UL 2096

STANDARD FOR SAFETY

Commercial/Industrial Gas and/or Oil-Burning Assemblies With Emission Reduction Equipment

UL Standard for Safety for Commercial/Industrial Gas and/or Oil-Burning Assemblies With Emission Reduction Equipment, UL 2096

Third Edition, Dated October 27, 2006

Summary of Topics

This revision to UL 2096 is being issued to remove the reference to the withdrawal date of UL 873 and to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. 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 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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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1

UL 2096

Standard for Commercial/Industrial Gas and/or Oil-Burning Assemblies

With Emission Reduction Equipment

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This UL Standard for Safety consists of the Third edition including revisions through March 9, 2015.

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

No Text on This Page

CONTENTS

PART I – ALL EQUIPMENT

INTRODUCTION

CONSTRUCTION

ELECTRICAL COMPONENTS

SPACINGS

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKING

INSTRUCTIONS

PART II - BURNER ASSEMBLIES

CONSTRUCTION

PERFORMANCE

PART III – BOILER ASSEMBLIES

CONSTRUCTION

PERFORMANCE

PART IV – FURNACES AND HEATERS

CONSTRUCTION

PERFORMANCE

PART V – DRAFT HOOD EQUIPPED DEVICES

PERFORMANCE

PART VI – OUTDOOR-USE EQUIPMENT

CONSTRUCTION

APPENDIX A

PART I – ALL EQUIPMENT

INTRODUCTION

1 Scope

1.1 These requirements cover fuel burning heating appliances that are provided with or are intended for installation with NO_x emissions reduction equipment.

1.2 These requirements apply to factory-built equipment having inputs of more than 400,000 Btu per hour (117 KW) (firing gas), and/or more than 3.0 gph (11.4 L/h) (firing oil), per individual combustion chamber and/or oil or combination gas-oil burning equipment which require flame failure and other safeguards and which are intended primarily for commercial and industrial installation.

1.3 Equipment covered by these requirements may be operated without a competent attendant being constantly on duty at the burners while the burners are in operation.

1.4 The heating appliance shall be suitable for installation in accordance with the National Fire Protection Association Standards for the Installation of Oil-Burning Equipment (National Fire Codes, Vol. 1), ANSI/NFPA 31, and/or National Fuel Gas Codes (IAS/A.G.A. Z223.1-1996), NFPA 54 and the National Electrical Code, NFPA 70.

2 Units of Measurement

2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

2.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are rms.

3 Components

3.1 Except as indicated in 3.2, 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.

3.2 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.

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

3.4 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.

4 Glossary

4.1 For the purpose of this Standard the following definitions apply.

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

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

4.4 AIR SHUTTER, MANUALLY OPERATED – An air shutter manually set and locked in the desired position.

4.5 APPLIANCE – Refers to any equipment covered by this standard.

4.6 APPLIANCE FLUE – The flue passages within the appliance.

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

4.8 BAFFLE – An object placed in an appliance to direct the flow of air or flue gases.

4.9 BASE – The main supporting frame or structure of the assembly, exclusive of legs.

4.10 BLUE FLAME – A visual flame condition which may be observed when firing distillate oil fuels.

4.11 BOILER – A closed vessel in which water or some other liquid is heated or in which steam is generated or superheated, under pressure or vacuum, by direct application of heat.

4.12 BOILER, HIGH PRESSURE STEAM – A boiler in which steam is generated at a pressure higher than 15 psig (103 kPa).

4.13 BOILER, HIGH TEMPERATURE WATER – A boiler intended for operation at a pressure exceeding 160 psig (1103 kPa) or at a temperature exceeding 250°F (121°C) or both.

4.14 BOILER, HOT WATER – A boiler that furnishes hot water at a pressure not exceeding 160 psig (1103 kPa) and at a temperature not exceeding 250°F (121°C).

4.15 BOILER, LOW PRESSURE STEAM – A boiler in which steam is generated at a pressure not exceeding 15 psig (103 kPa).

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

4.17 BURNER, MECHANICAL ATOMIZING TYPE – A power-operated burner which prepares and delivers the oil and all or part of the air by mechanical process in controllable quantities for combustion. Some examples are air atomizing, high and low pressure atomizing, horizontal rotary, vertical rotary atomizing, and vertical rotary wall-flame burner.

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

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

4.20 CASING – An enclosure forming the outside of the appliance, no parts of which are likely to be subjected to intense heat.

4.21 CENTRAL HEATING APPLIANCE – A stationary indirect-fired vented appliance comprising the following classes: boilers, central furnaces, and recessed heaters. A floor-mounted unit heater to be connected to a duct system is categorized also as a central heating appliance.

4.22 CHIMNEY CONNECTOR – The pipe which connects a fuel burning appliance to a chimney.

4.23 COMBUSTIBLE AND NON-COMBUSTIBLE – Refer to the Standard Glossary of Terms Relating to Chimneys, Vents, and Heat-Producting Appliances, ANSI/NFPA 97-1996.

4.24 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.

4.25 COMBUSTION AIR TEMPERATURE INTERLOCK – A safety control responsive to changes in temperature, normally set beyond the intended operating range of the controlled equipment to cause a safety shutdown.

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

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

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

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

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

4.31 CONTROL INPUT, COMBUSTION – A control which automatically regulates the firing rate at predetermined air-fuel ratio in accordance with load demand. It may be a type which positions the air and fuel supplies for low fire and for high fire as required to meet the load demands, or it may be a modulating type which gradually varies the air and fuel supplies within limits to meet the load demand.

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

4.33 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.

4.34 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) Programming Unit – 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) Combustion Detector – 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.

4.35 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.

4.36 CONTROL, SAFETY COMBUSTION – A primary safety control responsive directly to flame properties, sensing the presence of flame and causing fuel to be shut off in event of flame failure.

4.37 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.

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

4.39 DAMPER, MANUALLY OPERATED – An adjustable damper manually set and locked in the desired position.

4.40 DIRECT FIRED APPLIANCE – A device in which combustion products (flue gases) are mixed with the medium, e.g., air, being heated.

4.41 DRAFT – The differential in static pressure available, between any two locations, to provide the energy potential for the moving of air for combustion or products of combustion through a fuel-burning heat-exchanging apparatus, or both.

4.42 DRAFT REGULATOR – A device which functions to maintain a desired draft in the appliance by automatically reducing the chimney draft to the desired value.

4.43 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.

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

4.45 FLAME SAFEGUARD – See ″Control, Primary Safety.″

4.46 FLUE COLLAR – That portion of an appliance designed for attachment of the chimney or vent connector.

4.47 FLUE GASES – Combustion products and excess air.

4.48 FLUE GAS RECIRCULATION (FGR) – A combustion process involving recirculation of a proportional amount of combustion flue gases drawn from the flue gas outlet of a single source and reintroduced into the combustion zone.

4.49 FUEL OIL – Any hydrocarbon oil as defined by the Standard Specification for Fuel Oils ANSI/ ASTM D396-1997.

4.50 FURNACE – Refers to a central furnace.

4.51 FURNACE, CENTRAL, WARM AIR – A self-contained indirect fired appliance designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

4.52 FURNACE, FORCED-AIR TYPE, CENTRAL – A central furnace equipped with a fan or blower which provides the primary means for circulation of air.

4.53 FURNACE, DOWNFLOW – A forced-air type central furnace designed with airflow through the furnace essentially in a vertical path, discharging air at or near the bottom of the furnace.

4.54 FURNACE, DUCT – A central furnace designed for installation in a duct of an air distribution system to supply warm air for heating and which depends for air circulation on a blower not furnished as part of the furnace.

4.55 FURNACE, HORIZONTAL – A forced-air type central furnace designed with airflow through the furnace essentially in a horizontal path.

4.56 FURNACE, UPFLOW – A central furnace designed with airflow through the furnace essentially in a vertical path, discharging air at or near the top of the furnace.

4.57 GAS VENT – The piping and fittings for conveying flue gases to the outside atmosphere.

4.58 HEATER – Refers to a unit heater.

4.59 HEAT EXCHANGER, DIRECT – A heat exchanger in which heat generated in the combustion chamber of the appliance is transferred direct through walls of the appliance to the heating medium (such as air, steam or water) held in close contact with the combustion chamber walls. It is a self-contained combustion and heat transfer device, hence a direct heat exchanger.

4.60 HEAT EXCHANGER, INDIRECT – A heat exchanger which encloses or contains a heating medium, such as air, steam, or water, the heat from which is transferred to another heating medium separately contained in close contact with or directed through the heat exchanger.

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

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

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

4.64 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.

4.65 INDIRECT-FIRED DEVICE – A device designed so that combustion products (flue gases) are not mixed in the device with the medium, for example, air, being heated.

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

4.67 LINER – See Radiation Shield, 4.92.

4.68 LINING – Those interior surfaces of a combustion chamber which are exposed to combustion during use of the device.

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

4.70 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.

4.71 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.

4.72 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.

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

4.74 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.

4.75 OIL-FIRED BOILER ASSEMBLY – A boiler assembly as defined herein equipped with one or more oil burners, and all the necessary safety controls, electrical equipment as needed, and related equipment, manufactured for assembly as a unit.

4.76 ORIFICE – The opening in a cap, spud, or other device whereby the flow of gas is limited and through which the gas is discharged to a burner.

4.77 ORIFICE CAP (HOOD) – A movable fitting having an orifice which permits adjustment of the flow of gas by the changing of its position with respect to a fixed needle or other device.

4.78 ORIFICE SPUD – A removable plug or cap containing an orifice and which permits adjustment of the flow of gas either by substitution of a spud with a different sized orifice or by the motion of a needle with respect to it.

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

4.80 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.

4.81 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.

4.82 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.

4.83 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.

4.84 PLENUM – An air compartment in an air distribution system to which one or more ducts are connected.

a) Furnace Supply Plenum – A furnace plenum attached directly to, or an integral part of, the supply outlet of the furnace.

b) Furnace Return Plenum – A furnace plenum attached directly to, or an integral part of, the return air inlet of the furnace.

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

4.86 POST-PURGE PERIOD – The period of time after the fuel delivered to the burner is stopped and during which the burner motor or fan continues to run to supply air to the combustion chamber.

4.87 PREPURGE 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.

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

4.89 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.

4.90 PUMP, AUTOMATIC OIL – A pump, not an integral part of a burner, that automatically pumps oil from the supply tank and delivers the oil by gravity under a constant head to an oil-burning appliance. The pump is intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the appliance.

4.91 PUMP, OIL-TRANSFER – An oil pump, automatically or manually operated, that transfers oil through continuous piping from a supply tank to an oil-burning appliance or to an auxiliary tank, and which is not intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the appliance.

4.92 RADIATION SHIELD OR LINER – A separate panel(s) interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

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

4.94 RECIRCULATION BLOWER ASSEMBLY – A separate blower assembly provided to draw combustion flue gases from the appliance flue gas outlet. Also, see ″Recirculation System, High Pressure″, 4.99.

4.95 RECIRCULATION DAMPER – RECIRCULATION METERING VALVE – An automatically actuated device installed in the ductwork between the appliance flue gas outlet and the fuel burning equipment manifold to proportionally limit the amount of recirculated flue gases with respect to the main fuel input of the fuel burning equipment.

4.96 RECIRCULATION DUCTWORK – A general term for the conduit or passageway through which flue gases pass from the appliance flue gas outlet to the burning equipment.

4.97 RECIRCULATION FAN (BLOWER) INTERLOCK – A control other than an operating or safety control, responsive to changes in pressure, having a pressure range sufficient to operate at all normal operating conditions, including ″cold″ start, to cause a safety shutdown in the event of loss of pressure.

4.98 RECIRCULATION FLUE GAS TEMPERATURE INTERLOCK – A control other than an operating or safety control or interlock, responsive to changes in temperature, normally set higher than the maximum normal flue gas temperature to cause safety shutdown.

4.99 RECIRCULATION SYSTEM, HIGH PRESSURE – The method by which the recirculated combustion flue gases are drawn from the appliance flue gas outlet by a separate blower assembly and introduced via ductwork to a separate manifold provided as an integral part of the fuel burning equipment.

4.100 RECIRCULATION SYSTEM, LOW PRESSURE – The method by which the recirculated combustion flue gases are drawn from the appliance flue gas outlet and introduced via ductwork to the combustion air inlet of the fuel burning equipment, using only the combustion air fan for circulation.

4.101 RECIRCULATION SHUTOFF VALVE – A high temperature valve specified suitable for use at higher than the maximum flue gas temperature of the device at rated temperature and/or pressure. The valve shall be designed to permit no leakage when in the closed position.

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

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

4.104 REFRACTORY – A poured, cast or solid brick type high temperature insulating material, typically used in the installation of a burner onto an appliance.

4.105 SAFETY CONTROL – See Control, Safety, 4.35.

4.106 SAFETY SHUTDOWN (LOCKOUT) – The 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.

4.107 SECONDARY AIR – The air externally supplied to the flame at the point of combustion.

4.108 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; and

e) Replacing igniter cable.

4.109 SPECIAL PARTS AND TOOLS – Those parts and tools that are not available on the open retail market.

4.110 STRAINER, PRIMARY – The strainer through which all oil first passes on way to burner, being upstream from any other strainer.

4.111 STRAINER, SECONDARY – A strainer downstream from the primary strainer, interposed in the fuel line between the primary strainer and the point at which fuel is delivered for combustion.

4.112 THERMOSTAT – An automatic control actuated by temperature change to maintain temperatures between predetermined limits.

4.113 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.

4.114 UNIT HEATER:

a) Low-Static Pressure Type – A self-contained, automatically controlled, vented fuel burning device having integral means for circulation of air, normally by a propeller fan (or fans).

Such devices may be equipped with louvers or face extensions made in accordance with the manufacturer's approved specifications.

b) High-Static Pressure Type – A self-contained, automatically controlled, vented fuel burning device having integral means for circulation of air against 0.2 inch or greater static pressure and designed for installation in the space to be heated unless they are equipped with provisions for attaching both inlet and outlet air ducts.

4.115 VALVE, BURNER-INPUT CONTROL – An automatic-control valve for regulating the input of fuel to a burner.

4.116 VALVE, LUBRICATED PLUG TYPE – A valve of the plug and barrel type designed for maintaining a lubricant between the bearing surfaces.

4.117 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.

4.118 VALVE, MANUAL OIL SHUT-OFF – A manually operated valve in the oil line for the purpose of completely turning on or shutting off the oil supply to the burner.

4.119 VALVE, OIL CONTROL – An automatically or manually operated device consisting essentially of an oil valve for controlling the fuel supply to a burner.

a) Metering (Regulating) Valve – An oil control valve for regulating burner input.

b) Safety Valve – A normally closed valve of the ON and OFF type, without any bypass to the burner, that is actuated by a safety control or by an emergency device.

4.120 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.

4.121 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.

4.122 VENTED APPLIANCE – An indirect fired appliance provided with a flue collar to accommodate a chimney connector for conveying flue gases to the outside air.

4.123 VENT CONNECTOR – The pipe which connects a gas-fired device to a gas vent or chimney.

5 Undated References

5.1 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.

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 A burner part intended for the handling of fluids under pressure shall withstand, without rupture, a hydrostatic pressure equivalent to five times the maximum working pressure.

6.4 A burner part intended for the handling of recirculated flue gases under pressure shall withstand, without leakage, an aerostatic pressure equivalent to three times the maximum working pressure.

6.5 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.

6.6 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. An oil-conveying pipe or passage shall not be exposed to such temperatures as may result in carbonization or clogging when the burner is tested in accordance with these requirements.

6.7 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.

6.8 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.

6.9 A recirculation metering valve or damper assembly shall be constructed such that no external leakage of combustion gases is permitted in either the open or closed position when installed in a positive pressure location.

6.10 The fuel burning equipment shall be constructed such that supervised firing with operation as specified in 63.6.2 or 64.5.3, as appropriate, may be accomplished without further adjustment even when the FGR system becomes inoperative by fault (failure) or manual means. The manufacturer's instructions shall specify the method provided to secure burner operation from the FGR mode when long term firing cycles are necessary.

6.11 Joints in recirculation ducts shall be essentially gas-tight at the maximum pressure developed downstream of a recirculation blower assembly. Upstream of the recirculation blower assembly, joints in ducts shall be gas-tight as confirmed by examination of the joint construction. Any gaskets used shall be suitable for the temperatures involved.

6.12 There shall be no flow of combustion gases from the flue gas outlet to the fuel burning equipment during preignition and post-ignition purge periods.

6.13 All electrical and mechanical constructions that make up the FGR system shall be provided as part of the device shipment. Ductwork to convey recirculated flue gases may be provided by the field installer when the manufacturer's instructions provide adequate sizing and installation details.

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.

7.2 Surfaces of the burner assembly and flue gas conveying parts that may be in contact with flue gas condensation shall be evaluated with respect to resistance to corrosion. Among the factors to be considered are material thickness and type, length of time subjected to the condensate condition and type of corrosion protection provided.

7.3 Corrosion protection shall be provided on metering valve or damper assemblies, recirculation blowers, and any duct work or piping provided as a part of the FGR system.

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.

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.

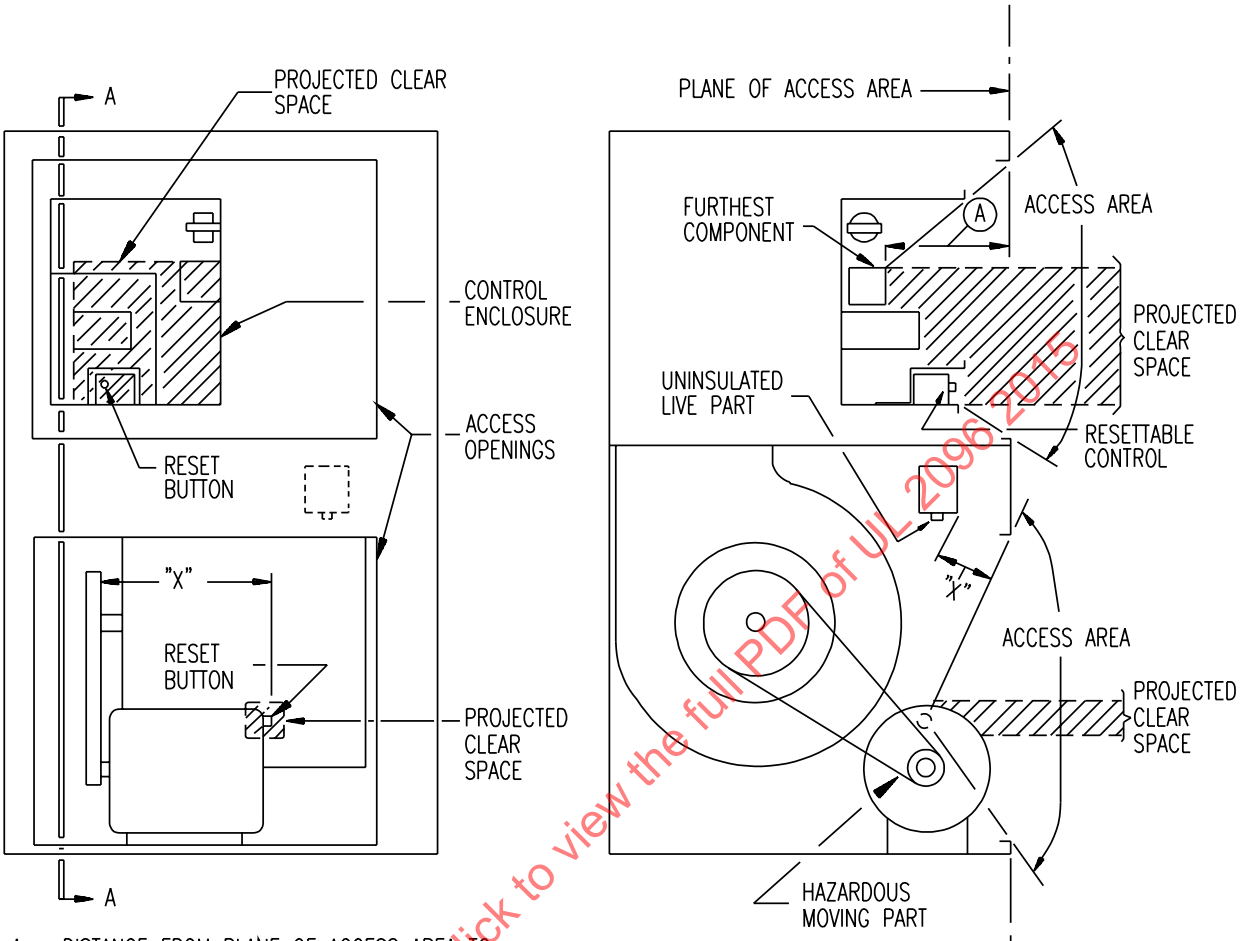
e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:

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



A = DISTANCE FROM PLANE OF ACCESS AREA TO FURTHEST COMPONENT – 14" (355.6 mm) MAXIMUM.

"X" = MINIMUM DISTANCE FROM HAZARDOUS MOVING PARTS, OR UNINSULATED LIVE PARTS TO ACCESS AREA = 6" (152.4mm) MINIMUM.

EA105

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) A warning marking shall be displayed which reads essentially as follows:

DANGER – TO AVOID INJURY FROM MOVING PARTS, SHUT OFF THE (EQUIPMENT) BEFORE (REMOVING-OPENING) THIS (COVER-DOOR).

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	(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)
1-1/2	(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.

8.11 A moving part is not to be considered when judging compliance with 8.1 and 8.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

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.

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 4.43.

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 (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
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		27.0	(68.6)	Not limited		0.053	(1.34)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)		(16)		(16)
22.0	(55.9)	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 lease 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, inches	
Maximum width[b], inches	(cm)	Maximum length[c], inches	(cm)	Maximum width[b], inches	(cm)	Maxinum length inches	(cm)	(mm)	(AWG)
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 lease 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 9.2, 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 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 9.3.

Figure 9.1
Probe for uninsulated live metal parts

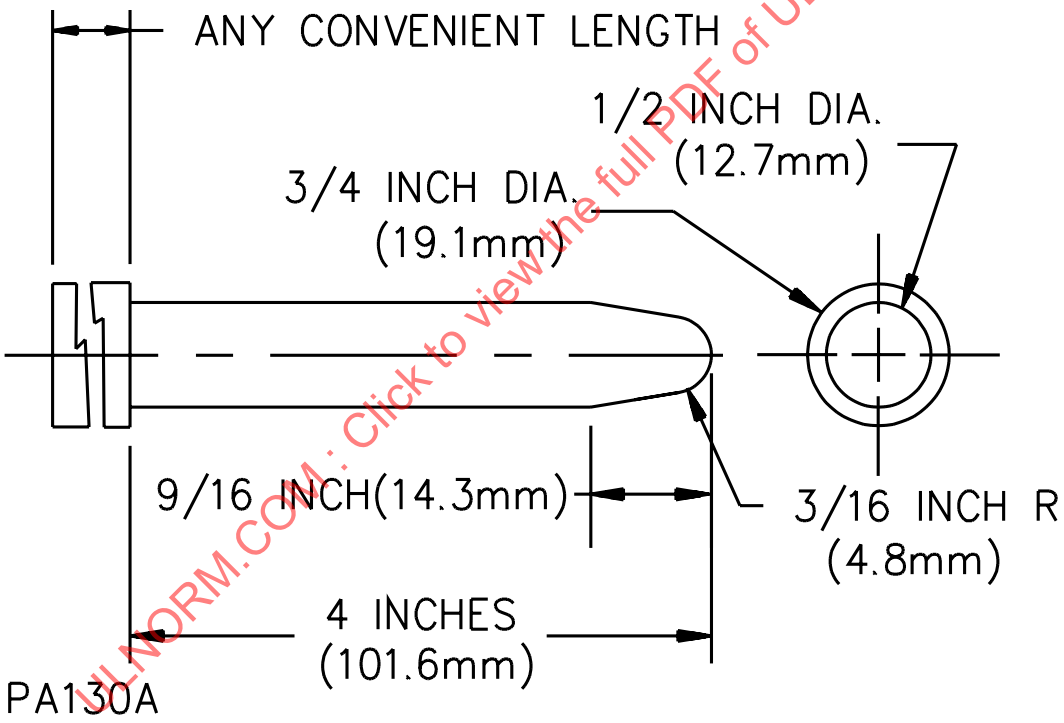


Figure 9.2
Probe for film-coated wire

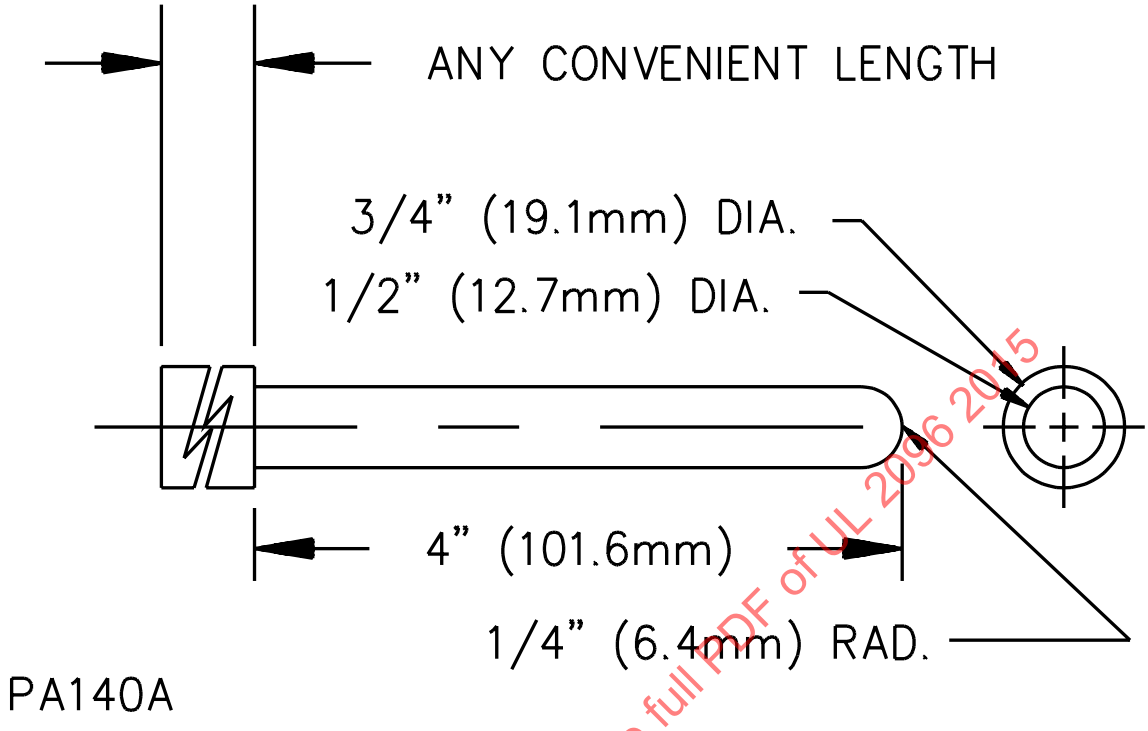
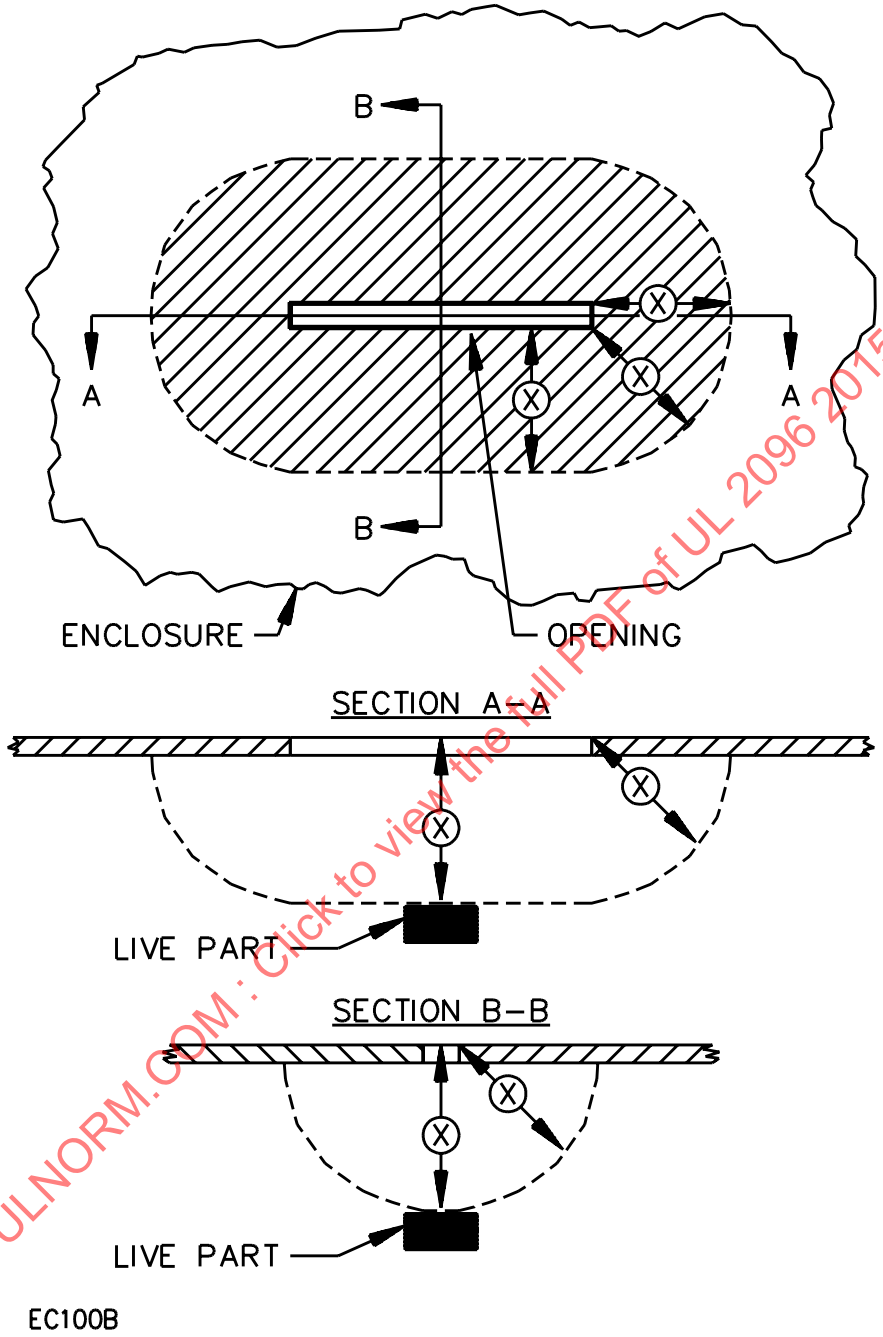


Figure 9.3
Opening in enclosure



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).

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.

10 Field Wiring

10.1 General

10.1.1 Provision shall be made for connection of a wiring system that would be suitable for power supply in accordance with the National Electrical Code, NFPA 70.

10.1.2 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that these connections may be inspected after the equipment is installed as intended.

10.1.3 The connections shall be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made. A component intended for use as the cover of an outlet box or compartment may serve as a cover.

10.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that indicated in Table 10.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 10.1
Size of junction boxes

Size of conductor AWG (mm^2)	Free space within box for each conductor, cubic inches (cm^3)
16 or smaller (1.3 or less)	1.5 (24.6)
14 (2.1)	2.0 (32.8)
12 (3.3)	2.25 (36.9)
10 (5.3)	2.5 (41.0)
8 (8.3)	3.0 (49.2)

10.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 10.2.

Table 10.2
Trade size of conduit in inches[a]

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	1	1	1-1/4	1-1/4
4	(21.1)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1-1/4	1-1/4	1-1/2	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
0	(53.5)	1-1/4	1-1/2	2	2	2-1/2
2/0	(67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107.2)	2	2	2-1/2	2-1/2	3

Table 10.2 Continued on Next Page

Table 10.2 Continued

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6

[a] This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of type THW wire.

10.1.6 Wiring exterior to an appliance assembly between the burner assembly and a limit control, a primary safety control, or a motor controller, that can be done readily with a wire enclosed in conduit or with metal-clad cable in accordance with the National Electrical Code, NFPA 70, need not be furnished by the manufacturer as part of the boiler assembly if adequate instructions for installing such wiring are furnished with each boiler assembly. See 11.1.4.

10.1.7 A box or enclosure, included as part of the assembly and in which a branch circuit supplying power to the boiler assembly is to be connected, shall not require that it be moved for normal care of the unit. This requirement does not apply to separate limit controls and stack switches, where permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

10.1.8 A box or enclosure in which field installed conductors are to be connected as indicated in 10.1.5, 10.1.6, 10.1.7, and 10.1.9 shall be so located that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for a wire having a 140°F (60°C) temperature rating when the assembly is tested in accordance with these requirements.

10.1.9 Except as otherwise permitted by 17.3.1, wiring to be done in the field between the assembly and devices not attached to the boiler assembly or between separate devices which are field installed and located, shall conform to these requirements if done with a 140°F (60°C) rated wire enclosed in suitable conduit or metal-clad cable.

10.1.10 The wiring of the appliance may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 10.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product is not more than 6 feet (1.83 m);

b) No circuit conductor protected by an overcurrent-protective device rated at more than 20 amperes is included; and

c) The conduit is no larger than 3/4 inch trade size, or the fittings for the conduit are identified as providing grounding.