

UL 295

Commercial-Industrial Gas Burners





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UL Standard for Safety for Commercial-Industrial Gas Burners, UL 295

First Edition, Dated December 7, 2007

Summary of Topics

This First Edition of the Standard for Commercial-Industrial Gas Burners, ANSI/UL 295 covers commercial-industrial burners with input ratings over 400,000 Btu per hour intended for installation in heating equipment.

The new requirements are substantially in accordance with UL's Proposal(s) on this subject dated March 9, 2007 and September 20, 2007.

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

Page	Date
1-94	December 7, 2007
A1-A2	December 7, 2007

DECEMBER 7, 2007



ANSI/UL 295-2007

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UL 295

Standard for Commercial-Industrial Gas Burners

First Edition

December 7, 2007

The most recent designation of ANSI/UL 295 as an American National Standard (ANSI) occurred on December 4, 2007. The ANSI approval for this standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

This ANSI/UL Standard for Safety consists of the First Edition.

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INTRODUCTION

1 Scope

1.1 These requirements cover commercial-industrial gas burners with input ratings over 400,000 Btu per hour (117.23 kW) intended for installation in heating equipment such as, but not limited to, appliances, furnaces, heaters, ovens, water heaters, and incinerators. These gas burners are required to be equipped with integral automatic primary safety controls to restrict the abnormal flow of gaseous fuel in case of ignition failure and/or flame failure.

1.2 Additional installation and operation requirements are available for commercial-industrial gas burners, as defined by the National Fuel Gas Code, NFPA 54 and by the Liquefied Petroleum Gas Code, NFPA 58, as applicable.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.2 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.

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

2.4 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.

3 Units of Measurements

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

4 Undated References

4.1 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.

5 Glossary

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

5.2 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary or secondary air.

5.3 AIR SHUTTER, AUTOMATICALLY OPERATED – An air shutter operated by an automatic control.

5.4 ALUMINUM-COATED STEEL – An aluminum coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy.

5.5 BURNER, GAS – A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

5.6 BURNER, AUTOMATICALLY LIGHTED – One where fuel to the main burner is normally turned on and ignited automatically.

5.7 BURNER, MANUALLY LIGHTED – One where fuel to the main burner is turned on only by hand and ignited under supervision.

5.8 BURNER, MECHANICAL-DRAFT – A burner that includes a power-driven fan, blower, or other mechanism as the principal means for supplying air for combustion.

5.9 BURNER, NATURAL-DRAFT – A burner that depends principally upon the natural draft created in the flue to induce into the burner the air required for combustion.

5.10 BURNER HEAD – That portion of a burner beyond the outlet end of the mixer tube which contains the ports.

5.11 COMBUSTIBLE AND NON-COMBUSTIBLE – Refer to the Standard Glossary of Terms Relating to Chimneys, Vents, and Heat-Producing Appliances, ANSI/NFPA 97.

5.12 COMBUSTIBLE MATERIAL – Combustible material as pertaining to materials adjacent to or in contact with heat-producing appliances, chimney connectors and vent connectors, steam and hot water pipes, refers to material made of or surfaced with wood, compressed paper, plant fibers, or other material that will ignite and burn. Such material shall be considered as combustible even through flameproofed, fire-retardant treated, or plastered.

5.13 COMBUSTION – As used herein, the rapid oxidation of fuel accompanied by the production of heat, or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen.

5.14 COMBUSTION CHAMBER – The portion of an appliance within which combustion occurs.

5.15 COMBUSTION DETECTOR – That part of a primary safety control which is responsive directly to flame properties.

5.16 COMBUSTION PRODUCTS – Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inerts, but excluding excess air.

5.17 CONDENSATE – The liquid which separates from a gas, including flue gases, due to a reduction in temperature.

5.18 CONTROL – A device designed to regulate the fuel, air, water, or electrical supply to the controlled equipment. It may be automatic, semiautomatic, or manual.

5.19 CONTROL, LIMIT – An automatic safety control, responsive to changes in liquid level, pressure, or temperature, for limiting the operation of the controlled equipment.

5.20 CONTROL, OPERATING – A control other than a safety control or interlock, to start or regulate burner firing according to load demand and to stop or regulate fire on satisfaction of demand or upon reaching normal temperature or pressure in the device being fired. Operating controls may also actuate auxiliary equipment.

5.21 CONTROL, PRIMARY SAFETY – An automatic control that monitors the operation of a gas-fired or an oil-fired burner. It normally consists of the following sections that may be integrated into a common unit or may be separate units, interconnected by wiring:

a) A device that programs the burner through start-up and shutdown operations in response to signals from regulating, limiting, and monitoring devices. It also provides the necessary timings, in proper sequence, for purging, pilot flame ignition, main flame ignition, and in case of ignition or flame failure, for safety shutdown (lockout).

b) A device that is responsive to flame properties. It monitors the flame at the point of flame supervision and transmits a signal to the programming unit, indicating absence or presence of flame.

5.22 CONTROL, SAFETY – Automatic controls, including relays, switches, and other auxiliary equipment used in conjunction therewith to form a safety control system, that is intended to reduce the risk of fire, electric shock, or injury to persons during operation of the controlled equipment.

5.23 DAMPER – A valve or plate for regulating draft or flow of flue gases. A damper is generally considered as being located on the downstream side of the combustion chamber, usually in a flue passage of the appliance or in the chimney connector.

5.24 DAMPER, AUTOMATICALLY OPERATED – A damper operated by an automatic control.

5.25 ELECTRICAL CIRCUITS:

a) 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.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating-current (42.4 volts peak) or direct current and supplied by:

1) A Class 2 transformer, or by a battery, by a battery and fixed impedance, or by a transformer and fixed impedance each of which, as a unit is in compliance with what is required for a Class 2 transformer; or

2) Is limited to a maximum of 100 volt-amperes. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

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

5.26 EXCESS AIR – Air which passes through the combustion area and the appliance flues in excess of that which is theoretically required for complete combustion.

5.27 FLAME FAILURE REACTION TIME – The interval between the occurrence of flame extinguishment and de-energizing the safety shutoff means.

5.28 HEATING SURFACES – All surfaces which transmit heat directly from flame or flue gases to the medium to be heated.

5.29 IGNITION, CONTINUOUS – Ignition by an energy source which is continuously maintained throughout the time the burner is in service, whether the main burner is firing or not.

5.30 IGNITION, INTERMITTENT – Ignition by an energy source which is continuously maintained throughout the time the burner is firing.

5.31 IGNITION, INTERRUPTED – Ignition by an energy source which is automatically energized each time the main burner is fired and subsequently is automatically shut off during the firing cycle.

5.32 IGNITION, MANUAL – Ignition by an energy source that is manually energized and where the fuel to the pilot is lighted automatically when the ignition system is energized.

5.33 INTERLOCK – A control to prove the physical state of a required condition, and to furnish that proof to the primary safety control circuit.

5.34 LIQUEFIED-PETROLEUM GAS – Fuel gases, including commercial propane, predominantly propane or propylene or commercial butane, predominantly butane, isobutane, and/or butylene.

5.35 LOW-FIRE HOLD INTERLOCK – A control other than an operating or safety control or interlock, responsive to changes in temperature, to retain the burner at low fire until such time as the heating appliance has obtained the normal minimum operating temperature .

5.36 LP-GAS AIR MIXTURE – Liquefied-petroleum gases distributed at relatively low pressures and normal atmospheric temperatures which have been diluted with air to produce desired heating value and utilization characteristics.

5.37 MAIN BURNER FLAME-ESTABLISHING PERIOD – The interval of time the main burner fuel safety shutoff valves are permitted to be open before the primary safety control is required to supervise the main burner flame.

5.38 MANIFOLD – The conduit of a device which supplies gas to the individual burner.

5.39 MIXER, GAS – The combination of mixer head, mixer throat, and mixer tube.

a) That portion of an injection type burner, usually enlarged, into which primary air flows to mix with the gas stream.

b) That portion of the mixer which has the smallest cross-sectional area and which lies between the mixer head and the mixer tube.

c) That portion of the mixer which lies between the throat and the burner head.

5.40 MIXER FACE, GAS – The air inlet end of the mixer head.

5.41 NORMAL CARE – The periodic tasks usually performed to operate and maintain an appliance, such as air, fuel, pressure, and temperature regulation, cleaning, lubrication, resetting of controls.

5.42 PILOT – A flame that is utilized to ignite the fuel at the main burner or burners.

5.43 PILOT FLAME-ESTABLISHING PERIOD – The interval of time fuel is permitted to be delivered to a proved pilot before the primary safety control is required to detect pilot flame.

5.44 PILOT, INTERMITTENT – A pilot which is automatically lighted each time there is a call for heat and which burns during the entire period that the main burner is firing.

5.45 PILOT, INTERRUPTED – A pilot which is automatically lighted each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.

5.46 PILOT, PROVED – A pilot flame supervised by a primary safety control which senses the presence of the pilot flame prior to permitting the main burner fuel to be delivered for combustion.

5.47 PORT – Any opening in a burner head through which fuel or an air-fuel mixture is discharged for ignition.

5.48 PROOF OF CLOSURE SWITCH – A non-field adjustable switch installed in a safety shutoff valve by its manufacturer that activates only after the valve is fully closed.

5.49 PRIMARY AIR – The air introduced into a burner which mixes with the fuel before it reaches the ignition zone.

5.50 PURGE PERIOD – The period of time during the burner start-up in which air is introduced into the combustion chamber and the associated flue passages in such volume and manner as to completely replace the air or fuel-air mixture contained therein prior to initiating ignition.

5.51 PURGE – To introduce air into the combustion chamber and the device flue passages in such volume and manner as to completely replace the air or gas-air mixture contained therein.

5.52 READILY ACCESSIBLE – Capable of being reached easily and quickly for operation, adjustment, and inspection.

5.53 REGULATOR, GAS-PRESSURE – A device for controlling and maintaining a uniform outlet gas pressure.

5.54 SAFETY SHUTDOWN (LOCKOUT) – The action of shutting off of all fuel and ignition energy to the device by means of a safety control or controls such that restart cannot be accomplished without a manual reset.

5.55 SECONDARY AIR – The air externally supplied to the flame at or beyond the point of ignition.

5.56 **SERVICING** – The periodic tasks usually performed to operate and maintain an appliance, such as air, fuel, pressure, and temperature regulation, cleaning, lubrication, and resetting of controls. Repair and replacement of parts other than those expected to be renewed periodically is not considered to be servicing. Some examples of servicing are:

- a) Cleaning or replacing nozzles, atomizers, and pilots.
- b) Setting ignition electrodes.
- c) Cleaning strainers or replacing strainer or filter element.
- d) Resetting safety control.
- e) Replacing igniter cable.

5.57 **SPECIAL TOOLS** – Those tools that are not available on the open retail market.

5.58 **TRIAL-FOR-IGNITION PERIOD** – That period of time the main burner fuel is permitted to be delivered into the ignition zone before the main flame-sensing device is required to detect main flame.

5.59 **VALVE, MANUAL GAS SHUTOFF** – A manually operated valve in a gas line for the purpose of completely turning on or shutting off the gas supply.

5.60 **VALVE, SAFETY SHUTOFF** – A valve that is automatically closed by the safety control system or by an emergency device. Such valve may be of the automatic or manually opened type.

CONSTRUCTION

6 General

6.1 Fuel confining parts, or operating parts if failure of the part will allow unsafe leakage of fuel, or unsafe operation, or prevent a safety device from functioning, shall be of sufficient strength, durability, and resistance to fire to insure safe and reliable service of the parts and the assembly. Such parts shall be made of material having a melting point (solidus temperature) of not less than 950°F (510°C) and a tensile strength of not less than 10,000 psi at 400°F (204°C). Such parts shall not sag, distort, melt, oxidize, or show leakage of fuel during any of the tests specified herein.

6.2 Fuel-confining parts not conforming to 6.1 may be employed if a fusible-link valve or the equivalent is included in the assembly of the burner so as to shut off the fuel supply in the event of excessive temperature or fire in the vicinity of such parts.

6.3 Soft solder shall not be used on any fuel-handling parts if melting of the solder may allow leakage of fuel. Soft-soldered joints, where permitted, shall be made mechanically secure before soldering.

6.4 The burner shall function so as to reduce to a minimum the generation of unburned vapors, and shall not include chambers or pockets in which unburned vapors may accumulate.

6.5 Electrical equipment and wiring shall be arranged so that oil or water will not drip or run on them during normal usage or from a connection required to be uncoupled for servicing the device also to avoid contact with water from humidifiers.

6.6 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may result in operation of the equipment in a manner that involves a risk of fire, electric shock, or injury to persons.

6.7 The gas burner shall be constructed such that supervised firing with operation as specified in 45.3, as appropriate, may be accomplished without further adjustment.

7 Corrosion Protection

7.1 Iron and steel parts shall be protected against corrosion by painting, galvanizing, plating or other equivalent means if the malfunction of such unprotected part would be likely to result in a hazardous condition.

Exception: Cast-iron parts, cast-aluminum parts and ASME coded pressure vessels are not required to be protected against corrosion.

8 Protection of Users and Service Personnel

8.1 An uninsulated high-voltage live part and a moving part that may involve a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by personnel performing service functions that may have to be performed with the equipment energized.

Exception: A moving part is not required to comply with 8.1 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

8.2 Service functions which may have to be performed with the equipment energized include:

- a) Adjusting the setting of temperature controls with or without marked dial settings;
- b) Resetting control trip mechanism;
- c) Operating manual switches; or
- d) Adjusting air-flow dampers.

A factory set and sealed control is not considered to be adjustable.

8.3 The requirements of 8.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

8.4 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated live parts, so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts or moving parts that may involve a risk of injury to persons are:

- a) Not located in front, in the direction of access, of the mechanism; and
- b) Are not located within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

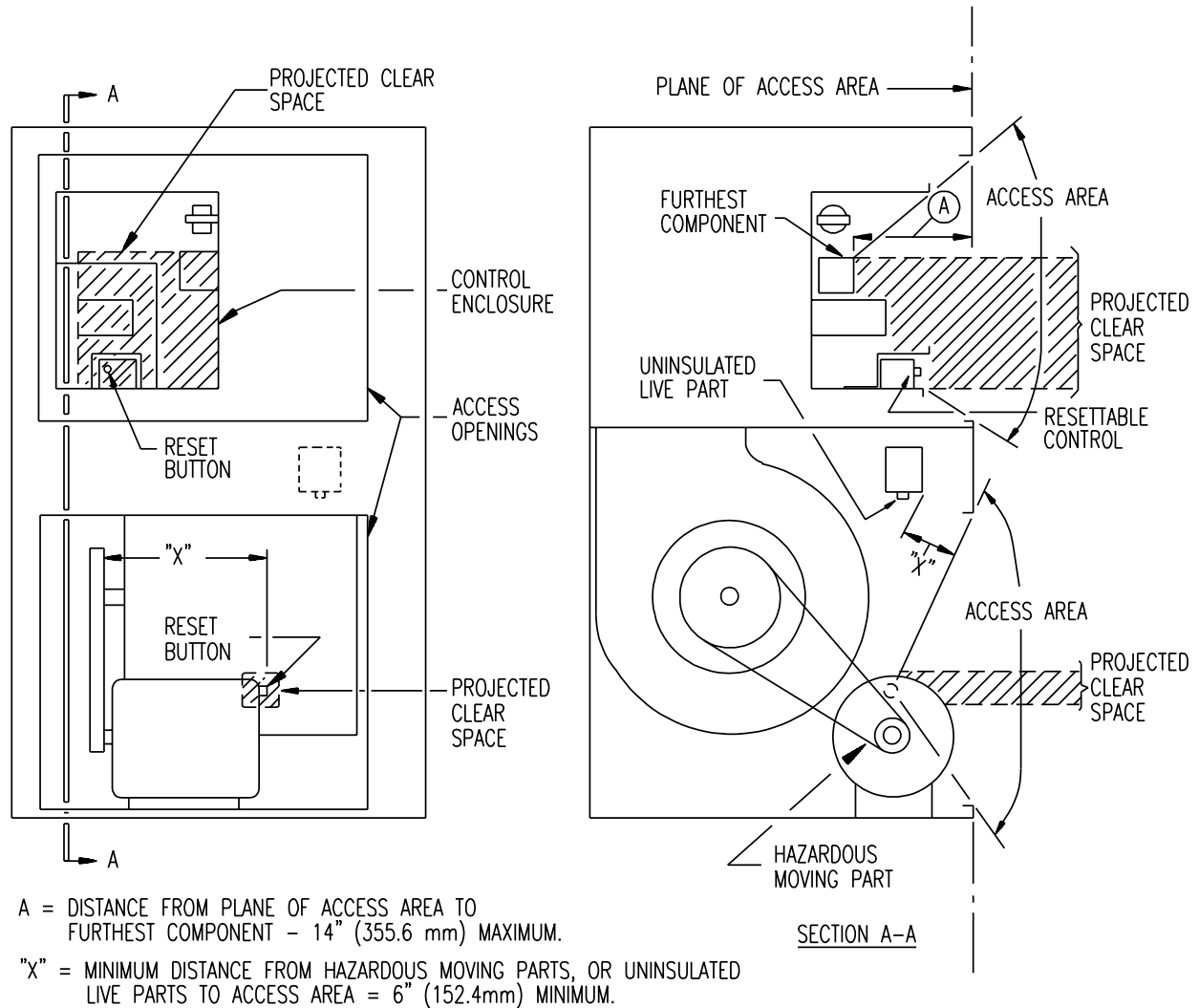
8.5 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized, not including voltage measurements, shall be located and mounted with respect to other components and grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to a risk of electric shock from adjacent uninsulated live parts or to unintentional contact from adjacent moving parts that may involve a risk of injury to persons.

8.6 Accessibility and protection from a risk of fire, electric shock, or injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through the access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement:

- a) The components are located with respect to the access opening in the cabinet so that the farthest component in the control assembly is not more than 14 inches (356 mm) from the plane of the access opening.
- b) Uninsulated live parts outside the control assembly projected clear space (except for live parts within a control panel) or unguarded moving parts that may involve a risk of injury to persons are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.
- c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet (within the access area is completely free of obstructions, including wiring.
- d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.
- e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:
 - 1) There is unimpeded access to these components through the access opening in the outer cabinet; and
 - 2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Also see Figure 8.1.

Figure 8.1
Accessibility and protection



8.7 Components in a low-voltage circuit shall comply with the requirements of 8.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

8.8 The following are not considered to be uninsulated live parts:

- a) Coils of controllers;
- b) Relays and solenoids;
- c) Transformer windings, if the coils and windings are provided with insulating overwraps;
- d) Enclosed motor windings;
- e) Insulated terminals and splices; and
- f) Insulated wires.

8.9 Moving parts such as fan blades, blower wheels, pulleys, belts, and the like, which may cause injury shall be enclosed or guarded. If the removal of doors, panels or shields will expose such moving parts;

- a) The opening or removal of the door, panel or shield shall require the use of tools; or
- b) An interlocking device shall shut off the mechanism; or
- c) The door, panel, or shield shall be marked in accordance with 62.19.

Exception: A moving part is not required to comply with 8.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

8.10 The distance from an opening in a required guard or enclosure to the moving part mentioned in 8.9 shall be in accordance with Table 8.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 8.1
Dimensions of openings

Minor dimensions of opening,		Minimum distance from opening to moving part,	
inches ^a	(mm)	inches ^a	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)
2	(50.8)	14-1/2	(369)
over 2	(over 50.8)	30	(762)

^a Openings less than 1/4 inch (6.4 mm) are not to be considered.

9 Enclosures

9.1 General

9.1.1 Uninsulated live high-voltage parts shall be enclosed or guarded to prevent unintentional contact by persons during normal use of the appliance. This applies to such parts located in a compartment where access is required for normal care of the appliance, such as resetting controls, replacing filters, lubrication, cleaning, and the like.

9.1.2 Among the factors taken into consideration when judging the acceptability of an enclosure are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Combustibility;
- e) Resistance to corrosion; and
- f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging according to the requirements in the Standard for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C.

9.1.3 The enclosure shall reduce the likelihood of the emission of molten metal, burning insulation, flaming particles, or the like through openings onto combustible material, including the surface on which the equipment is mounted.

9.1.4 Where the design and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 9.1 or 9.2 whichever applies, may be employed.

9.1.5 Electrical parts within the outer cabinet need not be individually enclosed if the assembly conforms with all of the following:

- a) Their design and location with respect to openings in the outer cabinet will not result in the emission of flame or molten metal through openings in the cabinet or if it can be shown that failure of the component would not result in a risk of fire;
- b) There are no openings in the bottom of the compartment in which the part is located which would permit dropping of molten metal, and the like, onto combustible material;
- c) The part is not in proximity to combustible material other than electrical insulation;
- d) The part is not located closer than 5 inches to the outer cabinet unless the thickness of sheet metal is in compliance with Table 9.1;
- e) The part is not located in an air-handling compartment;
- f) The thickness of the outer cabinet is not less than two-gage thicknesses thinner than indicated in Table 9.1 for the maximum dimensions of the cabinet enclosure.
- g) The part is not subject to unintentional contact by persons. See Protection of Users and Service Personnel, Section 8.

9.1.6 The requirements of 9.1.5 apply only to parts of high-voltage circuits as defined by 5.30.

9.1.7 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 9.1.3.

9.1.8 Cabinet compartments housing gas piping and controls shall be ventilated.

9.1.9 Steel enclosures shall be protected against corrosion by painting, plating, or equivalent means.

9.1.10 The thickness of a sheet metal enclosure shall be as indicated in Tables 9.1 and 9.2.

Exception: When the design and location of components and the strength and rigidity of the outer cabinet warrant, an individual enclosure thinner than specified in Tables 9.1 and 9.2 is able to be employed.

Table 9.1
Minimum thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing		Minimum thickness, inches (mm)	
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length	Uncoated	Metal coated
inches (cm)	inches (cm)	inches (cm)	inches (cm)	(MSG)	(GSG)
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 (0.51)	0.023 (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	(24)	(24)
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 (0.66)	0.029 (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)	(22)	(22)
8.0 (20.4)	Not limited	12.0 (30.5)	Not limited	0.32 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)	(20)	(20)
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)	(18)	(18)
18.0 (45.7)	Not limited	33.0 (83.8)	Not limited	0.060 (1.53)	0.063 (1.61)
25.0 (63.5)	31.0 (78.7)	35.0 (89.0)	43.0 (109.2)	(15)	(15)
25.0 (63.4)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.0)	51.0 (129.5)	(14)	(14)
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.04)	0.084 (2.13)
35.0 (89.0)	47.0 (119.4)	54.0 (137.1)	66.0 (167.6)	(13)	(13)
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
42.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)	(12)	(12)
52.0 (135.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.80)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)	(11)	(11)
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)	(10)	(10)

^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 essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is a rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 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, e.g., side panels of boxes, the length of the unsupported side shall be lifted to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

Table 9.2
Minimum thickness of sheet metal for enclosures - aluminum, copper, or brass

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width ^b 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	(0.58)
3.5 (8.9)	4.0 (10.2)	8.5 (21.6)	9.5 (24.1)	(22)	
4.0 (10.2)	Not limited	10.0 (25.4)	Not limited	0.029	(0.74)
5.0 (12.7)	6.0 (15.2)	10.5 (26.7)	13.5 (34.3)	(20)	
6.0 (15.2)	Not limited	14.0 (35.6)	Not limited	0.036	(0.91)
6.5 (16.5)	8.0 (20.3)	15.0 (38.1)	18.0 (45.7)	(18)	
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)	(16)	
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)	(14)	
18.0 (45.7)	Not limited	42.0 (106.7)	Not limited	0.075	(1.91)
20.0 (50.8)	25.0 (63.4)	45.0 (114.3)	55.0 (139.7)	(12)	
25.0 (63.4)	Not limited	60.0 (152.4)	Not limited	0.095	(2.41)
29.0 (73.7)	36.0 (91.4)	64.0 (162.6)	78.0 (198.1)	(10)	
37.0 (94.0)	Not limited	87.0 (221.0)	Not limited	0.122	(3.10)
42.0 (106.7)	53.0 (134.6)	93.0 (236.2)	114.0 (289.6)	(8)	
52.0 (132.1)	Not limited	123.0 (312.4)	Not limited	0.153	(3.89)
60.0 (152.4)	74.0 (188.0)	130.0 (330.2)	160.0 (406.4)	(6)	

^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 essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 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, such as, 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.

9.1.11 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) (No. 20 MSG) if uncoated steel, not less than 0.034 inch (0.86 mm) (No. 20 GSG) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

9.1.12 If insulating material other than electrical insulation is provided within the enclosure, consideration is given to the burning characteristics and combustibility of the material and the proximity of an ignition source.

9.1.13 Terminal housings of motors, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, NFPA 70.

9.1.14 A junction box partially formed by another part such as a fan scroll or a motor casing is to fit such that:

- a) An opening between the box and motor frame having a dimension exceeding 1/2 inch (12.7 mm) does not permit a flat feeler gauge, 5/64 by 1/2 inch (2.0 by 12.7 mm) wide to enter; and
- b) An opening between the box and motor frame having no dimension exceeding 1/2 inch (12.7 mm) does not permit the entrance of a 13/64 inch (5.2 mm) diameter rod.

9.1.15 The criteria for judging an opening in an electrical enclosure are given in the following items and the related figures:

- a) An opening that will not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:
 - 1) A probe, as illustrated in 9.1, cannot be made to touch any uninsulated live part when inserted through the opening; and
 - 2) A probe, as illustrated in 9.1, cannot be made to touch enamel insulated wire when inserted through the opening.
- b) An opening that will permit entrance of a 3/4 inch diameter rod is acceptable under the conditions described in Doors and covers, Section 9.3.

9.1.16 During the examination for conformance with the requirements in 9.1.15, a part of the enclosure, which may be removed with the use of tools is to be removed.

9.2 Accessibility of uninsulated live parts and film-coated wire - general

9.2.1 During the examination of a product to determine whether it complies with the requirements concerning accessibility of uninsulated live parts and film-coated wire:

- a) A part of the enclosure that may be opened or removed by the user without using a tool, (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed;
- b) Insulated brush caps are not required to be additionally enclosed;
- c) The probes shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure; and
- d) The probes shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

9.2.2 The criteria for judging an opening in an electrical enclosure are given in (a) – (b) and the related figures:

- a) An opening that will not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:
 - 1) A probe as illustrated in 9.1 cannot be made to touch any uninsulated live part when inserted through the opening; and
 - 2) A probe as illustrated in 9.2 cannot be made to touch film-coated wire when inserted through the opening.
- b) An opening that will permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Doors and covers, Section 9.3.

Figure 9.1
Probe for uninsulated live metal parts

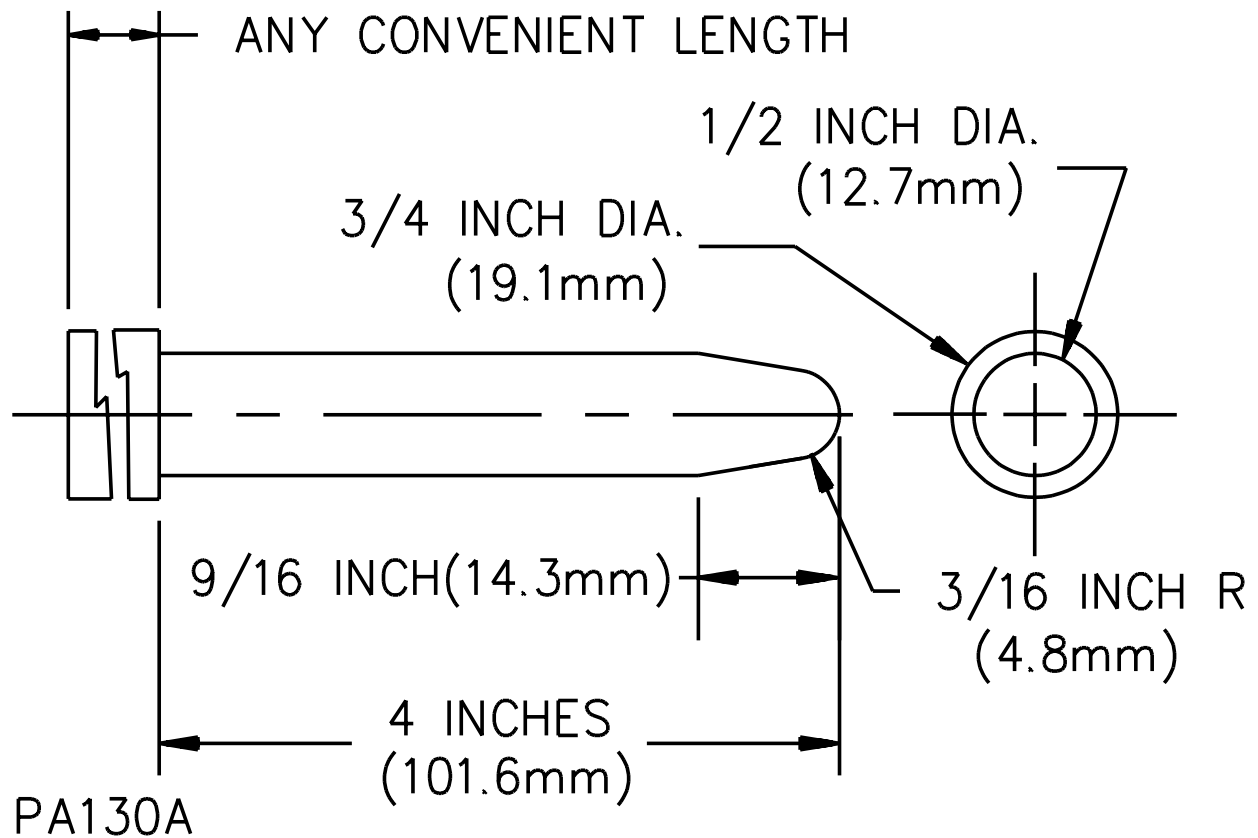


Figure 9.2
Probe for film-coated wire

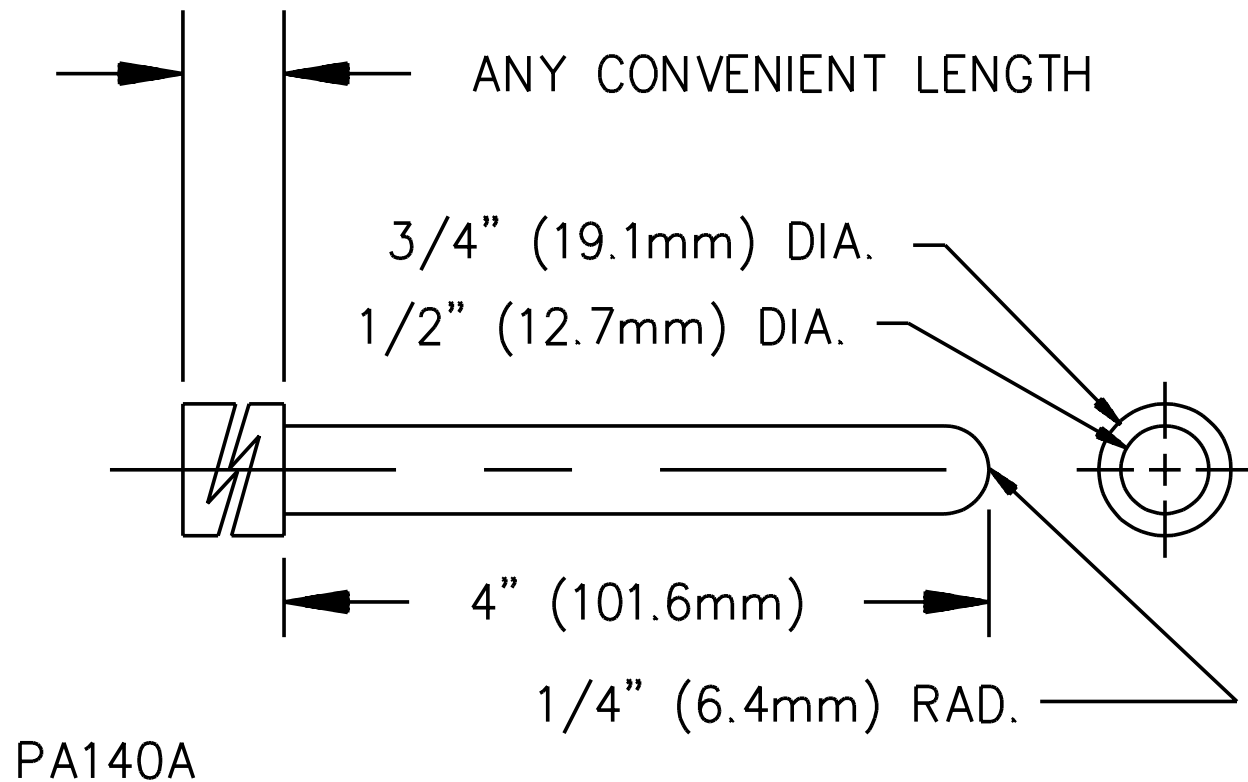
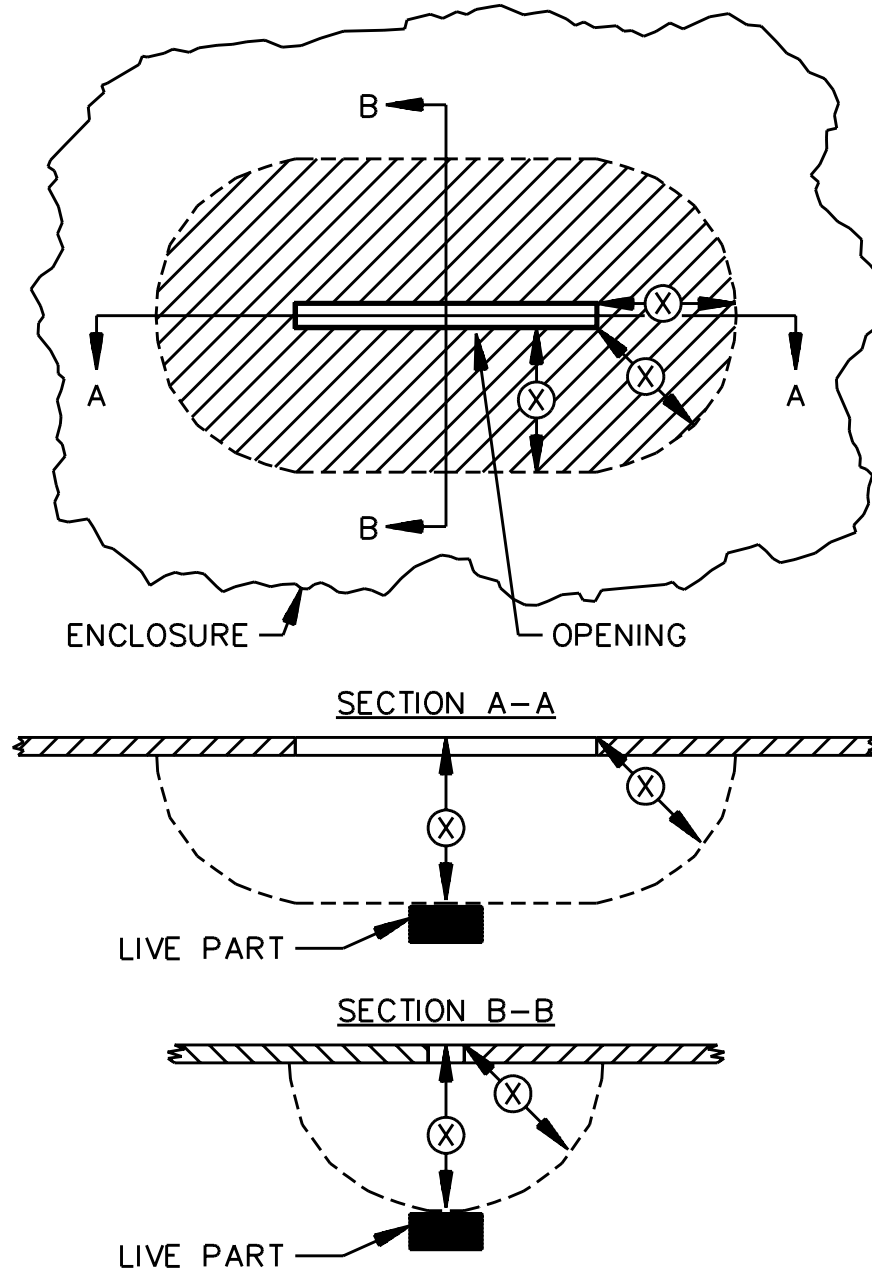


Figure 9.3
Opening in enclosure



EC100B

The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

- a) Less than X inches (mm) from the perimeter of the opening, as well as
- b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

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9.3 Doors and covers

9.3.1 A cover or access panel of an enclosure for uninsulated live parts shall be provided with means for securing it in place.

9.3.2 A hinged or pivoted panel or cover shall be positioned or arranged so that it is not subject to falling or swinging due to gravity or normal vibration in such a manner as to cause injury to persons by the panel or cover, or by hazardous moving parts or uninsulated live parts.

9.3.3 The assembly incorporating overcurrent protective devices shall be arranged so that fuses can be replaced and manual-reset devices can be reset, as applicable, without removing parts other than a service cover or panel and a cover or door enclosing the device. See 9.3.7.

9.3.4 A required protective device shall be wholly inaccessible from outside the assembly without opening a door or cover, except that the operating handle of a circuit breaker, the operating button of a manually operable motor protector, the reset button of a manually resettable pressure switch, and similar parts may project outside the boiler assembly enclosure.

9.3.5 An opening in an enclosure to provide clearance around a dial, knob, lever, or handle shall not allow the entrance of a rod having a diameter of 9/64 inch (3.6 mm) at any setting or position of the dial, knob, lever, or handle.

9.3.6 A fuseholder shall be so constructed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (102 mm), other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or equivalent material employed for this purpose shall be not less than 0.028 inch (0.71 mm) in thickness.

9.3.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device such as resetting a manual reset overload protective device.

Exception: A hinged cover is not required for a device in which the only fuses enclosed are:

- a) Control-circuit fuses of 2 amperes or less, provided the fuses and control-circuit loads, other than a fixed control-circuit load, such as pilot lamp, are within the same enclosure;*
- b) Extractor-type fuses each with its own enclosure; or*
- c) Fuses in low-voltage circuits.*

9.3.8 Hinged covers, where required, shall not depend solely upon screws or other similar means requiring the use of tools to hold them closed, but shall be provided with a catch or spring latch.

9.3.9 A spring latch, a magnetic latch, a dimple or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open, is an acceptable means for holding the door in place as required in 9.3.8.

9.3.10 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction which affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

9.3.11 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (41.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

9.3.12 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

- a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimensions; and
- b) 0.027 inch (0.68 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimensions.

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.

9.3.13 An electron tube or similar glass-enclosed device shall be protected against mechanical damage.

9.4 Field wiring system connection

9.4.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be attached.

9.4.2 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 be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

9.4.3 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging with the conduit.

9.4.4 A knockout in a sheet metal enclosure shall be capable of being removed without undue deformation of the enclosure.

9.4.5 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those required.