wired in the field to an NEC Class 1 circuit or to an NEC Class 2 circuit wired with Class 1 wiring shall be marked accordingly. A low-voltage valve intended to be wired in the field to a Class 2 circuit only shall be marked accordingly. A low-voltage valve that is intended for connection to either a Class 1 or Class 2 circuit is not required to be so marked.

44.11 If, in accordance with note a to Table 25.1, the temperature within a terminal box or compartment of certain valves or the temperature of the wires intended for supply connections exceeds 60°C (140°F), the valve shall be marked with the following statement or the equivalent: ″FOR SUPPLY CONNECTIONS, USE WIRES SUITABLE FOR AT LEAST ____°C (____°F).″

44.12 The temperature value to be used in the statement in 44.11 shall be in accordance with Table 44.1.

Table 44.1
Temperature marking

Temperature attained during test at points within terminal box or compartment, or on wires intended for supply connections,		Temperature marking,	
°C	(°F)	°C	(°F)
61 – 75	142 – 167	75	167
76 – 90	169 – 194	90	194

44.13 Marking required by 44.10 – 44.12 need not be located on the outside of an enclosure, provided it is visible when the cover is removed after installation. A marking that is not visible unless the cover is removed is acceptable only if the installation wiring will not be disturbed by removing the cover.

44.14 If a manufacturer produces valves at more than one factory, each valve shall have a distinctive marking, to identify it as the product of a particular factory.

45 Cautionary Markings

45.1 If more than one disconnect switch may be required to disconnect all power within a valve assembly or compartment, the assembly or compartment shall be marked with the word ″CAUTION″ and the following or the equivalent: ″RISK OF ELECTRIC SHOCK – MORE THAN ONE DISCONNECT SWITCH MAY BE REQUIRED TO DE-ENERGIZE THE DEVICE FOR SERVICING.″

45.2 The marking required in 45.1 shall be in letters not less than 1/8 inch (3.2 mm) high and shall be in a permanent location on the outside of the valve or on a stationary (fixed, nonremovable) part inside the valve. This marking shall not be placed inside the cover or on the connection diagram attached to the inside of a cover.

46 Visibility and Permanence of Markings

46.1 General

46.1.1 A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped on etched metal that is permanently secured, indelibly stamped lettering, or printed on pressure-sensitive labels secured by adhesive. Such labels, upon investigation, shall be acceptable and appropriate for the application. Ordinary usage, handling, and the like, of the valve and the atmosphere in which it is used are considered in the determination of the permanence of the marking.

46.1.2 A cautionary marking intended to instruct the operator shall be legible and visible by the operator during the intended operation of the appliance. A marking that provides servicing instructions shall be legible and visible when such servicing is being performed.

46.1.3 To determine if a pressure-sensitive label, or a label secured by cement or adhesive, is of a permanent nature, representative samples are to be subjected to exposure conditions for indoor use (standard atmospheric, water immersion, and oven aging), or, if applicable, to exposure conditions for outdoor use (the above plus low temperature and ultraviolet light and water exposure), to determine compliance with the Standard for Marking and Labeling Systems, UL 969.

46.2 Unusual-condition exposure test

46.2.1 If a label is exposed to unusual conditions in service such as oils, detergents, or the like, representative samples are to be subjected to an additional immersion test. This test is to be conducted in the same manner as the immersion test described in UL 969 except that the samples are to be immersed in a representative solution of service, use, instead of in demineralized water. For exposure to detergents, the solution is to consist of a mixture of 25 grams of a commercial detergent per liter of water. Following the test, the labels shall comply with the Standard for Marking and Labeling Systems, UL 969.

SUPPLEMENT SA - MARINE USE ELECTRICALLY OPERATED SHUT-OFF VALVES FOR FLAMMABLE LIQUIDS

SA1 Scope

SA1.1 The requirements in this supplement cover electrically operated shut-off valves rated 50 volts or less intended to be used with flammable liquids on boats.

SA1.2 The products covered by the requirements in this supplement are intended for installation in accordance with the manufacturer's instructions and the applicable requirements of the National Fire Protection Association Standard for Pleasure and Commercial Motor Craft, NFPA 302; the applicable requirements of the American Boat and Yacht Council (ABYC); and the applicable requirements of the United States Coast Guard (USCG).

SA1.3 A product intended for marine use shall comply with the requirements in Sections 2 and 4 – 46, as applicable, except as modified or superseded by the requirements in this supplement.

SA2 Installation and Operating Instructions

SA2.1 The manufacturer shall provide complete installation and operating instructions with each valve. The instructions shall include recommendations relative to the use of thread compound, recommendations on proper wire size and fusing, mounting instructions and any other data necessary for the proper installation and operation of the valve.

SA2.2 The operating instruction shall specifically cover the operation of any manual by-pass valve and shall include the statement ″Caution – Risk of Fire,″ and the following or equivalent statement, ″The electric valve will not function as a shut-off valve with the by-pass open.″ In addition, the manufacturer shall provide the following operating data for gasoline, diesel oil, or other liquids for which the valve is intended to be used:

a) The maximum operating pressure.

b) The flow capacity in gallons per minute or hour, as related to the pressure differential or pressure differential or pressure drop between the inlet and outlet, for specific liquids.

SA3 General

SA3.1 A valve intended to be used in the fuel feed system to propulsion engines shall be equipped with a manual emergency by-pass.

SA3.2 A valve used in the fuel feed lines to non-vital equipment, such as heater, auxiliary generator, and the like, shall not incorporate a manual by-pass.

SA3.3 A diaphragm type valve shall be constructed so that a damaged diaphragm will not cause external leakage.

SA3.4 A valve shall be provided with means for mounting independent of the fuel line.

SA3.5 A valve shall be constructed so that it will unseat before the pressure on the valve outlet exceeds 1000 psi (6895 kPa) in order to prevent pressure from building up in trapped sections of the fuel line due to heat. See the Fire Test, Section SA11.

SA3.6 A valve shall be capable of operating in any orientation without leakage or malfunction.

SA4 Materials

SA4.1 A metallic alloy shall be galvanically compatible with parts of the fuel system.

SA4.2 A metallic part shall be free from porosity, sandholes, or other imperfections likely to result in leakage.

SA4.3 A metallic part shall be formed from AISI 300 or 400 Series stainless steel or other material having at least equivalent resistance to the corrosive effects of salt spray as determined by the Method of Salt Spray (Fog) Testing, ASTM B117-97.

SA5 Electrical Connections

SA5.1 An electrical connection for low-voltage DC circuits operating at less than 32 volts shall be made by means of a two prong plug, two insulated terminals, or by means of a pigtail for use with an external junction box or block.

SA5.2 Exposed uninsulated terminals shall not be used.

SA5.3 A pigtail lead, if used for field wiring, shall be at least No. 16 AWG (1.3 mm^2) stranded copper wire and no less than 8 inches (203 mm) in length.

SA5.4 An actuating coil shall be constructed for a two wire system without an electrical ground.

SA6 General

SA6.1 The same sample is to be used for the Vibration Test, the Shock Test, and the Ignition Protection Test, Sections SA7 – SA9, respectively.

SA6.2 The same sample used for the Chemical Resistance Test, Section SA10, is to be used for the Fire Test, Section SA11.

SA7 Vibration Test

SA7.1 A valve shall function as intended without increasing the risk of fire or explosion following the vibration conditioning specified in SA7.2 – SA7.4. There shall not be evidence of leakage, and there shall not be fluid flow due to vibration.

SA7.2 The valve specified in SA6.1, with tubing sections connected in accordance with the manufacturer's instructions, is to be rigidly mounted directly to the surface of a vibration table in its normal operating position. The valve is to be subjected to a pressure of 10 psi (69 kPa) on the valve inlet when the valve is closed during the conditioning.

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SA7.3 The assembly specified in SA7.2 is to be subjected to variable frequency vibration along each of three rectilinear orientation axes (horizontal, lateral, and vertical) for 4 hours in each plane (12 hours total) at a peak-to-peak amplitude of 0.060 ±0.001 inches (1.5 ±0.025 mm). The frequency of vibration is to continuously varied, at a uniform rate, from 10 to 60 to 10 Hz every 4 minutes.

SA7.4 During the first hour of conditioning in each separate plane, the valve is to be energized. The valve is to be unenergized during the last three hours of conditioning; except for the last ten minutes in which the valve is to be randomly cycled on and off to check for leakage.

SA8 Shock Test

SA8.1 The same valve used for the Vibration Test, Section SA7, shall function as intended without increasing the risk of fire or explosion following the conditioning specified in SA8.2 – SA8.4. There shall not be evidence of leakage and no fluid flow due to shock.

SA8.2 The valve is to be mounted on a shock machine in the same manner as described in SA7.2 including all connections. The sample is to be subjected to 5000 shock impacts of 10 g acceleration (98 m/s^2) and having a shock duration of 20 – 25 milliseconds as measured at the base of the half-sine shock envelope. The valve is to be subjected to a pressure of 10 psi (69 kPa) during the entire test.

SA8.3 The machine used for this conditioning is to be of the automatic cycling type capable of producing a half-sine shock pulse at the acceleration level and duration specified in SA8.2. The acceleration and shock pulse duration is to be measured by a piezoelectric accelerometer, or other measuring device with equivalent accuracy, mounted on the test machine platform on an axis parallel to the axis of motion.

SA8.4 The valve is to be mounted so that the center of gravity of the sample is as close as possible to the geometric center of the machine platform.

SA9 Ignition Protection Test

SA9.1 The same sample used for the Vibration Test, Section SA7, and the Shock Test, Section SA8, is to be used. A valve shall comply with the requirements in the Standard for Ignition-Protection Test for Marine Products, UL 1500, following this test.

SA10 Chemical Resistance Test

SA10.1 All gaskets and O-rings used in the construction of a valve shall not show evidence of swelling or deterioration when submerged, consecutively, for 24 hours in each of the following liquids:

a) N-heptane and

b) IRM Oil No. 903.

SA10.1 revised March 23, 1999

SA10.2 A different sample is to be used for this test.

SA11 Fire Test

SA11.1 The valve used in the Chemical Resistance Test, Section SA10, shall withstand a 2-1/2 minute fire exposure as described in SA11.2 – SA11.6 and shall not leak following this exposure after being subjected to a 3 foot (914 mm) hydrostatic head pressure for at least 30 seconds.

SA11.2 The test set-up is to be as illustrated in Figure SA11.1. The fuel pan is to be approximately 8-1/2 by 14 by 1-1/2 inches (216 by 356 by 38 mm). The fuel used in the plan is to be n-heptane. The fire chamber is illustrated in Figure SA11.2.

SA11.3 Two thermocouples are to be positioned in the same horizontal plane as the sample, and on a line 1/2 inch (12.7 mm) away from, and parallel with, the sample. The thermocouple tips are to be positioned 1 inch (25 mm) from the end of each fitting of the sample.

SA11.4 The supply tank valve is to be opened and the system bled of all air by allowing fuel to run through the system from the tank to the discharge valve. With the system full of fuel, the fuel level in the tank is to be adjusted to provide a 3 foot (914 mm) head of fuel, the discharge valve is to be shut off, and the fuel tank valve is to be left open. The fuel in the pan is to be ignited and allowed to burn for 2-1/2 minutes. During the burning period a temperature of 648 ±2°C (1200±4°F) is to be attained sometime during the test. If this temperature is not attained, the test is to be repeated with a new sample.

SA11.5 The temperatures are to be recorded at 15-second intervals. At the end of the 2-1/2-minute period, the fire is to be extinguished with CO_2. The sample is not to be disturbed.

SA11.6 Immediately after the fire is extinguished, the discharge valve is to be opened to allow the fuel to flow through the sample. When a steady stream of fuel is obtained, the discharge valve is to be closed placing the sample under a 3-foot (914-mm) head of fuel for 30 seconds. The fuel level at the tank is to be adjusted if necessary.

Figure SA11.1
Fire test set-up

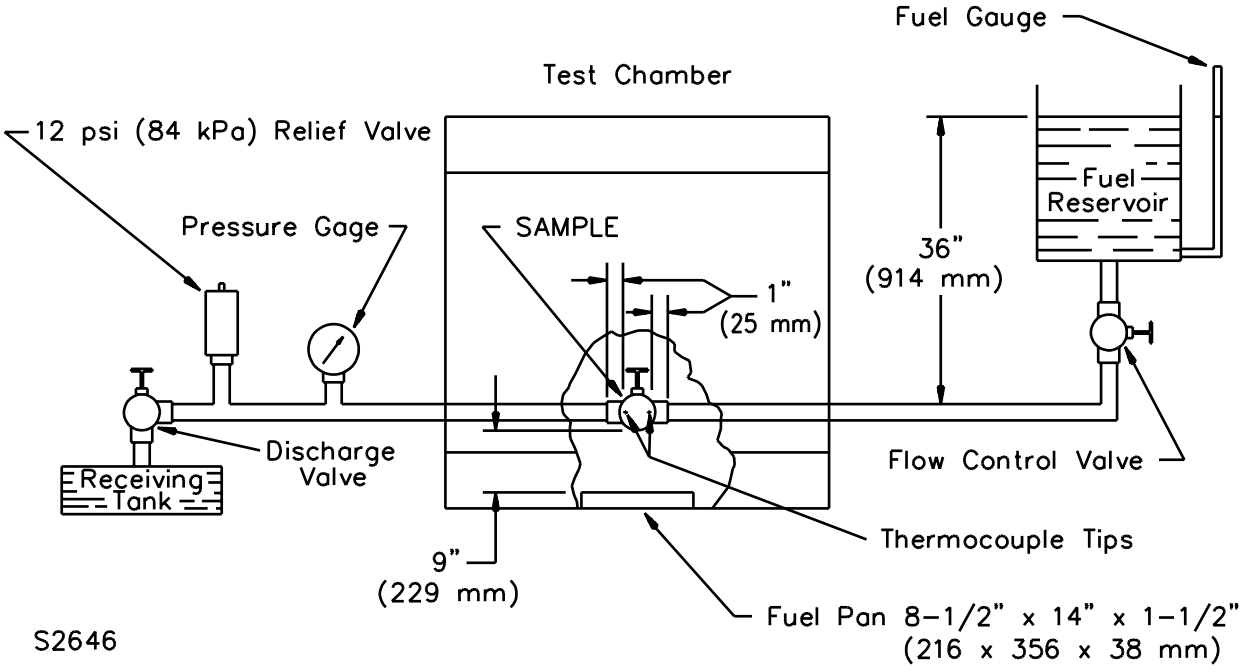
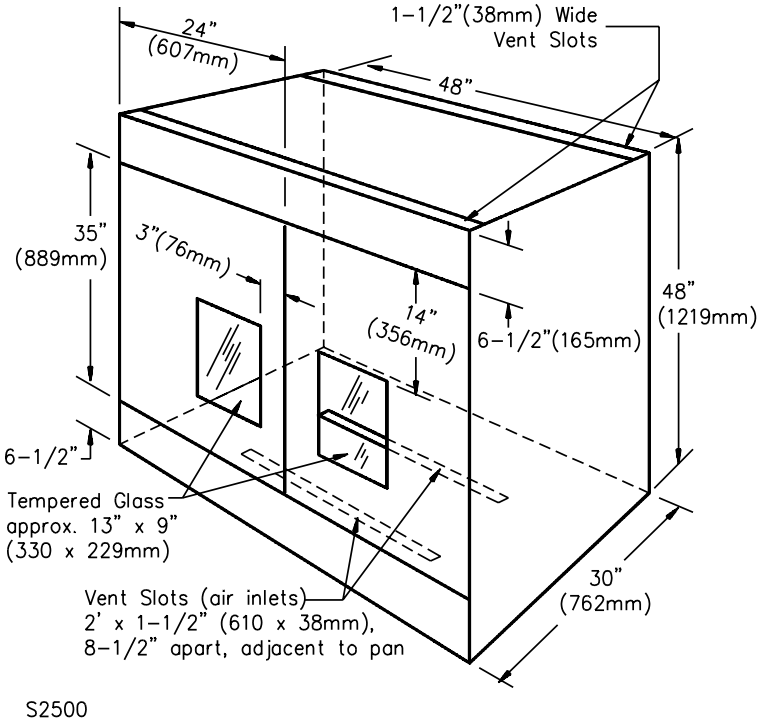


Figure SA11.2
Fire test chamber



SA12 Operation and Temperature Tests

SA12.1 Low temperature

SA12.1.1 Immediately following the low temperature conditioning specified in SA12.1.2, a valve shall operate as intended without increasing the risk of fire, and there shall not be leakage.

SA12.1.2 A valve is to be exposed to a temperature of minus 30 ±2°C (minus 22 ±4°F) for 50 hours. Immediately upon removal, the sample is to be dropped four times, using different orientations, from a height of 6 inches (152 mm) onto a rigid plywood surface.

SA12.2 Abnormal operation

SA12.2.1 The same valve used for the test specified in SA12.1.2 shall withstand 10,000 cycles of operation in accordance with SA12.2.2 – SA12.2.4 at an inlet pressure of 10 psi (69 kPa) with the valve closed. The valve is to be located in an ambient temperature of 50 ±2°C (122 ±4°F), there shall not be leakage, and a valve shall unseat before the pressure on the outlet exceeds 1000 psi (6895 kPa).

SA12.2.2 The valve is to be mounted in accordance with the manufacturer's installation instructions and electrically connected to an automatic switch set to cycle at a rate of not greater than 1 cycle every 2 seconds.

SA12.2.3 Thermocouples as specified in 25.15 are to be attached to the coil, the coil housing, and the valve body for recording temperatures during the test. Also, a means is to be provided to determine:

a) The pressure drop across the valve and

b) The fuel (such as Stoddard solvent) flow through the valve.

SA12.2.4 The valve is to be operated at 110 percent of the name plate rating. At the end of the cycling period, the valve is to stand unenergized for:

a) 16 hours while maintaining a pressure of 10 psi (69 kPa) at the intake for the first 8 hours and

b) The maximum rated pressure of the valve for the remaining 8 hours.

SA12.3 Normal operation

SA12.3.1 The same valve used for the tests in SA12.2.1 – SA12.2.4 is to be subjected to operation in accordance with SA12.3.2 and SA12.3.3 simulating an actual installation. The flow rate and pressure drop shall comply with the specifications provided by the manufacturer. Also the valve shall operate as intended without overloading the system fuel pump and no external temperature shall exceed 125 ±2°C (257 ±4°F). A manual by-pass valve, if provided, shall operate as intended following the test.

SA12.3.2 A fuel pump is to be connected on the outlet side of the valve, and the inlet is to be located approximately 6 inches (154 mm) above the supply tank level. The pump is to be located approximately 6 inches below the supply tank level and the test fluid (Stoddard) is to be at approximately 25°C (77°F).

SA12.3.3 The voltage is to be in accordance with the name plate rating.

SA13 Details

SA13.1 In addition to the marking specified in Section 44, the valve ports shall be marked ″in″ or ″inlet″ and ″out″ or ″outlet.″ Also, a valve that has been investigated for marine use shall be marked to so indicate.

SA13.2 A valve which complies with the Ignition Protection Test, Section SA9, shall be marked with the words ″Ignition Protected,″ or the equivalent.

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APPENDIX A

Standards for Components

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

Title of Standard − UL Standard Designation

Across-the-Line, Antenna-Coupling and Line-by-Pass Capacitors for Radio- and Television-Type Appliances – UL 1414
Attachment Plugs and Receptacles – UL 498
Capacitors – UL 810
Cord Sets and Power-Supply Cords – UL 817
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Fuses for Supplementary Overcurrent Protection – UL 198G
Grounding and Bonding Equipment – UL 467
Industrial Control Equipment – UL 508
Insulating Materials – General, Systems of – UL 1446
Marking and Labeling Systems – UL 969
Motor-Operated Appliances – UL 73
Motors, Electric – UL 1004
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Fabricated Parts – UL 746D
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed-Wiring Boards – UL 796
Protectors for Use in Electrical Equipment, Supplementary – UL 1077
Switches, Special-Use – UL 1054
Tape, Polyvinyl, Polyethylene Chloride, and Rubber Insulating – UL 510
Temperature-Indicating and -Regulating Equipment – UL 873
Terminal Blocks – UL 1059
Terminals, Electrical Quick-Connect – UL 310
Thermal Cutoffs for Use in Electrical Appliances and Components – UL 1020
Thermoset-Insulated Wires and Cables – UL 44
Time-Indicating and -Recording Appliances – UL 863
Transformers, Specialty – UL 506
Tubing, Bi-National Extruded – UL 224
Wire Connectors and Soldering Lugs for Use With Copper Conductors – UL 486A
Wire Connectors for Use with Aluminum Conductors – UL 486B
Wires and Cables, Thermoplastic-Insulated – UL 83

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