

UL 429

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Electrically Operated Valves

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UL Standard for Safety for Electrically Operated Valves, UL 429

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Revisions: This Standard contains revisions through and including May 9, 2006.

Summary of Topics

These editorial revisions to UL 429 replace all references to UL 1020, the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, with reference to UL 60691, the Standard for Thermal-Links – Requirements and Application Guide. UL 1020 was withdrawn and superseded by UL 60691.

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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 revisions dated May 9, 2006 include a reprinted title page (page1) for this Standard.

The revisions dated May 9, 2006 editorially replace all references to UL 1020 with the reference to UL 60691.

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

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net/ulforeword.html>

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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.

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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.

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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 RAIN-TIGHT 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 cm²) 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 inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Uncoated, inch (mm)	Metal coated, 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				Minimum thickness, inch (mm)	
Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)	Maximum width, ^b inches (cm)	Maximum length, ^c inches (cm)		
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	
	inch	(mm)	than the die-cast type,	(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

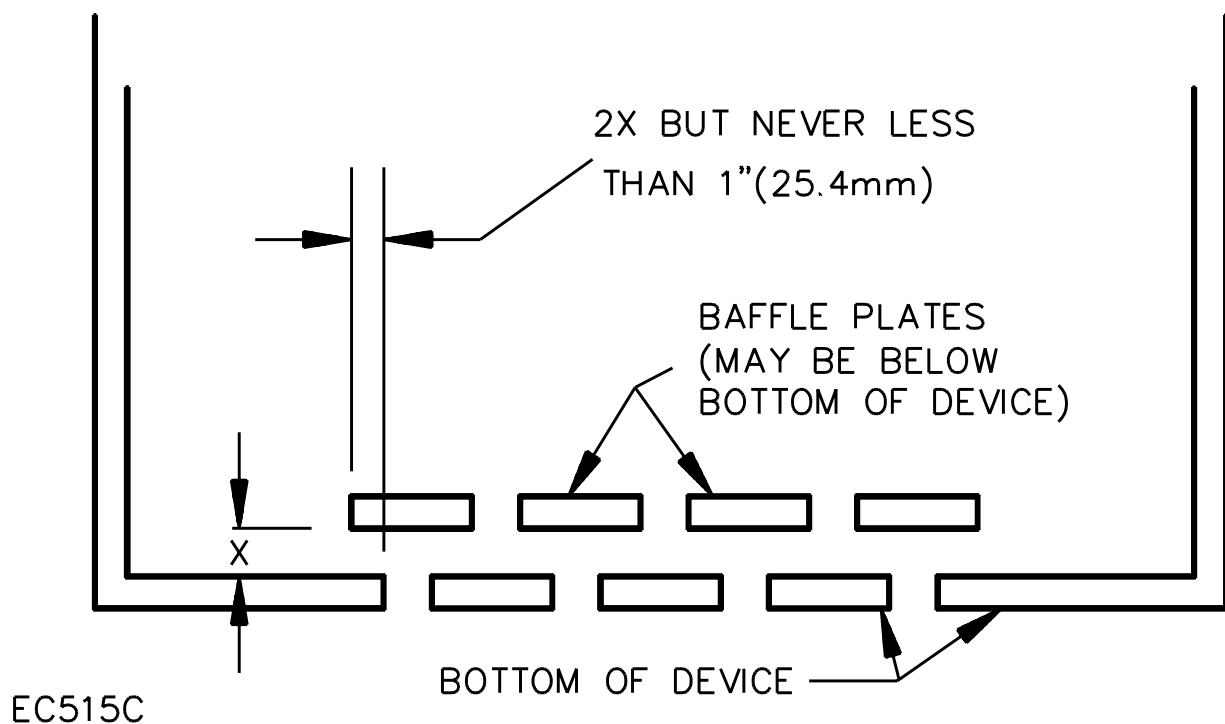
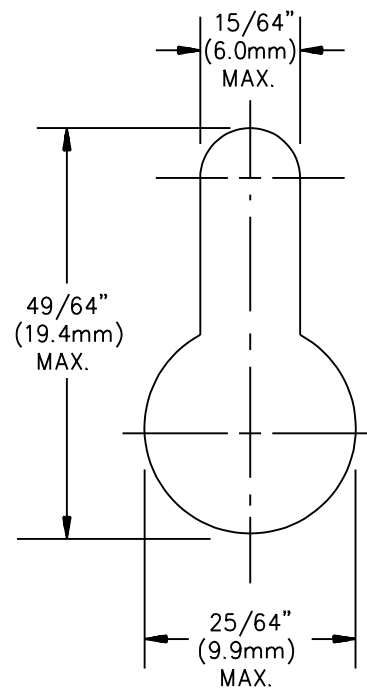


Figure 13.2
Keyhole slot



EC600

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.

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 mm²) if the screen openings are 1/2 square inch (3.23 cm²) or less in area, and not less than No. 12 AWG (3.3 mm²) 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 cm²) 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 cm²) 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).