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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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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.

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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.

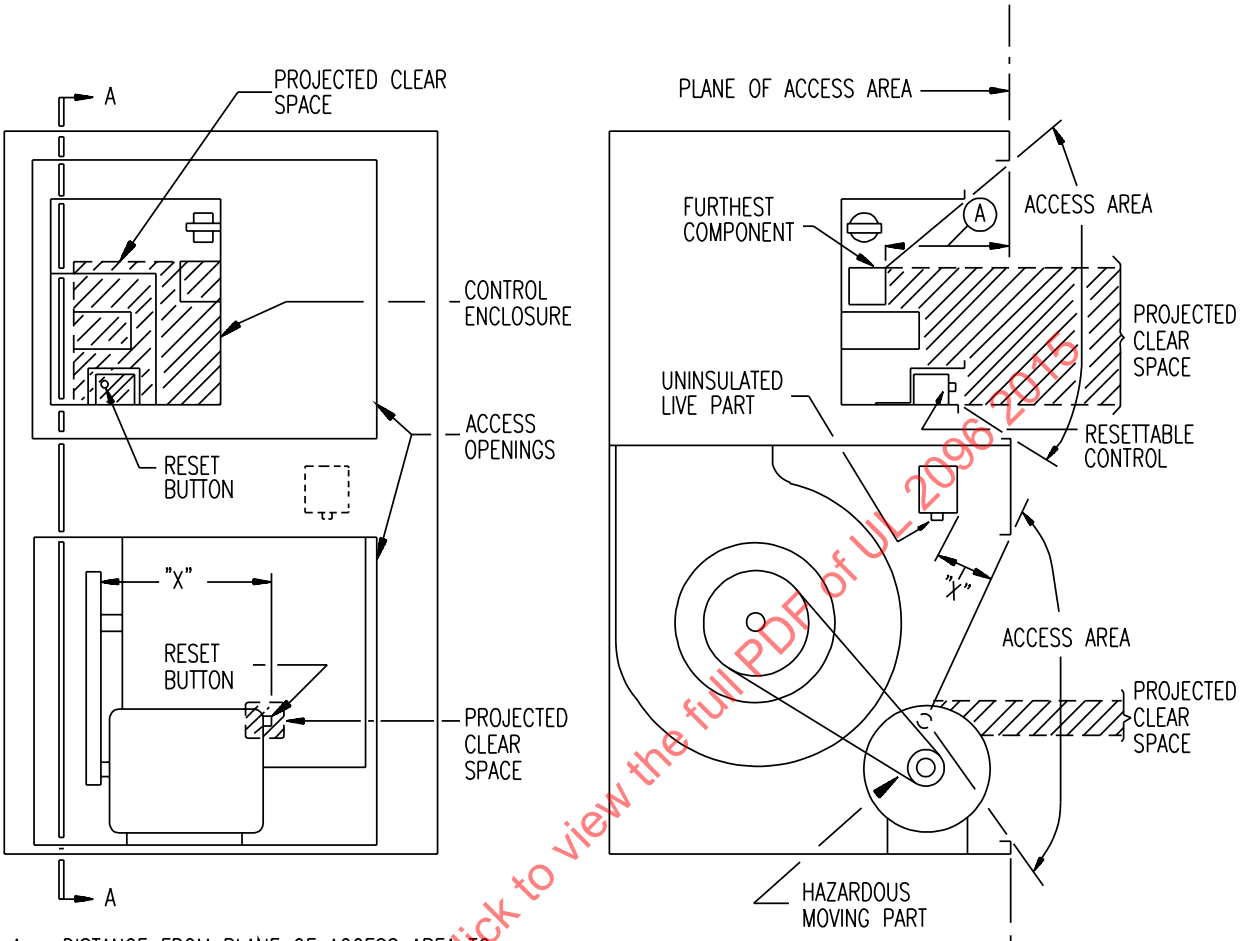
e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:

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.

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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

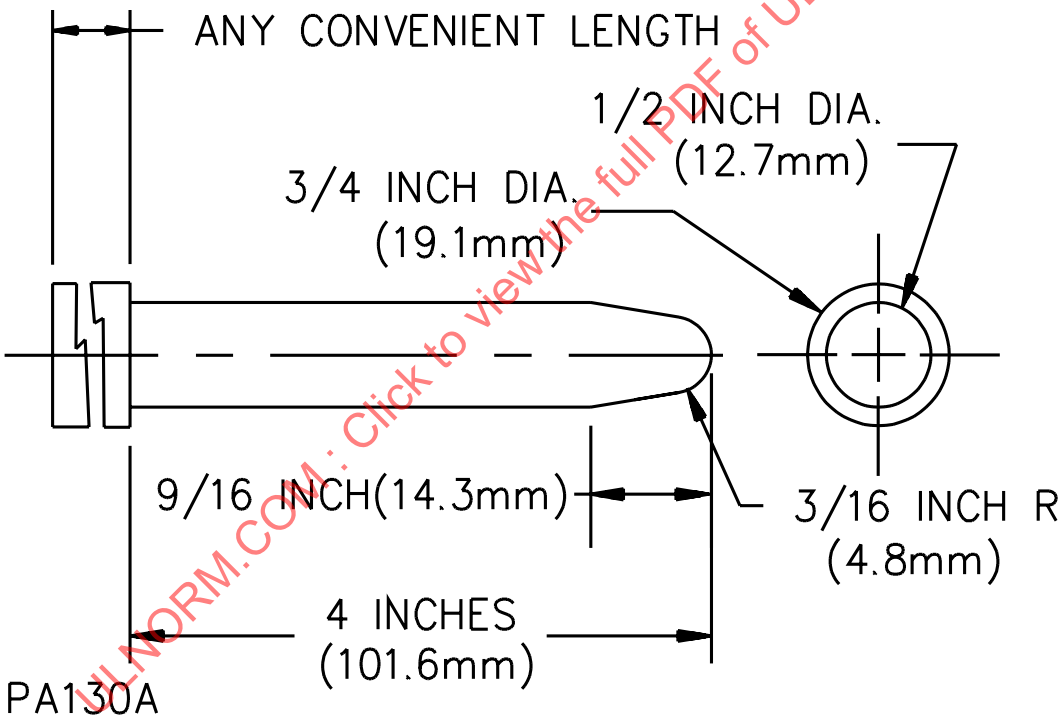


Figure 9.2
Probe for film-coated wire

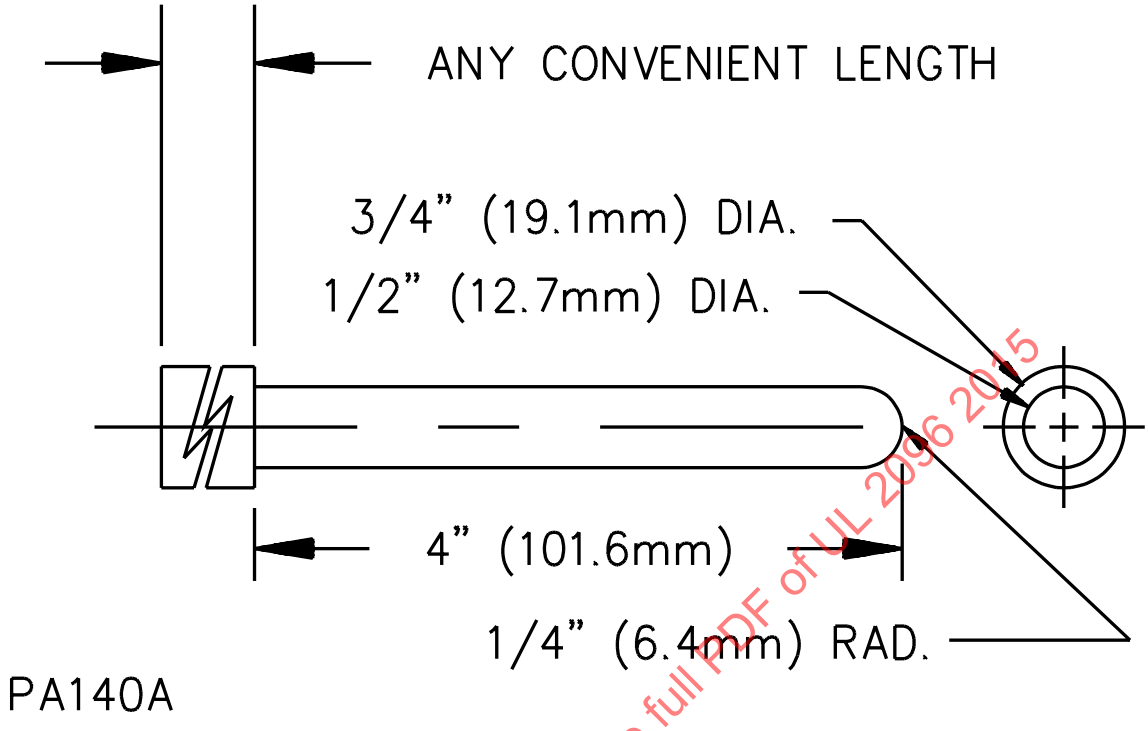
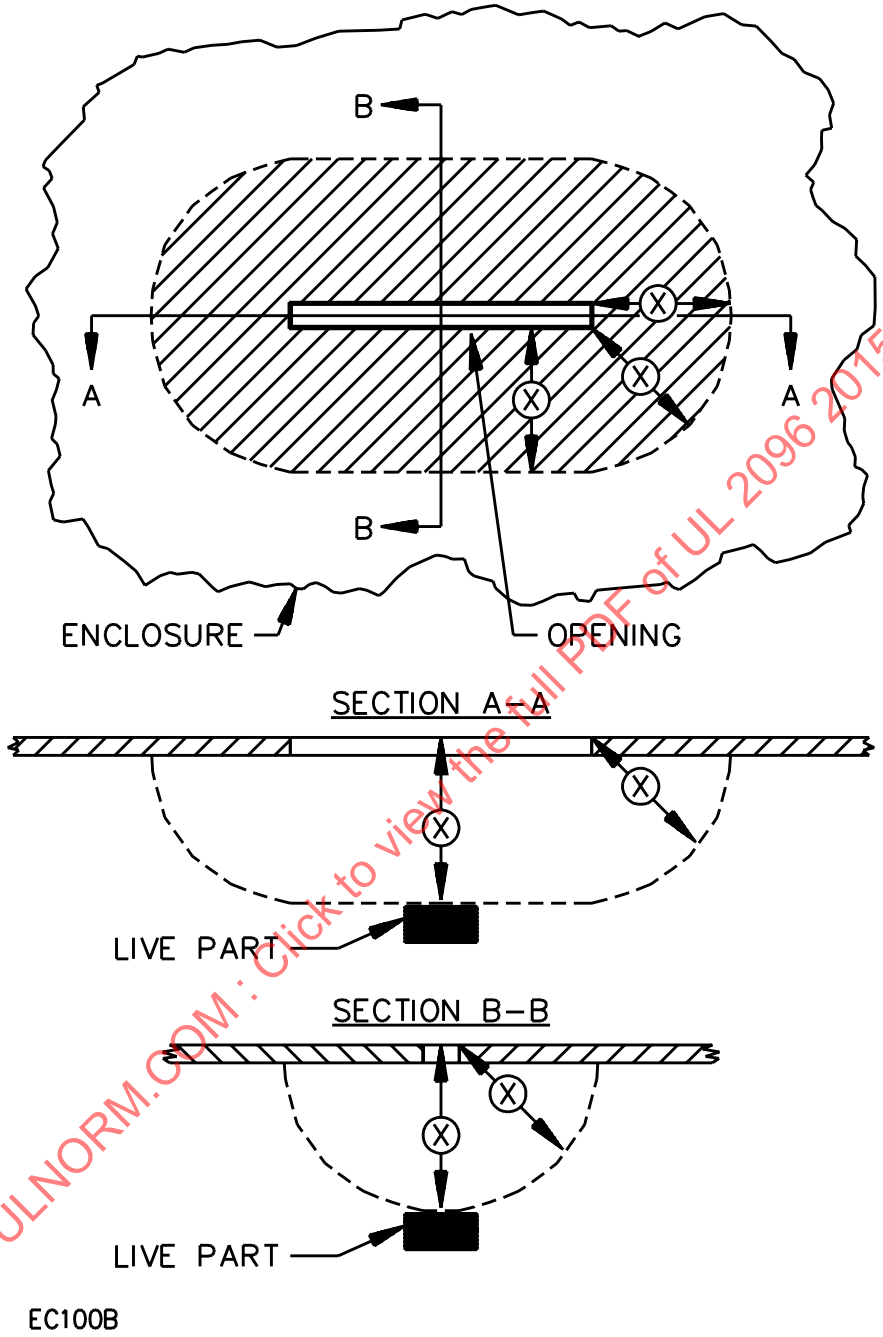


Figure 9.3
Opening in enclosure



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.

10.2 Leads and terminals

10.2.1 Wiring terminals or leads not less than 6 inches (152 mm) long for connection of field-wiring conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the marked rating of the assembly shall be provided.

10.2.2 Leads may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead might result in a risk of fire, electric shock, or injury to persons.

10.2.3 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring which may cause the lead to separate from its termination or result in damage to the lead from sharp edges. Each lead shall be capable of withstanding a pull of 10 pounds (44.5 N) for 1 minute without damage to the assembly.

10.2.4 An identified (grounded) terminal or lead shall not be electrically connected to a single-pole manual switching device which has an OFF position or to a single-pole overcurrent (not thermal) protective device.

10.2.5 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. An open slot-type connector shall not be used unless it is constructed to reduce the likelihood of disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

10.2.6 Field wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent means.

10.2.7 Conductors intended for connection to a grounded neutral line shall be identified, that is, finished in a continuous white or gray covering, three continuous white stripes on other than green insulation, or a marking of white or gray color at the termination. All other current-carrying conductors visible to the installer shall be finished in colors other than white, gray, or green. A terminal for connection of a grounded conductor shall be identified by a metallic-plated coating, substantially white in color and shall be readily distinguishable from other terminals, or it shall be identified in some other manner, such as on an attached wiring diagram.

10.2.8 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire-binding screws or pressure terminal connectors, located in the same compartment as the splice or visible to the installer, unless the screws or connectors are rendered unusable for field wiring connections or the leads are insulated at the unconnected ends.

10.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 10.2.5, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

10.2.10 A wire binding screw at a high-voltage wiring terminal for field connection shall not be smaller than No. 10 (4.8 mm major diameter).

Exception No. 1: A No. 8 (4.2 mm major diameter) screw may be used for the connection of a conductor not larger than 14 AWG (2.1 mm^2).

Exception No. 2: A No. 6 (3.5 mm major diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductor.

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10.2.11 A terminal plate for a wire binding screw shall be of metal not less than 0.030 inch (0.76 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm^2); and in either case there shall be not less than two full threads in the metal.

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

10.2.13 A wire binding screw shall thread into metal.

11 Internal Wiring

11.1 General

11.1.1 The wiring of high-voltage circuits shall conform to the requirements in this section.

11.1.2 Wiring shall be done with insulated conductors having current carrying capacity, voltage, and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be not smaller than 18 AWG (0.82 mm^2).

11.1.3 Except as indicated in 11.2.2, the wiring for each device assembly circuit shall be furnished by the manufacturer as part of the boiler assembly. If the boiler assembly is not assembled and wired at the factory, such wiring shall be furnished as harness with each boiler and be arranged to facilitate attachment when the boiler is assembled; and a pictorial diagram showing the exact arrangement of the wiring shall be included with each boiler assembly.

11.1.4 If insulated conductors rated for use at temperatures in excess of 140°F (60°C) are required, such wiring shall be furnished as part of the assembly and the devices to be connected by such wiring shall be factory-located on the equipment.

11.2 Methods

11.2.1 Electrical wiring to a part which must be moved for normal maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. Conductors to be disconnected from terminals of such part shall terminate in eyelets or connectors. If the wiring to a part which functions also as an access plate or cover, that is, a transformer closing the access to the nozzle assembly, is not readily detachable, the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any allowable movement of such part shall not unduly twist, bend, or pull the wiring.

11.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 11.2.15.

Exception: Factory wiring involving a potential of not more than 300 volts between parts attached to the same assembly with a predetermined fixed relationship one to the other may be done with Type SO or ST cord, provided all of the following conditions are fulfilled:

a) It is not practical to do the wiring in accordance with 11.2.2;

b) The cord is not required to be bent, twisted, or otherwise displaced to render normal maintenance and service; and

c) The length of cord exterior to the assembly is not more than 4 inches (102 mm) and strain relief is provided.

11.2.3 Group A of Table 11.1 includes some wiring materials suitable for use if enclosed as indicated in 11.2.2.

Table 11.1
Typical wiring materials

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire Size		Insulation thickness	
		AWG	mm^2	Inch	mm
A	FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, T, THW, XHHW, MTW, THWN, TW, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFHH-3 or thermoplastic appliance wiring material.	10 and smaller	5.3	2/64	0.8
		8	8.3	3/64	1.2
		6	13.3	4/64	1.6
		4	21.2	4/64	1.6
		3	25.7	4/64	1.6
		2	33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.0	5/64	2.0

Table 11.1 Continued on Next Page

Table 11.1 Continued

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire Size		Insulation thickness	
		AWG	mm^2	Inch	mm
B	SO, ST, SJO, SJT, S, SE, SJ, SJOO, SJTO, SJTOO, SOO, STO, STOO, or appliance wiring material with thermoplastic or neoprene insulation	18	0.82	4/64	1.8
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.3	6/64	2.4
		6	13.3	8/64	3.2
Thermoplastic wiring materials, as referenced in group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.3 mm^2) are considered equivalent to the wiring material referenced in group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type suitable for the purpose from the standpoint of dielectric properties, heat resistance, moisture-resistance, flammability, and the like.				

11.2.4 Flexible metal conduit, if used, shall be not smaller than 3/8 inch (9.5 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads. See 3.1.

11.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (914 mm) where flexibility is necessary.

11.2.6 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in risk of fire, electric shock, or injury to persons.

11.2.7 A splice shall be provided with insulation equivalent to that required for the wires involved if permanence of spacing between the splice and other metal parts is not ensured.

11.2.8 A splicing device, such as a fixture-type splicing connector, pressure wire connector, and the like, may be employed if the device has insulation suitable for the voltage to which it is subjected. Thermoplastic tape wrapped over a sharp edge is not acceptable.

11.2.9 Each splice shall be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials may be employed.

11.2.10 Splices shall be located, enclosed, and supported so that they are not subject to damage, flexing, motion, or vibration.

11.2.11 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which wiring materials, as specified in Group A of Table 11.1, may be employed. Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

11.2.12 At all points where conduit or metal tubing terminates, the conductor shall be protected from abrasion. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided between the conductors and the metal cladding, and the connector or clamp shall be of such design that the insulating bushing or its equivalent will be visible for inspection.

11.2.13 A wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and ensure electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges which might cause damage to the insulation on wires.

11.2.14 All wiring shall be supported and routed to prevent damage due to sharp edges or moving parts.

11.2.15 Cords or appliance wiring material as referenced in Group B of Table 11.1 may be employed if the wiring is enclosed by a casing or compartment conforming to all of the following:

a) There are no openings in the bottom, unless a U-shaped channel or trough is located under the wiring and the wires do not project through the plane of the top of the trough or channel;

b) If the appliance is for installation only on noncombustible flooring, the bottom of such compartment may be open provided all sides of the compartment extend to the floor level;

c) Louvers or openings in other than the bottom will not permit entrance of a rod having a diameter of 1/2 inch (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 inch in diameter larger than the object that will be installed through the opening;

d) Openings are not closer than 6 inches (152 mm) to the wiring unless metallic barriers or baffles are placed between the wiring and the openings; and

e) Combustible material, other than electrical insulation, located within the casing or compartment is separated from such wiring material.

11.2.16 With reference to 11.2.15(e), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

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11.2.17 Cords and other wiring material permitted in accordance with 11.2.15 shall be arranged to avoid being physically damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

11.2.18 Holes in walls or partitions through which insulated wires or cords pass and on which they may bear shall be provided with smoothly rounded bushings or surfaces upon which the wires or cords may bear, to prevent abrasion of the insulation. Bushings, if required, shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

11.2.19 A fiber bushing shall be not less than 3/64 inch (1.2 mm) in thickness, shall be so located that it will not be exposed to moisture, and shall not be employed where it will be subjected to a temperature higher than 194°F (90°C) under normal operating conditions.

11.2.20 To provide an acceptable unbushed opening in sheet metal, not requiring a bushing, usually requires roll or extrusion of the metal around the opening, or both, or the insertion of a grommet conforming to 11.2.18.

11.3 Short-circuit protection

11.3.1 Conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected and wired for connection to one supply line shall withstand the conditions of a short-circuit test without creating a risk of fire or electric shock. See Short-Circuit Test, Section 28.

Exception: Conductors that conform to the following are considered acceptable without test:

a) Conductors that have not less than one-third the ampacity of the required branch-circuit conductors; or

b) Conductors that are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length provided that the circuit will be protected by a fuse or HACR Type circuit breaker rated 60 amperes or less as specified on the product nameplate or provided as part of the product and acceptable for branch-circuit protection. This applies to any of the wiring materials specified in this standard, including those enclosed those enclosed in raceways; or

c) Conductors that serve as jumper leads between controls providing the length of the leads does not exceed 3 inches (76 mm) or the conductors are located in a control panel.

11.3.2 Factory wiring of a low-voltage safety circuit may be done with SP-2 cord having all-neoprene insulation, SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or power limited circuit cable, if such wiring is located in a cavity or compartment of an appliance and is adequately shielded from harm.

12 Separation of Circuits

12.1 Unless provided with insulation for the highest voltage involved, insulated conductors of different internal wiring circuits shall be separated by barriers or shall be segregated; and shall also be so separated or segregated from uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

12.2 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means which provides permanent separation from insulated or uninsulated live parts of a different circuit.

12.3 Field-installed conductors of any circuit shall be segregated or separated by barriers from:

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

b) Uninsulated live parts of any other circuit; and

c) Any uninsulated live parts whose short-circuiting may permit operation of the appliance that may result in a risk of fire, electric shock, or injury to persons except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that conductors having insulation at least equivalent to those referenced in group A of Table 11.1 are or will be installed when wired in accordance with the National Electrical Code, NFPA 70.

12.4 Segregation between field installed conductors and from uninsulated live parts connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits. If:

a) The number of openings in the enclosure does not exceed the minimum required for proper wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 12.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) More than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit is to be investigated.

12.5 To determine if an appliance complies with the requirements of 12.3, it is to be wired as it would be in service and in doing a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

12.6 If a barrier is used to provide separation between the wiring of different circuits or between operating parts and field installed conductors, it shall be of metal or insulating material and shall be held in place.

12.7 A metal barrier shall have a thickness at least as great as that required by Table 9.1 or 9.2, whichever applies, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

12.9 The output of a transformer device supplying a circuit classified as a Class 2 low-voltage circuit and provided as a part of the equipment shall not be interconnected with the output of another such transformer device unless the voltage and current measurements at the output terminals of the interconnected devices are within the values for a single Class 2, 30 volt, or less, transformer device.

12.10 Two or more transformer devices supplying circuits classified as Class 2, low-voltage circuits provided as a part of the appliance shall be treated as two separate circuits each having its own separate wiring compartment, and the output of each circuit shall be marked to warn that the separation shall be maintained.

ELECTRICAL COMPONENTS

13 Bonding for Grounding

13.1 Exposed or accessible noncurrent carrying metal parts which may become energized, and which may be contacted by the user or by service personnel during service operations likely to be performed when the appliance is energized, shall be electrically connected to the point of connection of an equipment ground.

13.2 Except as indicated in 13.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like, are to be bonded for grounding if they may be contacted by the user or serviceman.

13.3 Metal parts, as described below, need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, etc., which are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts;

b) Isolated metal parts, such as magnet frames and armatures, small assembly screws, and the, which are separated from wiring and uninsulated live parts;

c) Panels and covers which do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover; or

d) Panels and covers which are insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick.

13.4 A component, such as a switch, likely to become separated from its normal grounding means for purposes of testing or adjustment while the equipment is energized, is to be provided with a grounding conductor not requiring removal for such service.

13.5 Splices shall not be employed in wire conductors used for bonding.

13.6 Metal-to-metal hinge bearing members may be considered as a means for bonding a door for grounding.

13.7 A separate bonding conductor shall be of material rated for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

a) Be protected from mechanical damage, such as by being located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

13.8 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or by welding, soldering, or brazing with materials having a softening or melting point greater than 850°F (454°C). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

13.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 13.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

13.10 Where the bonding means depend on screw threads, two or more screws or two full threads of a single screw engaging metal is considered in compliance with 13.8.

13.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 13.12– 13.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 13.1 twice the current equal to the rating of the branch-circuit overcurrent device required to protect the equipment; and

b) During a short-circuit test in series with a fuse of proper rating. See Short-Circuit Test, Section 28.

Table 13.1
Duration of current flow, bonding-conductor test

Rating of overcurrent device, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

13.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 13.11, the size of the conductor or strap shall be in accordance with Table 13.2.

Table 13.2
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.3)
40	10	(5.3)	8	(8.3)
60	10	(5.3)	8	(8.3)
100	8	(8.3)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

13.13 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component(s) within the enclosure.

13.14 If more than one size of branch-circuit overcurrent device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

13.15 The following are considered to constitute means for connection to a ground:

a) In equipment intended to be connected to a metal-enclosed wiring system – A knockout or equivalent opening in a metal enclosure intended to receive the power-supply system; and

b) In equipment intended to be connected by a nonmetal-enclosed wiring system, for example, metal-clad cable – An equipment grounding terminal or lead.

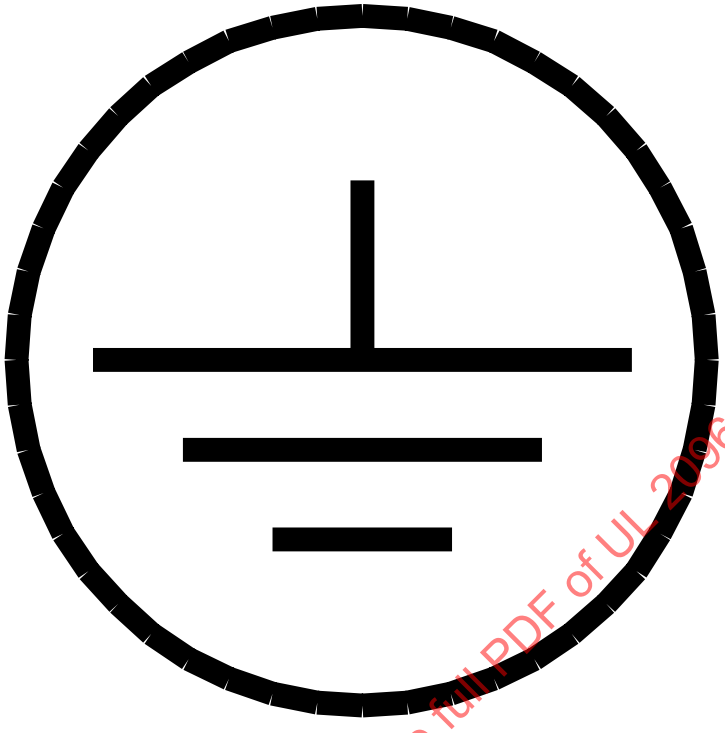
13.16 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application, in accordance with the National Electrical Code, NFPA 70.

13.17 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction fit connector shall not be used for the terminal for the field installed grounding conductor.

13.18 The terminal for the connection of the equipment grounding conductor shall be a green not readily removable terminal screw with a hexagonal head, a green, hexagonal, not readily removable terminal nut, or a green pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the words ″GREEN″, ″GROUND″, or ″GROUNDING″; the letters ″G″, ″GR″, a grounding symbol such as Figure 13.1, or otherwise identified by a distinctive green color. When the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be similarly marked.

13.18 effective January 30, 2009

Figure 13.1
Grounding symbol



13.19 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be finished continuous green color or a continuous green color with one or more yellow stripes, and no other lead visible to the installer shall be so identified.

14 Mounting of Electrical Components

14.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 14.2 and 14.3.

14.2 The requirement that a switch be prevented from turning may be waived if all of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during normal operation of the switch;

b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;

c) The spacings are not reduced below the required values if the switch rotates; and

d) The normal operation of the switch is by mechanical means rather than by direct contact by persons.

14.3 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the required values.

14.4 The means for preventing turning is to consist of more than friction between surfaces. A toothed lock washer which provides both spring take-up and an interference lock is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

14.5 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the acceptable values.

15 Motors and Motor Overload Protection

15.1 Each motor shall be protected by an integral thermal protector or by an overcurrent protective device or combinations thereof.

15.2 ″Overcurrent protective device″ as referred to in 15.1 means those that conform to the requirements of the National Electrical Code, NFPA 70, as follows:

a) A separate overcurrent device that is responsive to motor current. This device shall be rated or selected to trip at no more than the following percent of the motor full-load current rating:

1) Motors with marked service factor not less than 1.15, 125 percent;

2) Motors with a marked temperature rise not over 72°F (40°C), 125 percent; and

3) All other motors, 115 percent.

For a multispeed motor, each winding connector shall be considered separately and the motor is to be protected at all speeds.

b) If the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, or magnetic or thermal overload protective devices, the next higher size or rating may be used, but not higher than the following percent of motor full-load current rating:

1) Motors with a marked service factor not less than 1.15, 140 percent;

2) Motors with a marked temperatures rise not over 72°F (40°C), 140 percent; and

3) All other motors, 130 percent.

15.3 An integral thermal protective device shall comply with the Standard for Overheating Protection for Motors, UL 2111.

15.4 Separate overcurrent devices, except when included as part of a magnetic motor controller, are to be assembled as part of the equipment, and be readily identifiable as such after assembly to the equipment. Such protection is not to include means for manually interrupting the motor circuit if such interruption may result in the risk of fire, electric shock, or injury to persons.

15.5 Three-phase motors shall be provided with overcurrent protection as follows:

a) Three properly rated overcurrent devices shall be employed; or

b) Thermal protectors, combination of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide proper protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phase conditions. This marking may be a paper sticker, decal, or an attached wiring diagram.

15.6 Motors such as direct-drive fan motors which are not normally subjected to overloads, and which are determined to be adequately protected against overheating due to locked-rotor current by a thermal or overcurrent protective device, may be accepted under the requirement for overcurrent protection provided it is determined that the motor will not overheat under actual conditions of use.

15.7 Impedance protection may be accepted for motors which are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under the performance requirements of this standard.

15.8 Fuses shall not be used as motor overload protective devices unless the motor is adequately protected by the largest size fuse which can be inserted in the fuseholder.

15.9 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short-Circuit Test, Section 28.

15.10 A motor shall be designed for continuous duty as indicated by the designation ″CONTINUOUS″ or ″CONT″ on the nameplate.

15.11 In no case shall interruption of the circuit to a motor by the overcurrent or thermal protective device result in a risk of fire, electric shock, or injury to persons during operation of the equipment or the discharge of fuel that may result in a risk of fire or injury to persons. If a burner depends solely upon an electrical valve to stop the flow of fuel to the burner, the interruption of the circuit to the motor by the protective device shall also cause the interruption of the circuit to the valve.

15.12 Automatic-reset type protective devices shall not be used if the automatic reclosing of the circuit to the motor by the device may result in a risk of fire, electric shock, or injury to persons during operation of the equipment.

15.13 The enclosure of a motor shall have no openings which will permit a drop of liquid, or a particle falling vertically onto the motor, to enter the motor as applied to the assembly.

15.14 Conformance to 15.13 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

15.15 Motors having openings in the enclosure or frame shall be installed or shielded to prevent particles from falling out of the motor onto combustible material located within or under the assembly.

15.16 The requirement in 15.15 will necessitate the use of a barrier of nonflammable material under an open type motor unless:

a) The structural parts of the motor or the burner such as the bottom closure, provide the equivalent of such a barrier; or

b) The motor overload protection device provided with a single-phase motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions, as applicable to the particular type of motor:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

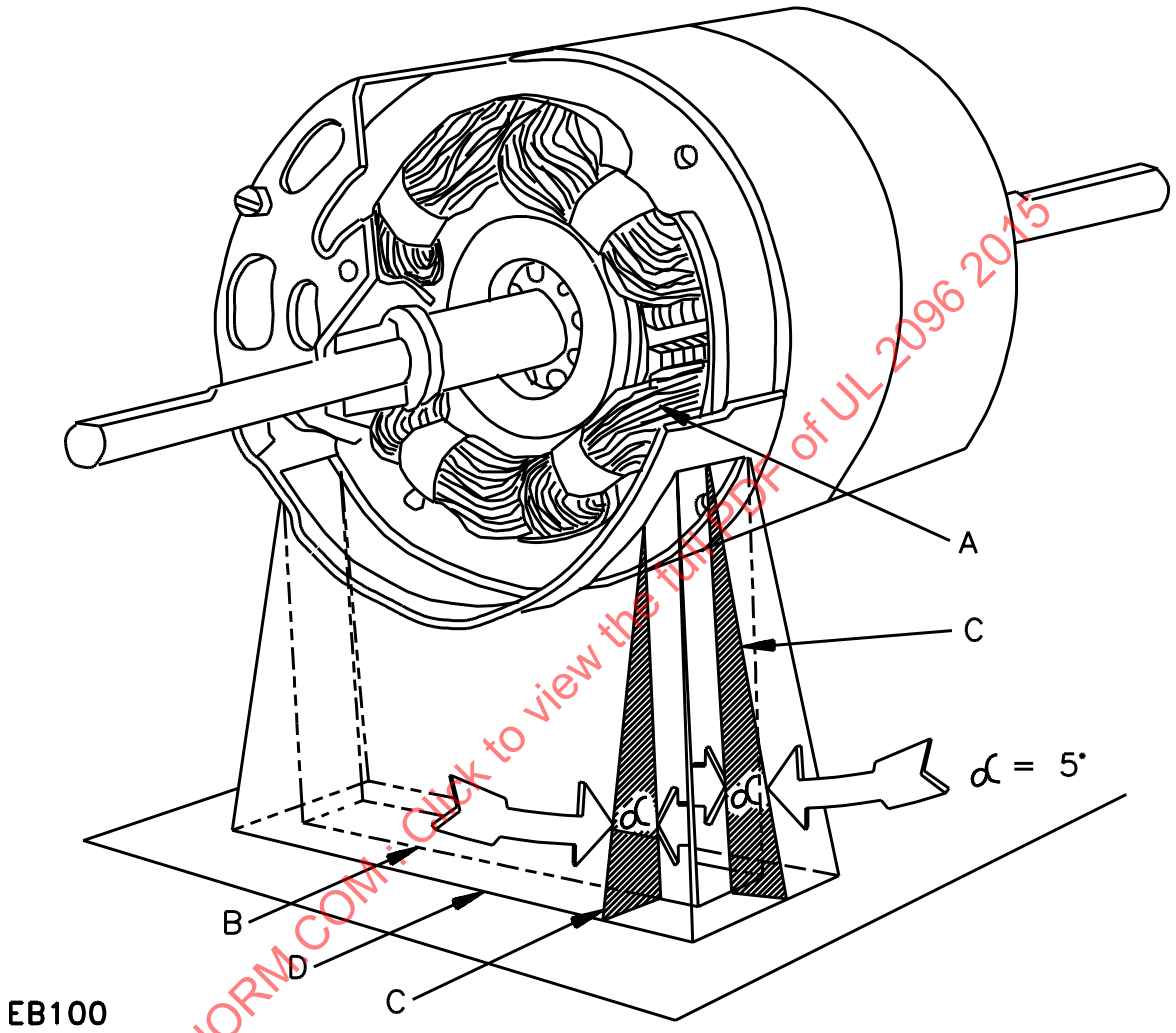
c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from becoming more than 275°F (125°C) under the maximum load below which the motor will run without causing the protector to cycle and from becoming more than 302°F (150°C) with the rotor of the motor locked.

d) The motor complies with the requirements for impedance-protected motors and the motor winding will not exceed a temperature greater than 302°F (150°C) during the first 72 hours of operation with the rotor of the motor locked.

15.17 The barrier mentioned in 15.16 shall be horizontal, located as indicated in 15.1, and have an area not less than that described in that illustration. Openings for drainage, ventilation, and the like, may be employed in the barrier provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 15.1
Location and extent of barrier

LOCATION AND EXTENT OF BARRIER



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding if it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding which is partially shielded by the motor enclosure or equivalent.

B – Projection of outline of motor winding on horizontal plane.

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always (1) tangent to the motor winding, (2) 5 degrees from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is to be that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

16 Overcurrent Protection of High-Voltage Control-Circuit Conductors

16.1 General

16.1.1 For the purpose of the requirements in 16.2.1 – 16.4.2, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 17, for additional requirements.

16.2 Direct-connected high-voltage control circuit

16.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 36.15.

16.3 Tapped high-voltage control circuits

16.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the burner on the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 16.3.3 – 16.4.2.

16.3.2 A high-voltage control circuit that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, NFPA 70.

16.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 16.1.

Exception No. 1: A 18, 16, or 14 AWG (0.82, 1.3, or 2.1 mm^2) conductor that is not more than 4 feet (1.2 m) long between points of opposite polarity may be protected by a fuse or an HACR Type circuit breaker rated 60 amperes or less.

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 28.13.

Exception No. 3: A lead that is not more than 12 inches (305 mm) long need not be provided with overcurrent protection.

Exception No. 4: A control-circuit conductor, supplied from the secondary of a single-phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device located in the primary side of the transformer if:

a) This protection is in accordance with the requirements specified in Overcurrent Protection of Transformers, Section 17, and

b) The rating of the device does not exceed the applicable value specified in Table 16.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 16.1
Overcurrent protective device rating for control circuit conductors

Tapped control-circuit conductor, size,		Minimum rating of overcurrent protective device, amperes			
		Conductors contained in control equipment enclosure		Conductors extending beyond control-equipment enclosure	
AWG	(mm^2)	Copper	Aluminum[a]	Copper	Aluminum[a]
18	0.82	25	–	7	–
16	1.3	40	–	10	–
14	2.1	100	–	45	–
12	3.3	120	100	60	45
10	5.3	160	140	90	75
Larger than 10		b	b	c	c

[a] Includes copper-clad aluminum.
[b] 400 percent of value specified for 60°C conductors in Table 310-17 of National Electrical Code, ANSI/NFPA 70.
[c] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70.

16.4 Overcurrent-protective devices

16.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 16.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 36.13.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 16.1.

16.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 16.3.3; and

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker or a fuse that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, or R cartridge fuse and a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 28.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 36.14.

17 Overcurrent Protection of Transformers

17.1 High-voltage transformers – general

17.1.1 A transformer, other than as described in 17.4.1 and 17.4.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 17.2.1; or

b) Be protected by an overcurrent device or devices in accordance with the requirements in 17.3.1; or

c) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 30.

Exception: This requirement is not applicable to an interchangeable ignition transformer that has been investigated in accordance with the requirements for ignition transformers in the Standard for Specialty Transformers, UL 506.

17.2 High-voltage transformers– thermal protection

17.2.1 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High-Voltage Transformers, Section 29.

Exception: If the thermal-overload-protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test, High-Voltage Transformers, Section 30.

17.2.2 A thermal cutoff shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manually or automatically reset thermal protector shall have an endurance rating of not less than 6000 cycles and shall comply with the requirements for calibration of temperature-limiting controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

17.2.2 revised March 9, 2015

17.3 High-voltage transformers– overcurrent protection

17.3.1 Each overcurrent device that protects a high-voltage transformer shall comply with the requirements specified in 17.3.2, 17.3.3 and 17.5.1 – 17.5.3.

17.3.2 A high-voltage transformer shall be protected by an overcurrent device, or devices, that is located in the primary circuit and that is rated or set as indicated in Table 17.1 for the primary. See 17.3.3 and 17.5.1.

Table 17.1
Maximum rating of transformer overcurrent protective device

Rated primary or secondary current, amperes	Maximum rating of overcurrent device, percent of transformer current rating, when in :	
	Primary	Secondary
Less than 2	300[a]	167
2 or more, less than 9	167	167
9 or more	125[b]	125[b]

[a] Does not apply to an autotransformer; may be increased to 500 percent if transformer supplies a motor control circuit.

[b] If 125 percent of the current does not correspond to the standard rating of fuse or circuit breaker, the next highest standard rating may be used. For the purpose of this requirement, standard ratings are 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60 amperes.

17.3.3 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device rated or set as indicated in Table 17.1 for the secondary.

17.4 Low-voltage transformers – general

17.4.1 Except as specified in 17.4.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 17.5.1.

17.4.2 A transformer that directly supplies a Class 2 circuit [see 4.43(b)] shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

17.4.2 revised December 11, 2009

17.5 Low-voltage transformers– overcurrent protective devices

17.5.1 Overcurrent protection in the primary circuit of a transformer, as described in 17.3.2 and 17.4.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 17.3.2 or 17.4.1, as applicable.

17.5.2 Overcurrent protection in the secondary circuit of a transformer, as required by 17.3.3 shall be provided as part of the appliance. If a fuse is used, the appliance shall be marked in accordance with 36.13.

17.5.3 A required transformer overcurrent-protective device provided as part of the product shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 17.3.2 – 17.4.1, as applicable, and

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker, or a fuse, that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, or R cartridge fuse and a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 28.1. The product shall be marked in accordance with 36.14.

18 Switches and Controllers

18.1 A controller(s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

Exception: A controller is not required for an assembly with more than one motor if the marked maximum fuse size does not exceed 20 amperes at 125 volts or less or 15 amperes at 600 volts or less and with not more than 6 amperes full-load current for each motor.

18.2 Motor controllers shall be arranged so that they will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

18.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 36.16 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

18.4 A controller or switch shall be rated for the load that it controls. The load controlled is to include any load external to the assembly for which connections in the controller or switch circuit are provided.

18.5 A controller that may be called upon to break a motor load under locked-rotor conditions shall have a current-interrupting capacity not less than the locked-rotor load of the motor controlled.

18.6 If the controller is cycled by the operation of an automatic-reset overload device, it is to withstand an endurance test under locked-rotor conditions without malfunction. The endurance test is to be of a duration equivalent to that required for the overload device and at an equivalent rate.

18.7 The locked-rotor load of a motor is based on six times the full-load current rating of the motor if alternating current, and ten times the full-load current rating if direct current.

18.8 If the marked maximum fuse size of the boiler assembly does not exceed the maximum size for protecting the motor of the smallest rating, two or more motors each having individual running overcurrent protection may be connected to the same power supply if it can be determined that a fuse of the marked size will not open under the most severe conditions of service that might be encountered.

19 Capacitors

19.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 19.2 and 19.3, the container shall be of metal providing strength and protection not less than that of uncoated steel 0.020 inch (0.51 mm) thick.

19.2 The individual container of a capacitor may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the device assembly, and provided that such box, case, or the like, is acceptable for the enclosure of current-carrying parts.

19.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts in accordance with Table 16.1.

19.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 28.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 28.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

20 Electrical Insulating Materials

20.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

20.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

20.3 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall be not less than 0.028 inch (0.71 mm) in thickness, except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.

SPACINGS

21 High-Voltage Circuits

21.1 Except as noted in 21.2 – 21.4, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 21.1.

Table 21.1
Minimum spacings

Ratings		Minimum spacings[a], inch (mm)					
Volt-amperes	Volts	Through air		Over surface		To enclosure[d]	
0 – 2000	0 – 300[b]	1/8[c]	(3.2)	1/4	(6.4)	1/4	(6.4)
more than 2000	0 – 150	1/8[c]	(3.2)	1/4	(6.4)	1/2[e]	(12.7)
	151 – 300	1/4	(6.4)	3/8	(9.5	1/2[e]	(12.7)
	301 – 600	3/8	(9.5)	1/2[d,e]	(12.7)	1/2[e]	(12.7)

[a] See 20.3.

[b] If over 300 volts, spacings in last line of table apply.

[c] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and grounded metal, shall not be less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greated than that given in the above table. Wiring terminals are those connected to the field and not factory wired. Measurements are to be made with solid wire of adequate ampacity for the load connected to each terminal.

[d] Includes fittings for conduit or metal-clad cable.

[e] The spacings at wiring terminals of a motor shall be at least 1/4 inch (6.4 mm) for a motor rated 250 volts or less and 3/8 inch (9.5 mm) for a motor rated more than 250 volts.

21.2 The through-air and over-surface spacings at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load(s) that the component controls. However, the spacing from the component to the enclosure shall be judged on the basis of the total load on all components in the enclosure. For example, the through-air and over surface spacings at a component which controls only a motor is judged on the basis of the volt-ampere of the motor. A component that controls loads in addition to the motor is similarly judged on the basis of the sum of the volt-ampere of the loads so controlled; however, a component that independently controls separate loads is judged on the basis of the volt-ampere of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

21.3 The spacing requirements in Table 21.1 do not apply to the inherent spacings of a component which is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, shall be those indicated.

21.4 All uninsulated live parts connected to different circuits, except subdivided or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated in 21.1 – 21.3 and shall be judged on the basis of the highest voltage involved.

21.5 For circuits not exceeding 300 volts, the over-surface spacings for glass-insulated terminals of motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in the table; and may be 1/4 inch where 3/8 inch (9.5 mm) is specified.

22 Low-Voltage Circuits

22.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons shall comply with 22.2 – 22.4.

22.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 21.4.

22.3 The spacing between wiring terminals regardless of polarity, and between the wiring terminal and a dead metal part (including the enclosure and fittings for the connection of conduit) which may be grounded when the device is installed shall be not less than 1/4 inch (6.4 mm).

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

22.5 The spacings in low-voltage circuits that do not contain devices such as indicated in 22.1 are not specified.

PERFORMANCE

23 General

23.1 A heating appliance shall be capable of operation in compliance with these requirements when firing any grade of fuel oil recommended and/or the type of gas as marked on the appliance nameplate. Each size and type of device, or a sufficient number of sizes and types to be representative of the entire range of sizes and types submitted, are to be subjected to all or part of the tests prescribed herein. If optional features affecting performance are furnished, the burner may be tested with each such optional equipment.

23.2 A device, when tested in accordance with these requirements, shall be uniform and reliable in operation and free from excessive carbonization or other phenomena that may adversely affect the intended operation of the heating appliance.

23.3 An appliance which is equipped with an FGR system to provide for low NO_x emissions shall be tested with and without the system operating. There shall be no mechanical changes made to the device other than blocking off or deenergizing the FGR system.

23.4 The appliance shall be installed and arranged for operation in accordance with the manufacturer's operating instructions furnished with the product.

23.5 The flue gas recirculation equipment shall be installed in accordance with the instructions furnished with the burner assembly.

23.6 An analysis of the electrical and mechanical system components shall be undertaken with the burner equipment firing the appropriate test fuels. Depending on the equipment provided, the evaluation may consist of firing the appliance with imposed misadjustments on either/or the electrical/mechanical components and will include an evaluation of the test points of any controls provided to monitor/maintain burner operation with the FGR system operating.

Exception: When a recirculation damper is driven by a modulating motor through mechanical linkage, only the electrical positioning of the modulating motor must be evaluated.

23.7 An evaluation of any condensation that may collect in the recirculated flue gas ductwork or components shall be undertaken to determine the pH content. It is assumed the condensate will have an acidic range from pH 3 to pH 4.5. If the pH concentration is less than 3, further evaluation of the system components may be necessary with respect to corrosion protection.

23.8 Appliances equipped, or intended to be equipped in the field, with preheaters to heat the fuel oil before it is delivered for combustion are not required to burn cold oil. Such burners shall be arranged so that no oil can be delivered to the burner for combustion until it has been heated to the intended temperature.

24 Instrumentation

24.1 Draft

24.1.1 Draft is to be measured by a draft gauge which may be read directly to 0.005 inch (or 0.13 mm) water column and which has an accuracy of ±0.0025 inch (0.064 mm). A gauge is to be checked for zero reading at the beginning and the end of each test.

24.2 Fuel input

24.2.1 For oil-fired appliances, the fuel input rate is to be determined by a scale accurate to 1.0 pound (453.6 g) or a burette capable of the same resultant accuracy.

24.2.2 Gas-fired appliances are to be connected to a calibrated orifice plate or dedicated (and calibrated) gas meter of the appropriate size for the maximum hourly input in cubic feet per hour and be provided with connections to provide both temperature and pressure correction.

24.3 Power measurement

24.3.1 The total electrical input to a fuel burning assembly is to be measured in amperes.

24.3.2 An electrical meter is to have a maximum scale range of not more than 1-1/2 times the value to be measured. The smallest scale division is to be not more than 1/50 of the maximum scale range.

24.4 Speed measurement

24.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or of a mechanism driven by it. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (94 W).

24.5 Temperature measurement

24.5.1 Temperatures are to be determined by means of a potentiometer and bead-type thermocouples. Unless otherwise indicated, a thermocouple is to be made of wires not heavier than 24 AWG (0.21 mm^2).

24.5.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 27.1.

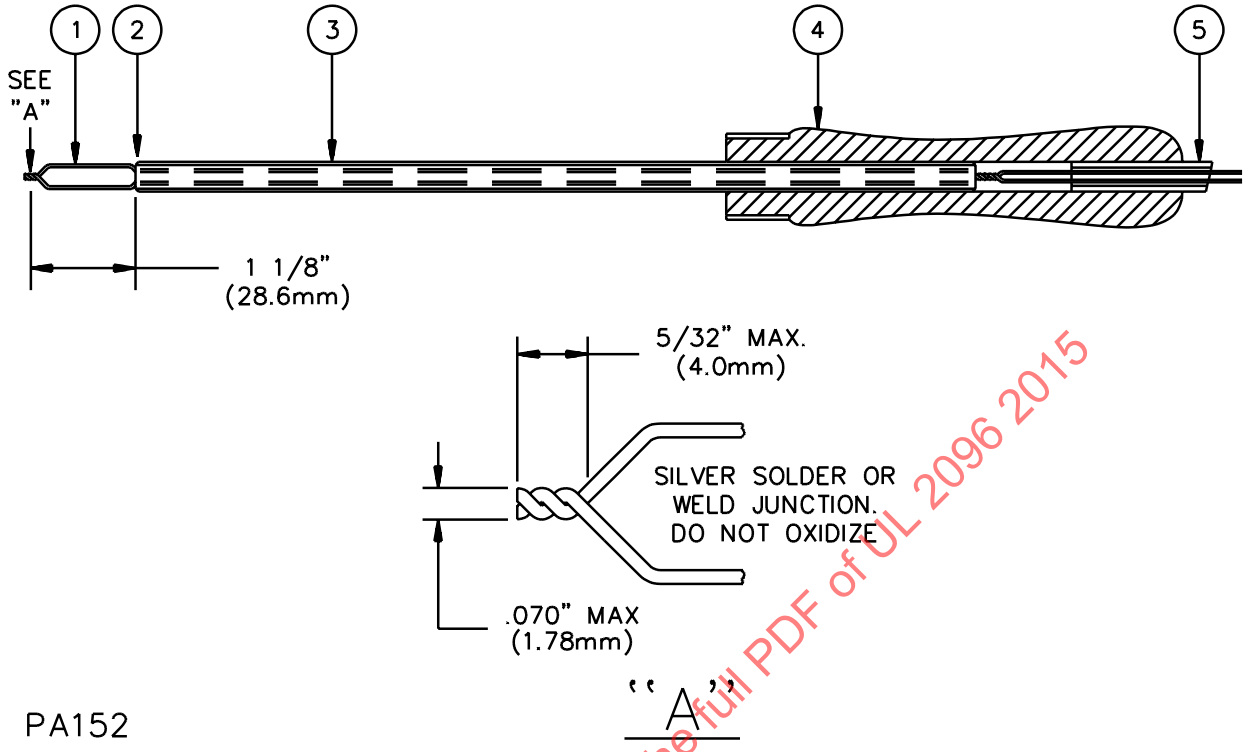
24.5.3 Each thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material whose temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place; but where a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

24.5.4 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with the tip held in a good thermal contact with the surface by pressure-sensitive tape; except that for zero clearance, the thermocouples are to be applied to surfaces of the boiler assembly at points of zero clearance.

24.5.5 Thermocouples are to be attached to surfaces other than as described in 24.5.3 and 24.5.4 by being cemented or taped to the surface in a manner to assure good thermal contact with the surface.

24.5.6 The flue-gas temperature is to be measured by a thermocouple such as illustrated by Figure 24.1 inserted into the chimney connector as shown on Figure 24.2. There is to be no draft control between the appliance and the point where the flue-gas temperature is measured. If a draft control is incorporated in the boiler assembly, it is to be dependably sealed in the position allowing maximum draft during all tests.

Figure 24.1
Standard thermocouple for flue-gas temperature



1. 20 AWG (0.51 mm^2) iron-constantan, asbestos, or woven-glass-covered thermocouple wires extending from hot junction to potentiometer or reference junction.

2. 1 – Leeds & Northrup Standard 714B, or equal, 1/4 inch (6.4 mm) outside diameter of two-hole porcelain insulator cut to length and ends beveled on two sides.

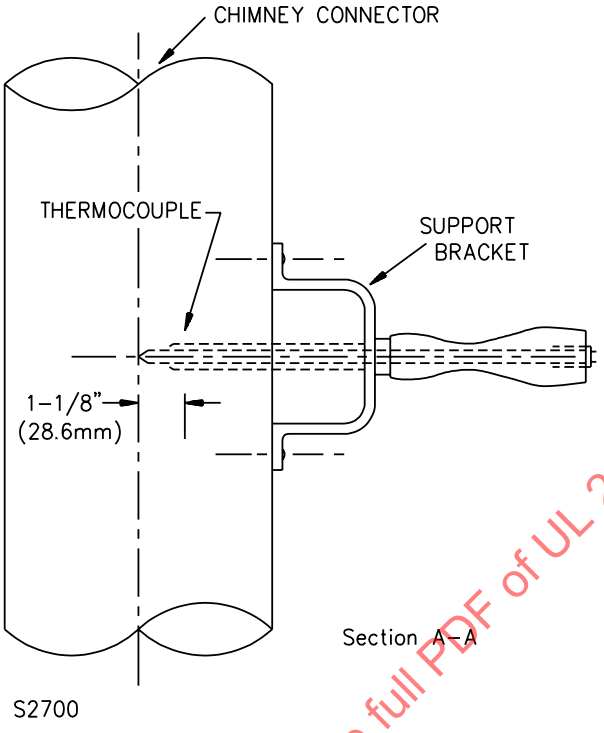
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

5. 1 – Piece of rubber tubing, approximately 5/16 by 3/32 by 2 inches long (7.9 by 2.4 by 50.8 mm long).

6. In lieu of individual components described in (1), (2), and (3) above, any combination of preassembled parts of tubing, insulators and thermocouples may be used.

Figure 24.2
Flue-gas thermocouple and support bracket



24.5.7 Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation such as more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

24.6 Flue-gas sampling and temperatures

24.6.1 Appliances having a vertically discharging draft hood outlet are to have attached to and vertically above the outlet sufficient uninsulated black-iron vent pipe, the same size as the draft hood outlet, to extend not less than 5 feet (1.52 m) nor more than 5 feet 6 inches (1.68 m) above the highest point of the draft hood relief opening. Devices having a horizontally discharging draft hood outlet are to have attached an uninsulated black-iron 90 degree elbow, the same size as the draft hood outlet, and sufficient vertical uninsulated black-iron vent pipe so that the outlet is not less than 5 feet nor more than 5 feet 6 inches above the highest point of the draft hood relief opening.

24.6.2 Two lines, intersecting at right angles, are to be established in the horizontal plane of measurement which is to be located in the vent pipe 4 feet 6 inches (1.37 m) above the highest point of the draft hood relief opening. They are to be oriented so that they will divide the internal area into quadrants. One temperature is to be taken at the intersection of the two lines. Eight temperatures are to be taken in two sets of four along each line at points one-third and two-thirds of the distance from the intersection to the periphery. Temperatures are to be determined with a bead type thermocouple not larger than 24 AWG placed successively at the specified locations. The flue-gas temperature is to be the arithmetic average of these nine individual readings.

24.6.3 Appliances not equipped with draft hoods are to have attached a 3 foot (0.91 m) high length of uninsulated black-iron pipe, the same size as the vent collar or induced-draft fan outlet of the device. The pipe may be attached directly to a vertical or horizontal flue-gas outlet.

24.6.4 Two lines, intersecting at right angles, are to be established in the plane of measurement at right angles to the axis of the vent pipe within 1 foot (304.8 mm) of the normal flue-gas outlet of the device. They are to be oriented so that they will divide the cross-sectional area in the vent pipe into quadrants. One temperature measurement is to be taken at the intersection of the two lines. Eight temperature measurements are to be taken, in two sets of four along each line, at points one-third and two-thirds of the distance from the intersection to the periphery. The temperature is to be determined with a bead type thermocouple not larger than 24 AWG successively placed at the specific positions. The flue-gas temperature is to be the average of these nine individual readings.

24.6.5 Any flue-gas sample is to be taken in a plane in the vent pipe not more than 3 inches (76.2 mm) from the plane of temperature measurement specified in the preceding unless the device is equipped with a draft hood in which case the flue-gas sample is to be taken at a location where uniform undiluted samples can be obtained. Any draft hood relief opening shall be effectively closed when flue gas temperatures are measured for the purpose of determining stack loss. As an alternate to closing the draft hood relief openings, the flue gas sample can be obtained at a location upstream of the draft hood inlet opening.

25 Test Voltage

25.1 Unless otherwise specified, burners are to be tested at the potentials indicated in Table 25.1 for each test as detailed in the describing the test.

Table 25.1
Test voltages

Rated voltage	Normal test voltage	Overvoltage	Undervoltage[a]
110 – 120	120	132	102
280	208	229	177
220 – 240	240	264	204
254 – 277	277	305	235
440 – 480	480	528	408
550 – 600	600	660	510
Other	Rated	110 percent rated	85 percent rated

[a] Values in this column are applicable to alternating-current potentials. Undervoltage tests for a direct-current burner or component are to be conducted at 80 percent rated voltage.

26 Power Input Test

26.1 The power input to an appliance shall be no more than 110 percent of the marked rating of the appliance.

26.2 To determine if an appliance complies with the requirement specified in 26.1, the power input is to be measured with the appliance at the temperature attained under intended operating conditions, full-load conditions, and while connected to a supply circuit of rated voltage as specified in 25.1.

27 Temperature Test

27.1 When an appliance is tested in accordance with these requirements, no part shall attain a temperature sufficient:

a) To damage required corrosion protection;

b) To adversely affect the operation of safety controls;

c) To impair the value of required thermal or electrical insulation; and

d) To cause creeping, distortion, sagging, or similar damage if such damage to the material or part may result in a risk of fire.

The temperature rises at specific points shall be no greater than those specified in Table 27.1 unless otherwise indicated.

Table 27.1
Maximum temperature rises[a]

Item	Maximum rise above inlet-air temperature			
	Column 1		Column 2	
	Degrees F	Degrees C	Degrees F	Degrees C
Surfaces of test enclosure, ceiling, walls, and the like	90	50	175	97
Surfaces of floor beneath and within 3 feet (0.91 m) of a device to be classified for installation on combustible floors	90	50	175	97
Surface of device in lieu of test structure – standard clearances	180	100	310	173
Surface of device in lieu of test structure – increased clearances	280	156	490	272
Surfaces of device at points of zero clearance to test structure or exterior surfaces, vent pipe excepted, of a portable or mobile heater	90	50	175	97
Air filters	90	50	175	97
Diaphragms, nonmetallic Aluminum alloys:	73	41	84	47
1100	330	183	430	239
3003	430	239	530	294
2014, 2017, 2024, 5052	530	294	630	350
Flame spreaders and combustion heads:				
Gray cast iron	930	517	930	517
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1230	683	1230	683
Ductile, nodular, cast iron	1230	683	1230	683

Table 27.1 Continued on Next Page

Table 27.1 Continued

Item	Maximum rise above inlet-air temperature			
	Column 1		Column 2	
	Degrees F	Degrees C	Degrees F	Degrees C
Types 501, 502 iron-chromium steels	1230	683	1230	683
Type 430 iron-chromium steel	1430	794	1430	794
Type 442 iron-chromium steel	1560	867	1560	867
Type 446 iron-chromium steel	1560	867	1560	867
Type 309 iron-chromium-nickel steel	1730	961	1760	961
Flue-gas baffles:				
Aluminum coated steel	1030	572	1030	572
Ceramic coated steel (A19 or equivalent)	1030	572	1030	572
Low carbon steel	930	517	930	517
Gray cast iron	930	517	930	517
Ductile, nodular, cast iron	1230	683	1230	683
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1230	683	1230	683
Types 501, 502 iron-chromium steels	1230	683	1230	683
Type 430 iron-chromium steel	1430	794	1430	794
Type 442 iron-chromium steel	1560	867	1560	867
Type 446 iron-chromium steel	1560	867	1560	867
Type 309 iron-chromium-nickel steel	1730	961	1730	961
Heating surfaces:				
Aluminum coated steel	1030	572	1130	648
Ceramic coated steel (A19 or equivalent)	1030	572	1130	648
Low carbon steel	830	461	930	517
Gray cast iron	830	461	930	517
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1010	561	1110	617
Type 410 iron-chromium steel	1080	600	1180	656
Type 430 iron-chromium steel	1130	648	1330	738
Type 442 iron-chromium steel	1560	867	1660	922
Type 446 iron-chromium steel	1560	867	1660	922
Type 321 iron-chromium-nickel steel	1340	744	1530	850
Type 347 iron-chromium-nickel steel	1375	764	1530	850
Type 316 iron-chromium-nickel steel	1440	800	1580	878
Type 309 iron-chromium-nickel steel	1345	747	1545	858
Aluminum coated steel liners and radiation shields[b]	830	461	830	461
Galvanized steel[c]	480	267	630	350
Points on or within a terminal box or compartment, unless marked in accordance with 36.7	63	35	108	60
Wire, code[d]	25°C (45°F) less than temperature rating in National Electrical Code, ANSI/NFPA 70		Temperature rating in National Electrical Code, ANSI/NFPA 70	
Appliance wiring material[d]				
75°C rating	90	50	117	65
80°C rating	99	55	126	70
90°C rating	117	65	144	80
105°C rating	144	80	171	95
200°C rating	315	175	360	200

Table 27.1 Continued on Next Page

Table 27.1 Continued

Item	Maximum rise above inlet-air temperature			
	Column 1		Column 2	
	Degrees F	Degrees C	Degrees F	Degrees C
250°C rating	405	225	450	250
Flexible cord –				
Types SO, ST, SJO, SJT[g]	63	35	108	60
GTO cable	63	35	108	60
Electrical insulation material				
Class A insulation on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) of direct-current motors, and of universal motors.[e,h]				
In open motors –				
Thermocouple method	117	65	208	115
Resistance method	135	75	208	115
In totally enclosed motors –				
Thermocouple method	126	70	208	115
Resistance method	144	80	208	115
Class A insulation on coil windings of alternating current motors having a frame diameter of 7 inches or less, (not including universal motors)[e,h]				
In open motors –				
Thermocouple or resistance method	135	75	208	115
In totally enclosed motors –				
Thermocouple or resistance method	144	80	208	115
Class B insulation on coil windings of alternating current motors having a frame diameter of more than 7 inches, of direct-current motors and of universal motors.[e,h]				
In open motors –				
Thermocouple method	153	85	252	140
Resistance method	171	95	252	140
In totally enclosed motors –				
Thermocouple method	162	90	252	140
Resistance method	180	100	252	140
Class B insulation on coil windings of alternating current motors having a frame diameter of 7 inches or less, not including universal motors.[e,h]				
In open motors –				
Thermocouple or resistance method	171	95	252	140
In totally enclosed motors –				
Thermocouple or resistance method	180	100	252	140
Class 105 insulation on coils other than motor coils.[e]				
Thermocouple method	117	65	208	115
Class 130 insulation on coils other than otor coils.[e]	153	85	252	140
Class 155 insulation	Not specified			
Class 180 insulation	As determined by test			
Fuses[i]	117	65	Not specified	
Varnish-cloth insulation	108	60	153	85
Phenolic composition employed as electrical insulation or as a part whose deterioration will result in a risk of fire or electric shock.[d]	225	125	270	150
Fiber employed as electrical insulation	117	65	162	90

Table 27.1 Continued on Next Page

Table 27.1 Continued

Item	Maximum rise above inlet-air temperature			
	Column 1		Column 2	
	Degrees F	Degrees C	Degrees F	Degrees C
Class 2 transformer enclosure	108	60	153	85
Power and ignition transformer enclosure	117	65	162	90
Capacitors – Electrolytic type[f]	72	40	Not specified	
Other types[g]	117	65	Not specified	
Sealing compounds	Maximum temperature 15°C (27°F) less than the melting point			

[a] The specified maximum temperature rises apply to parts of a burner assembly or appliance if malfunction of the part may result in a risk of fire, electric shock, or injury to persons.

[b] The specified maximum temperature rise applies if the reflectivity of aluminum coated steel is utilized to reduce a risk of fire; otherwise the allowable temperature rise is as given under Heating Surfaces.

[c] The specified maximum temperature rises apply if the galvanizing is required as a protective coating or the reflectivity of the surface is utilized to reduce a risk of fire.

[d] The limitations on rubber and thermoplastic insulation and on phenolic composition do not apply to compounds which have been investigated and found to be acceptable for higher temperatures than those specified in Table 27.1. Thermoplastics shall in no case attain temperature at which the material begins to flow. Rubber-insulated conductors within a Class A insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than (63°F) 35°C, provided that a suitable braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords. See note e.

[e] Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices, for example, a coil immersed in sealing compound or unless the coil wrap includes thermal insulation or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be 9°F (5°C) for Column 1 limits for Class A insulation on coil windings of alternating current motors having a diameter of 7 inches (178 mm) or less, open type, not including universal motors; 18°F (10°C). For Column 1 limits for Class B insulation on coil windings of alternating current motors having a diameter of 7 inches (178 mm) or less, open type, not including universal motors; 27°F (15°C), for Column 1 limits for Class A insulation on coil windings of alternating current motors having a diameter of more than 7 inches (178 mm), open type, not including universal motors; and 36°F (20°C), for Column 1 limits for Class B insulation on coil windings of alternating current motors having a diameter more than 7 inches (178 mm), open type, not including universal motors, more than the indicated maximum, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

[f] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may not be more than 117°F (65°C).

[g] A capacitor which operates at a temperature higher than 117°F (65°C) rise may be judged on the basis of its marked temperature rating.

[h] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes, and the like, used solely for motor cooling, mounting, assembly, or connection.

[i] Includes both casing and ferrule. However, a temperature not more than 20°C (36°F) higher than the values indicated in the table is acceptable on the casing (not ferrule) of a Class G, J, T, or L fuse.

27.2 Temperatures are to be ascertained by temperature changes of not more than 5°F (3°C) for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

27.3 The specific conditions of the temperature test for central furnaces and unit heaters are covered in Sections 103 – 107. The specific conditions of the continuous operation temperature test for a burner is covered in Tests Firing Oil, Section 63. The specific conditions of the continuous operation temperature test for a boiler is covered in Continuous Operation Temperatures – Test No. 3, Section 80.

28 Short-Circuit Test

28.1 Inherent overheating-protective devices, bonding conductors or connections when required, and conductors of multiple motor circuits shall withstand short-circuit and ground-fault conditions when protected by:

a) A device that is recognized for branch-circuit protection and located in the product; or

b) A branch-circuit protective device of the type and maximum rating specified on the product nameplate.

There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line and low-voltage circuits.

28.2 For the purpose of these tests:

a) Circuit breakers and fuses are not considered to be interchangeable;

b) Fuses of the same rating are considered to be interchangeable;

c) HACR Type circuit breakers of the same rating are considered to be interchangeable; and

d) Other types of circuit breakers are not considered to be interchangeable with each other or with HACR Type circuit breakers.

28.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the appliance as indicated in Table 28.1. The appliance full-load current is determined by adding the motor full-load current of each motor, as determined in accordance with the National Electrical Code, NFPA 70, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current is to be used as the basis for selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit.

Table 28.1
Short-circuit test currents

	Single phase			
115 V	208 V	230 – 240 V	277 V	Circuit capacity amperes
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 –1 6.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
	Three phase			
208 V	220 – 240 V	440 – 480 V	550 – 600 V	Circuit capacity amperes
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	1500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

28.4 Except as indicated in 28.6 – 28.9, an overcurrent protective or a thermal protective device in an appliance having more than one motor wired for connection to one supply line shall withstand short-circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

28.5 The nearest standard size fuse, rated no higher than the current indicated in 28.4 but no less than 15 amperes, is to be used for the test. The maximum fuse size marked on the appliance, as specified in 35.2, is not to exceed this value.

28.6 With reference to 28.4, the protective device may be tested with a fuse having a lower rating than indicated if the appliance:

a) Will start and operate without blowing the fuse; and

b) Is marked to indicate such a maximum limit of fuse protection.

28.7 The test specified in 28.1 need not be conducted if:

a) A thermally protected motor or a separately enclosed motor-overload protective device is within an outer cabinet of the appliance;

b) The motor or device is intended to be protected by a fuse or HACR Type circuit breaker as specified on the unit nameplate or provided as part of the unit and is acceptable for branch-circuit protection;

c) The assembly is constructed so that flame and molten metal will be confined within the cabinet;

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 11.2.16; and

e) Short-circuiting between live parts of different circuits will not result.

28.8 Short circuit tests need not be conducted on an assembly provided with more than one motor, each not exceeding 1 horsepower (746 W output) in rating and intended to be used on a branch circuit protected at no more than 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, if the following conditions are met:

a) The marked maximum branch circuit protective device size does not exceed 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts; and

b) The full-load current rating of each motor does not exceed 6 amperes.

28.9 Short circuit tests need not be conducted on an assembly provided with more than one motor if the motors have full-load current or horsepower rating(s) in excess of those ratings specified in 28.8 if:

a) The marked maximum branch circuit protective device size of the assembly does not exceed the maximum size for protecting the motor of the smallest rating; and

b) It is determined that a fuse of marked size will not open under the most severe conditions of service that might be encountered.

28.10 A nonrenewable cartridge fuse is to be connected in series with the device. A new fuse and device, connection, or conductor are to be used for each test.

28.11 Bonding conductors and bonding connections shall not open when the appliance is subjected to the conditions of this test.

28.12 Motor-circuit conductors shall not become damaged when the appliance is subjected to the conditions of this test.

28.13 For the test referenced in Exception No. 2 of 16.3.3, three samples of each conductor under consideration are to be subjected to each test condition specified and a new protective device is to be used for each test. The conductor and connection to be tested are to be connected in series with the overcurrent-protective device. Consideration is to be given to both short-circuit and ground-fault conditions. The capacity of the circuit is to be based on the ratings of the unit in accordance with Table 28.1 and is to be measured without the lead to be tested in the circuit. The voltage source for the test circuit is to be as specified in Table 28.1 and the power factor is to be 0.9 – 1.0 unless a lower power factor is determined to be acceptable. None of the conductors or lead terminations shall be damaged as a result of the test.

28.14 There shall be no ignition of cheesecloth surrounding the enclosure of a protective device when three samples are tested.

29 Overload Test, High-Voltage Transformers

29.1 A high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type mentioned in the exception of 17.2.1 shall be subjected to the test described in 29.4 and 29.5.

29.2 Temperatures of a thermally protected high-voltage transformer, as measured on the surface of the windings, are not to exceed the insulation-temperature rating. The insulation-temperature rating is defined as the rating for the class of insulation; such as 221°F (105°C) for Class 105 insulation and 266°F (130°C) for Class 130 insulation.

29.3 The transformer shall comply with the dielectric voltage-withstand test described in Section 31 immediately following the test described in 29.4 and 29.5.

29.4 Three samples of the transformer-protector combination are to be tested. Average temperatures of the three samples are not to exceed the winding-insulation rating and the temperature of any one sample is not to exceed the insulation rating by more than 9°F (5°C).

29.5 A variable-resistance load is to be connected to the output terminals and the transformer is to be operated continuously at the normal test voltage specified in Table 25.1. If the protective device controls a switching device that in turn interrupts primary current to the transformer, the switching device is to be in the circuit. The ambient (room) temperature during the test is to be approximately 77°F (25°C). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 18°F (10°C) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

30 Burnout Test, High-Voltage Transformers

30.1 A high-voltage transformer shall be subjected to the test described in 30.2 and 30.3. There shall be no emission of flame or molten metal from the transformer enclosure.

Exception: A high-voltage transformer that is provided with thermal-overload protection of other than the nonrenewable thermal-cutoff type, as specified in the exception of 17.2.1 or that is protected by an over-current device or devices, as specified in 17.3.1, need not be tested.

30.2 Three samples of the transformer are to be operated continuously at the normal test voltage specified in Table 25.1, and at rated frequency, with the enclosure grounded. The test is to be conducted at an ambient (room) temperature of approximately 77°F (25°C) and operation is to be continued until:

a) Burnout occurs; or

b) Constant temperatures are indicated by a thermocouple secured to the transformer enclosure.

The test circuit is to be protected by fuses rated no less than required for the product.

30.3 The load connected to the output terminals of the transformer is to be the highest of the following and is to be readjusted, if necessary, to the specified value after 2 minutes of operation, with no further readjustment during the remainder of the test:

a) A resistance load that draws a current equal to three times the full rated transformer secondary current;

b) If the transformer supplies a motor with or without additional loads, a resistance load that draws a current equal to the motor locked-rotor current plus any additional loads; or

c) If the transformer supplies an inductive load (other than a motor), such as the coil of a relay or a solenoid, a resistance load that draws a current equal to the sum of such loads with the armature of the largest blocked open.

Exception: A transformer that cannot provide the output current specified in (a) – (c) is to be tested with the output terminals of the transformer short-circuited.

31 Dielectric Voltage-Withstand Test

31.1 General

31.1.1 An appliance shall be capable of withstanding without breakdown for a period of 1 minute, the application of a 60 hertz potential between high-voltage live parts and dead metal parts, and between live parts of high- and low-voltage circuits. The test potential is to be:

a) 1000 volts plus twice the rated voltage; or

b) 1000 volts for a motor rated at no more than 1/2 horsepower (373 W output) and no more than 250 volts.

31.1.2 If higher than rated voltage is attained in a motor circuit through the use of capacitors, the rated voltage of the appliance is to be used in determining the dielectric voltage-withstand test potential. However, if the developed steady-state capacitor voltage exceeds 500 volts, the test potential for the involved parts is to be 1000 volts plus twice the attained voltage.

31.1.3 A low-voltage circuit shall be capable of withstanding without breakdown for a period of 1 minute, the application of a 60 hertz alternating potential of 500 volts applied between low-voltage live parts of opposite polarity and between low-voltage live parts and dead metal parts.

31.1.4 The dielectric voltage-withstand test between low-voltage live parts of opposite polarity need not be conducted on the complete assembly if the components have been separately subjected to this test condition and if the wiring material is as indicated in Table 11.1.

31.1.5 A transformer rated 500 volt amperes or more, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 31.1.1 – 31.1.3. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute.

Exception: A transformer rated 500 volt amperes or more need not be used if the high potential testing equipment used for the test maintains the specified high potential voltage at the equipment for the duration of the test.

31.2 Dielectric withstand – Ignition assembly

31.2.1 The ignition system shall be capable of withstanding for 1 minute, without breakdown, the application of a 60 hertz potential of:

a) 150 percent of the maximum voltage to ground between high-tension live parts and noncurrent-carrying parts; and

b) 150 percent of the maximum voltage between live parts of opposite polarity.

31.2.2 To determine if an appliance complies with 31.2.1, the ignition transformer shall be disconnected. An arc occurring during the test at a location adjacent to the electrode tips that will result in effective ignition shall not be considered a failure.

31.3 Dielectric withstand – Electrode insulator

31.3.1 An insulator shall successfully withstand for 1 minute without breakdown, through the wall of the insulator, a 60 hertz potential of three times the maximum open-circuit voltage to ground of the ignition transformer provided with the burner.

31.3.2 The test to determine compliance with 31.3.1 shall be conducted immediately after the insulator has been conditioned for 24 hours in air having a relative humidity of 85 ±5 percent at a temperature of 90 ±3°F (32 ±2°C).

MANUFACTURING AND PRODUCTION TESTS

32 General

32.1 To determine compliance with these requirements in production, the manufacturer of the appliance shall check, inspect, and test the components and assemblies of each as specified in 32.2.

32.2 Deleted effective August 13, 2012

33 Production Line Dielectric Voltage-Withstand Test

33.1 The manufacturer shall conduct a dielectric voltage-withstand test on each appliance. A 60 hertz potential as indicated in (a) and (b) shall be applied between high-voltage live parts and dead metal parts for a period of 1 minute:

a) 1000 volts plus twice the rated voltage; or

b) 1000 volts for a motor rated at no more than 1/2 horsepower (373 W output) and no more than 250 volts.

Exception: The application of the potential may be reduced to a period of 1 second if the value of the test potential is 120 percent of the value specified in (a) or (b).

33.2 For an appliance using a low-voltage circuit, the test is to be conducted with the low-voltage circuit connected to the cabinet, chassis, or other dead metal part so that the potential that is applied between the high-voltage live parts and dead metal parts will simultaneously be applied between high-voltage live parts and the low-voltage circuits.

33.3 If an appliance is provided with components, such as a solid state control which can be damaged by the dielectric potential, the test may be conducted before the component(s) is electrically connected. However, to determine compliance with 33.1, a random sampling of each day's production is to be tested with the components electrically connected.

33.4 A transformer rated 500 volt amperes or more, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 33.1.

Exception: A transformer rated 500 volt amperes or more need not be used if the high potential testing equipment used for the test maintains the specified high potential voltage at the appliance for the duration of the test.

33.5 The test equipment used for the test described in 33.1 is to include a visible indication of application of the test potential and an audible, visible, or both audible and visible indication of breakdown. In the event of breakdown, manual-reset of an external switch is to be required or an automatic reject of an appliance under test is to result.

MARKING

34 General

34.1 All required markings shall be appropriately located and be easily read when the assembly is in the normally installed position. A location within a burner compartment equipped with a door or removable panel for ready access is considered an acceptable location. The marking shall be reasonably permanent, as afforded by a metal nameplate or decalcomania transfer.

34.2 Among the factors taken into consideration when judging the acceptability of a nameplate depending on adhesives, are the adhesive properties and the resistance to defacement or removal at temperatures and in atmospheres to which it may be subjected under conditions of normal or abnormal use.

35 Nameplate

35.1 The following information shall appear on each burner assembly or device:

a) The manufacturer's or private labeler's name or identifying symbol and a distinctive type, model or catalog designation of the equipment;

b) The voltage rating, frequency, and total current in amperes of the motor(s) and other loads. If the burner or device includes more than one circuit to be supplied by individual external supply circuits, the voltage and current of each motor in the circuit shall be indicated in addition to other loads. The horsepower rating of each motor of 1/8 horsepower or more and the number of phases of each polyphase motor shall be indicated;

c) The firing rate or rates, expressed to the nearest 0.1 gph and the grade of fuel. Assume Nos. 1 and 2 fuel oils have calorific values of 138,500 and 140,000 Btu per gallon (38.1 and 38.6 MJ/dm^3), respectively;

d) The Btu input rate or rates of the equipment and the type of gas for which equipped and the designed manifold pressure(s);

e) A furnace shall be marked to declare the static pressure at which the furnace was tested;

f) The date or the period of manufacture not exceeding any consecutive 3 months. The date of manufacture may be abbreviated; or in a nationally accepted conventional code or in a code affirmed by the manufacturer provided that the code:

1) Does not repeat in less than 20 years; and

2) Does not require reference to the manufacturer's records to determine when the product was manufactured.

35.2 In addition to the information required in the preceding, the following marking shall appear on a burner or device: The minimum circuit ampacity and the maximum rating of the circuit protective device if the burner or appliance employs more than one motor incorporating inherent overheating or overcurrent protection and is to be operated from a single supply line. If a unit is intended for use on two or more circuits, the marking shall include the above information for each circuit.

35.3 The minimum circuit ampacity shall be equal to the sum of all of the following loads which may operate concurrently:

a) Full-load current rating of each motor;

b) 25 percent of the full-load current rating of largest motor; and

c) Rating of all other loads.

35.4 The maximum size of branch circuit fuses shall be marked if more than one motor is operated from a single supply line.

35.5 The marking indicated in 35.4 may additionally specify a maximum HACR Type circuit-breaker size if the required short-circuit tests have been conducted in accordance with 28.1 using an HACR Type circuit breaker.

36 Supplemental Marking

36.1 The type of flooring, combustible or noncombustible, the minimum clearances to adjacent construction to be provided when installed, and the location and size of ventilation openings to be provided in closet doors or panels; also directions as to the kind and thickness of insulation to be applied to the boiler if safe installation requires it to be covered with insulation not furnished by the manufacturer as part of the assembly, or directions as to how insulation furnished by the manufacturer but not factory-assembled on the boiler is to be applied.

36.2 The appropriate ASME boiler and pressure vessel code marking on a boiler.

36.3 Explicit directions for locating an air filter if not factory located, if safe operation in accordance with these requirements is obtained only when the filters are so located.

36.4 The instruction plate or filter access panel of a furnace equipped with filters shall include directions stating the size, type, and number of filters required for replacement and precaution not to operate furnace without filters or filter access panel in place.

36.5 If a forced air furnace is tested without circulating air filters for compliance with these requirements, the furnace shall be marked appropriately that it is not to be used with air filters, and the design of the furnace shall incorporate no provision for mounting air filters.

36.6 A device suitable for outdoor installation only shall be marked ″For Outdoor Installation Only″. A device suitable for either indoor or outdoor installation shall be marked ″For Either Indoor or Outdoor Installation″.

36.7 If any point within a terminal box or wiring compartment in which field installed conductors are intended to be connected (including such conductors themselves) attains a temperature higher than 140°F (60°C) during the Continuous-Operation Temperature Test, the assembly shall be marked ″For Connections, Use Wires Suitable for at Least ...°F (...°C)″ or with an equivalent statement. The temperature value shall be in accordance with Table 36.1. The statement shall be legible and so located that it will be clearly visible during installation or examination of the wiring connections.

Table 36.1
Required temperature markings for terminal box or compartment

Temperature attained during test in terminal box or compartment		Temperature marking	
Degrees F	Degrees (C)	Degrees F	Degrees (C)
142 – 167	(61 – 75)	167	(75)
169 – 194	(76 – 90)	194	(90)

36.8 A burner or device equipped with an electrically operated gas vent valve shall include a tag wired to the standard threaded pipe plug in the discharge side of the valve which reads:

a) Full size 3/4 inch (19.1 mm) or larger pipe to be run from valve to outside of building if for indoor use;

b) No traps to be provided in pipe;

c) Piping shall terminate away from all windows and doors; and

d) Provisions shall be made to prevent rain and foreign objects from entering vent piping.

36.9 Downflow furnaces which require a separate base for installation on combustible flooring shall be marked ″This Furnace Must Be Placed on Special Base Part No.... When Installed on Combustible Flooring.″

36.10 Burners or devices furnished without a gas pressure regulator shall be marked ″This Burner (Or Device) Must Be Installed With A Pressure Regulator Capable Of Being Adjusted To An Outlet Pressure Of ____.″

36.11 Each essential individual assembly not a part of the equipment shall include on the assembly the manufacturer's or private labeler's identification and part number.

36.12 If a manufacturer produces commercial-industrial heating equipment at more than one factory, each such assembly shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory.

36.13 A fuse-replacement marking shall be provided for a replaceable fuse that is part of the equipment or a remote-control assembly. The marking shall specify the current rating of the fuse in amperes and it shall be visible when the cover or the door of the fuse compartment is opened.

36.14 If a supplementary fuse is provided in accordance with the exception to 16.4.2 or 17.5.3, the marking specified in 36.13 shall also include the identification of acceptable fuses by manufacturer's or private labeler's name, catalog designation, and voltage rating.

36.15 If the equipment employs a direct-connected high-voltage control circuit, see 16.2.1, it shall be marked with the maximum size of an overcurrent device or devices for that control circuit. The rating of an overcurrent device shall be based on the ampacity of the control circuit conductors, as determined from the ampacity tables in the National Electrical Code, NFPA 70 for 14 AWG (2.1 mm^2) or larger conductors and shall not exceed 10 amperes for 16 AWG (1.3 mm^2) conductors or 7 amperes for 18 AWG (0.82 mm^2) conductors. The marking shall appear on the wiring diagram, adjacent to the field wiring terminals, or on the equipment nameplate.

36.16 If a motor which is connected in a circuit as described by 18.3 is installed remote from its controller, the rating of the remote motor, the size of the conductors supplying it, and reference to the location of the disconnect device for the remote motor shall be shown.

36.17 If more than one disconnect switch may be required to disconnect all power within a control assembly or compartment, the assembly or compartment shall be clearly marked to so indicate. The marking shall be in letters not less than 1/8 inch (3.18 mm) high, reading essentially as follows:

CAUTION – Hazard Of Electric Shock – More Than One Disconnect Switch May be Required To Disconnect All Power Other Than NEC Class 2.

The marking shall be located where it will be apparent before or immediately after exposing the live parts which may be connected to different circuits.

36.18 If the unit requires a time-delay fuse, it shall be marked to so indicate.

36.19 Unless proper field wiring connections are evident, a wiring diagram shall be provided on the burner or device or within the control cabinet.

36.20 A unit intended for connection to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is suitable. The marking shall be so located that it will be visible when power supply connections are made.

36.21 Terminals for field wiring shall be marked, ″Use Copper Conductors Only, For Use With Aluminum Or Copper Conductors″, or with an equivalent statement, as appropriate. This marking shall be independent of any marking on terminal connectors.

36.22 If an air-atomizing burner is not equipped with means to supply atomizing air, the assembly shall be marked with the minimum volume of air in cubic feet (m^3) per minute and the minimum operating pressure of air to be supplied.

36.23 Burners or devices furnished without an oil pump shall be marked with the minimum volume of oil in gallons per hour and the minimum operating pressure of oil to be supplied.

36.24 A burner or device, firing oil as a main fuel having a guaranteed low fire start of 20 gph (76 L/h) or less, with a high-fire input in excess of 20 gph and equipped with a direct spark ignition system, shall be marked as follows:

″Maximum Low Fire Start Input 20 Gal/h (76 liters/h) or Less.″

36.25 Burners or devices furnished without a primary oil strainer shall be marked as follows:

″Field Installer – The Oil Supply Piping To This Burner (Device) Must Be Provided With A Listed Oil Strainer Specified Suitable For The Maximum Fuel Input And Oil Grade Marked On The Burner (Device) Data Plate.″

36.26 The positions of the fuel selector switch on a combination gas-oil burner shall be identified with the type of fuel. See 61.8. The ″Off″ position of the switch, if any, shall also be identified, except it shall not be marked with a single word ″Off″ unless all ungrounded circuits to the burner are disconnected when the switch is in the off position. The wording such as ″Burner Off″ or ″All Fuel Off″ is acceptable to identify the off position if not all the undergrounded circuits to the burner are interrupted.

36.27 If field installation conductors, to be connected to a low-voltage (30 volts) safety-control circuit of a burner, are required to be wired with Class 1 wiring, a marking to so indicate shall appear on the burner at the point where such connectors are to be made.

INSTRUCTIONS

37 General

37.1 Operating and installation instructions, or equivalent information, is to be furnished with each device. These instructions are to be used as a guide in the examination and test and for this purpose, a printed edition is not required.

37.2 The instructions shall include such directions and information as deemed by the manufacturer to be necessary to cover the intended installation, maintenance, and use of the equipment. The following shall also be included:

a) Detailed instructions for testing controls and safety devices both when the equipment is operating and when it is out of service;

b) Detailed instructions on maintenance and service procedures of the equipment, including its controls and safety devices;

c) Instructions that all cover plates, enclosures, and guards must be maintained in place at all times, except during maintenance and servicing;

d) Instructions for venting of gas train components that require atmospheric air pressure to balance a diaphragm;

e) A statement to the effect that the heating appliance shall be installed by a qualified installer, that is, one who is engaged in, is responsible for, or is thoroughly familiar with, the installation and operation of commercial-industrial gas and or oil fired appliances, who is experienced in such work, is familiar with the precautions required, and will comply with all the requirements of the authority having jurisdiction over the installation;

f) A description of the major components and a general arrangement drawing illustrating method of mounting these components, their functions and normal settings; and

g) Information on the principle of operation of the heating appliance when equipped with the pertinent emissions reduction equipment.

37.3 The instructions for a combination gas-oil burner intended to burn one fuel at a time shall include detailed directions for accomplishing the changeover form one fuel to the other. If this requires manual opening and closing of fuel valves and manipulation of a switch, proper sequence for their operation shall be included.

37.4 An appliance that is not equipped by the manufacturer with an operating control shall be furnished with instructions for installation of the operating control in the field. The instructions shall include information as to the type of the control and its setting and an electrical circuit diagram for its wiring.

PART II - BURNER ASSEMBLIES

CONSTRUCTION

38 General

38.1 In addition to the requirements specified in Sections 1 – 37, a burner shall comply with the requirements specified in Sections 38 – 64.

39 Assembly

39.1 Except as indicated in 39.2, 39.3, 39.4, 39.6, and 39.7, a burner shall be factory-built and shipped as a unit assembly and shall include all the essential parts necessary for its intended function when installed as intended. The equipment may be shipped as two or more subassemblies.

Exception: The equipment necessary to supply atomizing air to an air-atomizing burner need not be provided with the assembly if the burner is marked in accordance with 36.22.

39.2 The burner may incorporate individual assemblies which are installed remotely from the burner. Such individual assemblies shall be marked in accordance with 36.11.

39.3 A strainer needed to protect small orifices need not be provided with the burner. See 43.1.

39.4 In accordance with clause 39.1, the complete primary safety control shall be furnished with each burner by the burner manufacturer.

39.5 Parts of a safety control that are required to be burner-mounted shall be factory-attached. If the combustion detector is burner-mounted but the safety switch is not, the burner shall be marked to declare the safety switch with which it is to be used.

39.6 The burner equipment, if not manufactured as a unit assembly, shall consist of as few subassemblies as practicable. Except as indicated in 39.7, each subassembly shall be capable of being incorporated readily and correctly into the final assembly without requiring alteration, cutting, threading, welding, or similar tasks by the installer. Two or more subassemblies which must bear a definite relationship to each other for the proper and safe operation of the equipment shall be designed and marked so that they may readily be incorporated into the final assembly in their correct relationship.

39.7 Burner piping components such as the main automatic gas shutoff valve, main manual gas shutoff valve, pressure regulator, etc., may be furnished as separate parts provided they can be joined in the field with standard piping. The standard piping may be furnished, cut, and threaded by the field installer.

39.8 The burner shall provide a uniform and definite supply of fuel and air for combustion when installed and adjusted in accordance with the manufacturer's installation instructions. The means for regulating the supply of air and oil shall be arranged so that the adjustments may be fixed or restricted in a manner to prevent accidental changes in settings.

39.9 The burner and/or subassemblies shall incorporate provisions for support, adjustment, and attaching to the heating plant or to the foundation on which it rests in order that installation can be so made as to prevent its twisting, sliding, or dropping out of the intended position.

39.10 A burner of the ″swing-type″ shall be provided with means for locking the burner in the firing position and, for an automatically-lighted burner, to prevent it from discharging fuel when in other than the firing position.

39.11 An adjusted or movable part shall be provided with a locking device to prevent accidental shifting.

39.12 The base or frame on which burner parts are mounted shall be made of noncombustible material.

39.13 Bolt holes shall not intersect gas ways unless provision is made to provide gas tightness.

39.14 Burner heads, mixer heads, and mixer tubes shall be of metals having a melting point, solidus temperature in excess of 1450°F (787.8°C).

39.15 A ribbon burner shall be so constructed that the ribbon assembly can be removed, cleaned, and replaced without the need for special tools.

39.16 The burner orifice and orifice holder shall be made of a material having a melting point, solidus temperature of not less than 1450°F (787.8°C) for use with manufactured and mixed gases and not less than 1100°F (593.3°C) for natural LP-Gas, and LP-Gas-air mixtures.

39.17 Main burner gas orifice spuds shall be threaded into their holders with at least 3-1/2 full threads.

39.18 Screws or bolts used to attach parts which are detached for servicing of the burner shall be capable of holding upon the application of the torques indicated in Table 39.1 after removal and replacement.

Table 39.1
Torque requirements for screws or bolts

American standard screw size		Torque		I.S.O. screw size	Torque	
No.	**mm**	**Lb-In**	**N·m**	**mm**	**N·m**	**Lb-In**
–	–	–	–	4	1.8	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
Inch	**mm**					
1/4	6.4	100	11.3	6	8.7	77
–	–	–	–	7	15.0	133
5/16	7.9	200	22.6	8	23.5	208
–	–	–	–	9	33.6	297
3/8	9.5	350	39.6	10	45.2	400
7/16	11.1	575	65.0	12	81.0	715
1/2	12.7	850	96.0	14	128.0	1130
9/16	14.3	1200	136.0	–	–	–
5/8	15.9	1600	181.0	16	185.0	1640

39.19 Flame spreaders and flame spreader supports used with upshot type burners shall be constructed so that they cannot be incorrectly fitted together, or they shall be marked to indicate the correct method of assembly. When it is necessary for service or assembly to remove the flame spreader. It shall not be threaded to its support unless the support is readily removable.

39.20 Flame spreader supports used with upshot type burners shall be so constructed that the flame spreader cannot be supported at other than the correct distance above the burner.

39.21 Burners shall be provided with means to prevent disintegrated ceramic flame spreader material from falling into the burner port(s). They shall also be designed so that disintegration of the ceramic will not cause a hazardous change in the operating characteristics of the burner.

39.22 Joints in the pressure zone or in the burner head of a burner assembly, shall be gastight and shall not depend for mechanical strength nor primarily for tightness on cement or other sealing material, except where such joints form part of the port area. Joints shall be bolted, screwed, machined, welded, brazed or of equivalent construction.

40 Accessibility for Servicing

40.1 All parts requiring adjustment or manipulation by the user in the course of operation of the burner shall be accessible and easily moved. Any part that may normally come in contact with the operator's hand during usage shall be free from sharp edges or projections and projecting sharp screw ends.

40.2 Accessibility shall be afforded to all burner parts, controls, and safety devices requiring servicing. The disposition of parts in the assembly removed for servicing shall be such that their restoration, following removal, will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special facilities that may be required for servicing to be performed by the operator shall accompany the burner to the user.

40.3 A firing assembly, atomizer and nozzle assemblies, and the like, intended to be removed and replaced for servicing shall be constructed so that, upon replacement, the assembly will self-restore the atomizer or nozzle to its correct position.

41 Fan Housings and Air Tubes

41.1 A fan housing and an air duct shall be made of noncombustible material having the strength and durability to not be damaged during test under these requirements.

41.2 A housing in which oil leaking from any oil-handling part of the assembly may accumulate shall be provided with an open drain, that is, an inverted fan housing on a gun-type burner.

41.3 An air tube of a gun-type oil burner shall prevent the accumulation of oil within it. Any drippage from the nozzle shall drain to the fire box. A drain shall be located to avoid blockage by refractory or cement.

41.4 The exterior portion of a firing head within 6 inches (152 mm) measured parallel to its axis, from the firing end and all parts which may be in contact with masonry when the burner is installed as intended, shall be made of iron or steel. Interior parts shall be made of materials conforming with 6.1 – 6.6.

41.5 An outer shell of a blast tube or firing head, if made of sheet metal, shall be such as to assure strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a thickness of not less than 0.053 inch (1.35 mm) or Type 309 stainless steel having a thickness of not less than 0.026 inch (0.66 mm).

42 Combustion Air Controls

42.1 An air shutter shall be capable of being adjusted readily to any desired setting and be provided with means for preventing accidental change in setting.

42.2 The air inlet shall be of sufficient area to supply adequate air for complete combustion under the specified draft condition and at the maximum rate of firing when the burner assembly is installed as intended. All the air required for complete combustion shall be introduced in a manner which will assure thorough mixing of the fuel and air.

42.3 An air shutter shall provide for a reasonably smooth surface between the shutter and the matching face.

42.4 Sheet metal air shutters shall be of a thickness not less than 0.0254 inch (0.65 mm). If sheet metal air shutters are of a thickness less than 0.0508 inch (1.29 mm), they shall have the outer edges turned at right angles or be otherwise properly reinforced.

42.5 An air shutter shall by its design or assembly and selection of materials be guarded against sticking or corroding in position. Screws or bolts used for attaching or adjustment shall be of corrosion resistant material.

42.6 An adjustable part shall be guided to prevent its movement from its normal path during adjustment, and the means for adjusting the part shall be readily accessible.

42.7 A burner assembly, when adjusted according to the manufacturer's instructions furnished with the equipment, shall maintain complete and stable combustion at all firing rates called for by the input and the air-gas ratio controls.

42.8 Linkage for operating air and fuel controls shall be designed to reliably maintain the correct fuel-air ratio and to resist accidental damage and disengagement.

42.9 If air under pressure is mixed with the gas supply in a mixer and is automatically controlled, effective means shall be provided to prevent air from passing back into the gas line, or gas into the air supply. The gas and air supply shall be suitably controlled to prevent gas from entering burners until the air supply is available and, in the event of air failure, to shut off the gas supply.

42.10 If air for combustion is supplied mechanically by a source from which the flow may be interrupted, provision shall be made to shut off the fuel supply to the main burner and pilot assembly upon failure of the air supply. For a burner assembly having an input in excess of 2,500,000 Btu per hour (732 Kw) the loss of combustion air shall result in safety shutdown so that a manual reset is required to restore the burner operation.

Exception: Fuel shutoff and safety shut-down, if applicable, upon failure of combustion air is not required for a burner that is equipped with a supervised secondary pilot as described in 55.8.

42.11 An oil burner having an input in excess of 20 gph (76 L/h) shall be provided with an interlock which shuts off the burner and causes safety shutdown upon loss of combustion air, so that a manual reset is required to restore the burner operation when the combustion air is reestablished. See 42.14.

42.12 For an oil burner having an input not in excess of 20 gph (76 L/h) for which combustion air is supplied by a forced or induced draft fan which is not integral with the burner motor shaft, the loss of combustion air shall result in shutting off the fuel. The burner operation may be resumed automatically when the combustion air is reestablished.

42.13 For requirements for mechanical draft oil burners not equipped with a combustion air interlock in regard to operation during the interruption and restoration of the combustion air supply see 63.3, Combustion air failure test – Test No. 3.

42.14 With respect to 42.10 and 42.11, loss of air during prepurge or any time at start-up prior to delivery of fuel, need not result in safety shutdown. However, no delivery of fuel shall be initiated before the combustion air flow has been reestablished and the required prepurge has been completed. See 56.1 and 56.2.

42.15 A gas-burning appliance shall be equipped to provide preignition purging in accordance with 56.1.1 or 56.2.1, as applicable, except such preignition purging is not required if the device is equipped with a continuous pilot and the assembly is arranged so that any and all gas from the burner ports will be safely lighted and burned.

42.16 The following types of mechanical draft oil burners shall include a prepurge period in accordance with Section 56 before the ignition and fuel deliver are initiated:

a) A burner having an input in excess of 20 gph (76 L/h);

b) A burner having an input in excess of 7 gph (26.5 L/h) when the oil pump operates independently of the burner.

43 Fuel Strainers

43.1 A small orifice or other opening in an oil-supply system shall be protected by a strainer in accordance with the requirements of 43.2 – 43.12. The strainer need not be provided with the burner if the marking on the burner or the installation instructions furnished with the burner specify that a strainer suitable for the maximum fuel input and grade of oil marked on the burner shall be provided by the installer.

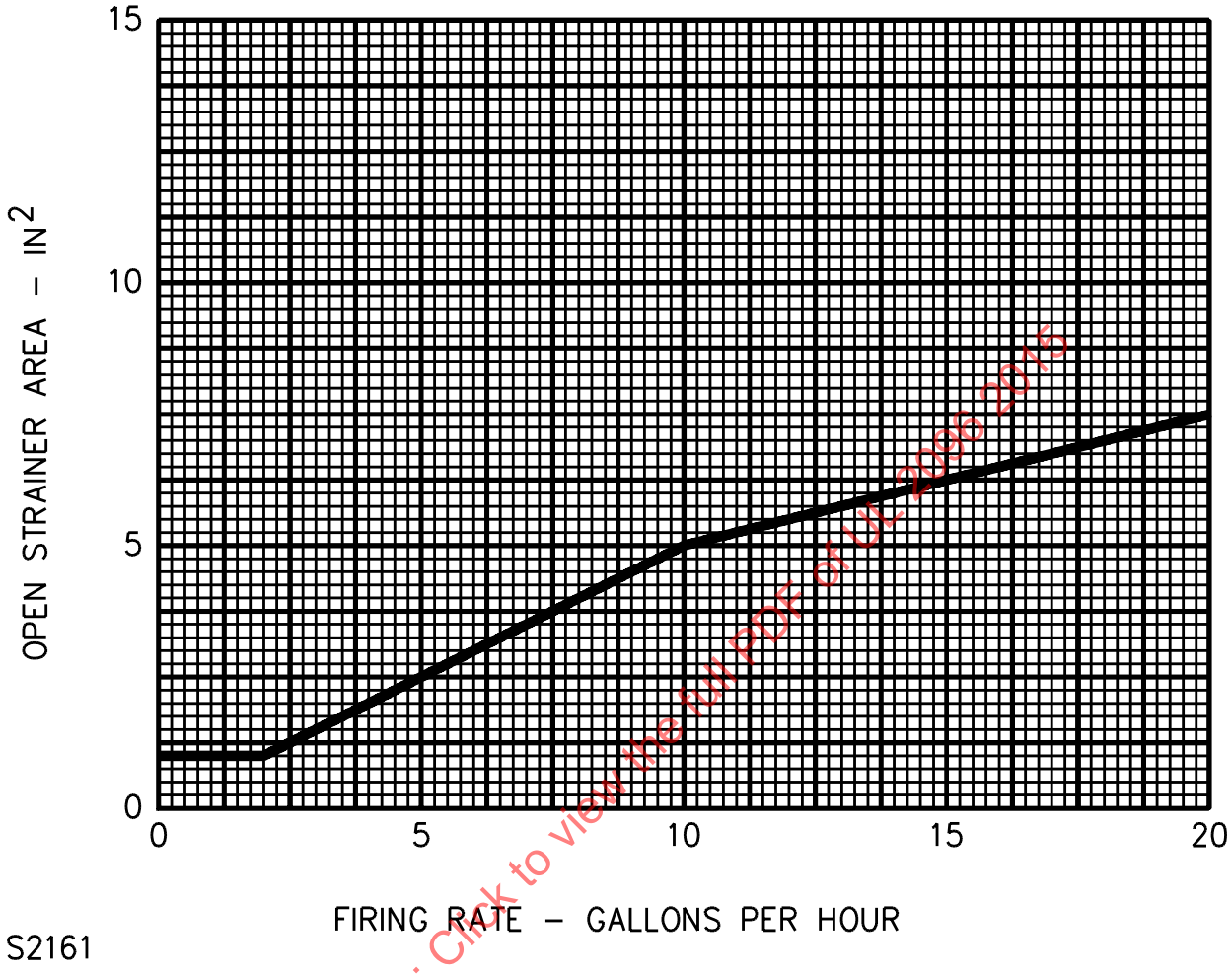
43.2 The largest opening of the strainer element shall be of such size that its larger dimension will be not greater than 90 percent of the smaller dimension of the smallest fixed opening protected by the screen.

43.3 For the purpose of these requirements, a metering valve, a float valve, and an automatic safety valve shall be considered as a fixed opening, having a diameter of 1/32 inch (0.79 mm) when Nos. 1 and 2 oils are used, and 1/16 inch (1.59 mm) when Nos. 4, 5, and 6 oils are used.

43.4 A primary strainer shall be based on the maximum firing rate of the burner and the heaviest grade of fuel for which the burner is intended.

43.5 The effective area of a screen (total area of screen openings), shall not be less than as indicated in Figures 43.1 and 43.2. A strainer shall be applied so that there will be no air trapped therein to affect rate of fuel flow to the burner or reduce the effective area of the straining element.

Figure 43.1
Strainer area for * No. 1 fuel oil



No. 1 Oil

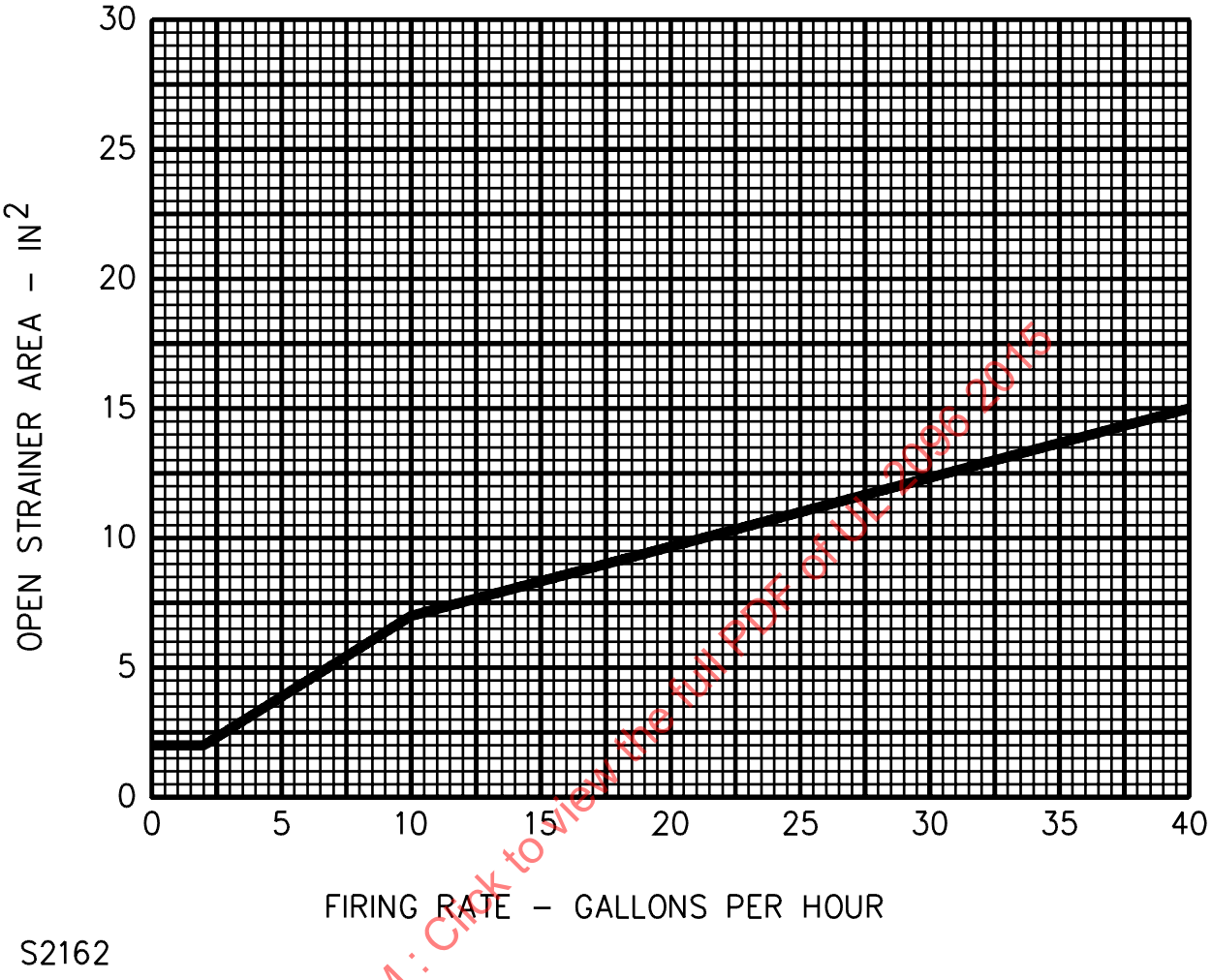
Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1997

Note: 1 square inch = 6.45 cm^2

1 gallon = 3.79 L

Figure 43.2
Strainer area for * No. 2 fuel oil



No. 2 Oil

Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1997

Note: 1 square inch = 6.45 cm^2

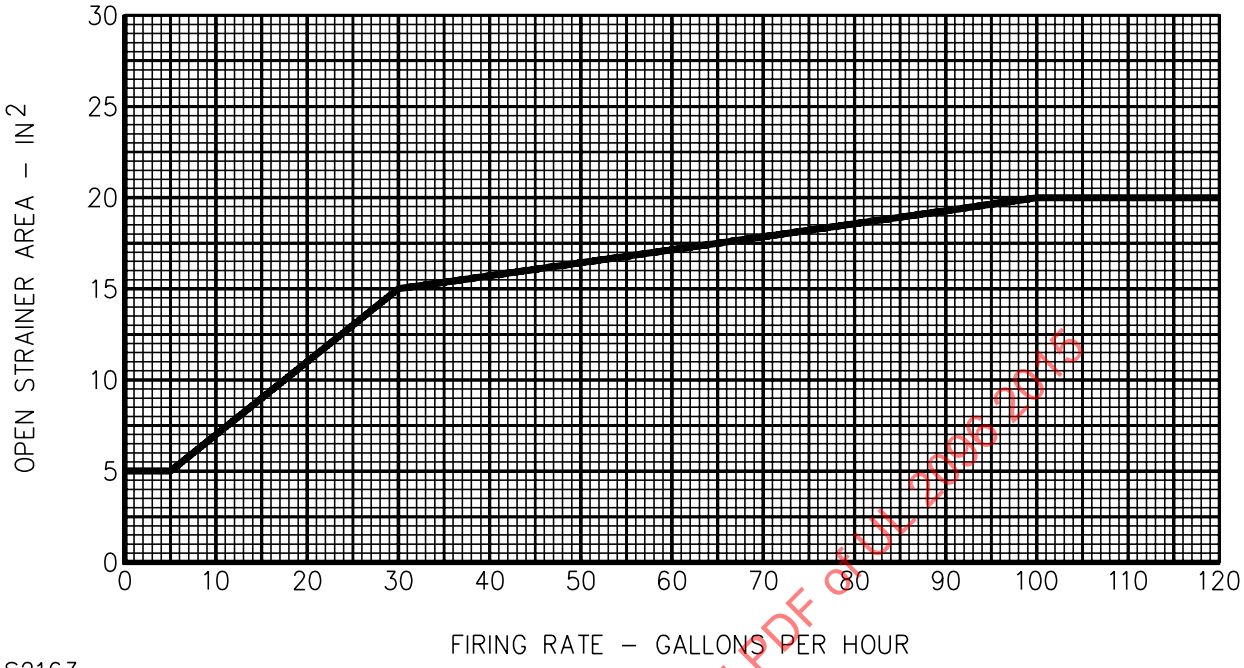
1 gallon = 3.79 L

43.6 The effective area of a screen is not required to be greater than the maximum value shown in Figures 43.1 – 43.3, regardless of the burner firing rate, but in any case the strainer is not to impair the flow of fuel supplied to fire the burner at maximum rated input.

43.7 A strainer employing an element other than a screen shall have a rated capacity not less than the maximum firing rate of the burner to which it is applied.

43.8 When two strainers installed in series are provided instead of a single primary strainer, each shall be of approximately equivalent size, and the screen area or rated capacity of each shall be 1.4 times that required for a single strainer. The strainer downstream from the other shall be equipped with a screen or element in which the size of the individual straining opening is not larger than 90 percent of the size of the straining opening in the element of the other strainer.

Figure 43.3
Strainer area for* Nos. 4, 5, 6 fuel oil



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Nos. 4, 5, 6 Oil Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1997

Note: 1 square inch = 6.45 cm^2

1 gallon = 3.79 L

43.9 A secondary strainer, one supplementary to the main strainer, smaller in area than required in 43.5 may be used in the fuel line, downstream from the primary strainer.

43.10 A strainer shall be applied to permit the removal and replacement of the straining element. The force necessary to open a strainer shall not permanently distort the lines or assembly to which it is attached.

43.11 A strainer required for the protection of an automatic safety valve or a float valve shall be furnished as part of the assembly incorporating such valve.

43.12 Pipe or other fuel conduit used to connect a float valve, metering valve, or safety valve to the protecting strainer shall be free of dirt and scale at the time of assembly.

44 Fittings, and Piping and Tubing

44.1 An opening threaded for pipe connection shall be threaded in accordance with the Standard for General Purpose (Inch) Revision and Redesignation of Pipe Threads, ANSI/ASME B1.20.1-1983.

44.2 An opening for field attachment to pipe larger than nominal 3 inch ANSI/ASME B1.20.1 pipe size shall be provided with a flanged pipe connection conforming to Class 25, 125, 250, and 800 requirements of the Standard for Cast Iron Pipe Flanges and Flanged Fittings, ANSI/ASME B16.1-1989.

44.3 A fitting, other than one conforming with the appropriate American National Standard, having openings threaded for pipe connections, shall be capable of withstanding, without damage or leakage, the turning effort (torque), see Table 44.1, exerted as if to screw the fitting onto a pipe or into a pipe fitting.

Table 44.1
Torque requirements for pipe connections

Pipe size ANSI/ASME B36.10M	Outside diameter		Torque	
Nominal inches	Inches	(mm)	Pound-inches	N·m
1/8	0.405	10.29	150	17
1/4	0.540	13.72	250	28
3/8	0.675	17.15	450	51
1/2	0.840	21.34	800	90
3/4	1.050	26.67	1000	113
1	1.315	33.40	1200	137
1-1/4	1.660	42.16	1450	164
1-1/2	1.900	48.26	1500	175
2	2.375	60.33	1650	186
2-1/2	2.875	73.03	1750	198
3	3.500	88.90	1800	203
4	4.500	114.30	1900	215

44.4 A tool which fits snugly about the fitting, or to a section of the shank shaped for a wrench, if such section is provided, is to be utilized to apply the turning force. The turning force is to be applied to the hex of the fitting adjacent to where it is attached to piping or, if no hex is provided in this position, to the body of the fitting. The measured torque specified in Table 44.1 is to be applied to the fitting to screw it onto an extra-heavy pipe or into a pipe fitting of appropriate size. After the force has been applied, the fitting is not to leak when subjected to a hydrostatic pressure equivalent to one and one-half times the maximum working pressure.

44.5 Tapped holes for gas valves, pilots, or other branch supply lines shall have not less than 3-1/2 pipe threads.

44.6 Iron or steel, gas-supply pipe employed on devices shall comply with the Standard for Welded and Seamless Wrought Steel Pipe, ANSI/ASME B36.10M-1996. If brass or copper pipe is employed, it shall be dimensionally equivalent to iron pipe. Substantial malleable iron, steel, brass, or copper pipe fittings shall be used with pipe. Unions, where used, shall be the ground-joint type or the equivalent.

44.7 Ends of piping and tubing shall be reamed to remove obstructions or burrs.

44.8 Compounds used on threaded joints of gas piping shall be resistant to the action of liquefied petroleum gases.

44.9 Bent supply piping shall have the bends smoothly made without any appreciable reduction in the cross-sectional area, shall reveal no imperfections occasioned by the bending process, shall be annealed if necessary to remove internal stresses; and shall be cleaned inside to remove loose particles.

44.10 Tubing shall be arranged to avoid being physically damaged, such as by closely following the contour of the burner assembly. Tubing connections shall be made by means of compression or flare type fittings with steel or brass nuts. A fitting requiring the use of a gasket to obtain a gas-tight joint shall not be used.

44.11 If a vertical section of piping is supplied on the upstream side of the gas controls, a trap in this piping shall be supplied by the manufacturer. If a vertical section of piping is not supplied, the installation instructions shall require the installation of a trap at the inlet of the gas connection of the unit.

44.12 Seamless drawn aluminum or copper tubing employed in the fabrication of factory assembled equipment shall be not less than 1/4 inch (6.35 mm) outside diameter and shall have a wall thickness not less than that shown in Table 44.2.

44.13 Aluminum tubing shall not be exposed to condensate or to temperatures in excess of 700°F (371.1°C) and shall not be acceptable for use where it passes through insulating material of other than neutral reaction unless the tubing is adequately protected from the insulation.

44.14 Steel tubing of the seamless, brazed, or welded type shall be not less than 1/4 inch (6.35 mm) outside diameter and shall have a wall thickness not less than shown in Table 44.2.

Table 44.2
Wall thickness for aluminum, copper, and steel tubing

Outside diameter,		Minimum wall thickness, inches[a] (mm)	
inches	(mm)	Aluminum and copper	Steel
1/8	(3.2)	0.029 (0.74)	0.028 (0.71)
3/16	(4.8)	0.029 (0.74)	0.028 (0.71)
1/4	(6.3)	0.029 (0.74)	0.028 (0.71)
5/16	(7.9)	0.029 (0.74)	0.028 (0.71)
3/8	(9.5)	0.032 (0.81)	0.028 (0.71)
7/16	(11.1)	0.032 (0.81)	0.028 (0.71)
1/2	(12.7)	0.035 (0.89)	0.028 (0.71)
9/16	(14.2)	0.038 (0.96)	–
5/8	(15.9)	0.038 (0.96)	0.035 (0.89)
3/4	(19.1)	0.045 (1.14)	0.035 (0.89)
7/8	(22.2)	0.045 (1.14)	0.049 (1.24)
1	(25.4)	0.049 (1.24)	0.049 (1.24)
1-1/8	(28.6)	0.049 (1.24)	0.049 (1.24)
1-1/4	(31.7)	0.055 (1.40)	0.049 (1.24)
1-3/8	(34.9)	0.055 (1.40)	–
1-1/2	(38.1)	–	0.065 (1.65)

[a] Nominal wall thickness of tubing will have to be greater than the thickness indicated to maintain the minimum wall thickness.

44.15 Steel tubing having a wall thickness of 0.053 inch (1.35 mm) or less shall be constructed of corrosion resistant material such as stainless steel or shall be plated, dipped, coated, or otherwise treated to resist external corrosion.

44.16 Cadmium plating shall have a thickness of not less and 0.0003 inch (0.0076 mm) except on a part where threads constitute the major portion of the area, in which case the thickness of the cadmium plating shall be not less than 0.00015 inch (0.0038 mm). Zinc plating shall have a thickness of not less than 0.0005 inch (0.013 mm) except on a part where threads constitute the major portion of the area, in which case the thickness of the zinc plating shall be not less than 0.00015 inch.

44.17 Copper tubing or tubing with internal copper surfaces, used for conveying gas, shall be internally tinned or equivalently treated to resist sulphur corrosion. Such tubing shall not be exposed to temperatures in excess of 350°F (176.7°C).

44.18 Flexible metallic hose is not considered a substitute for rigid piping or tubing as ordinarily employed. Its use should be confined to applications where rigid piping or tubing is impractical and where flexible connections cannot be avoided. It is not intended to be subjected to torsional, tensile, or excessive vibration or bending stresses or to abrasion. It is not considered suitable for use in conjunction with safety devices or where bending is caused by automatic operation.

44.19 A fuel line shall terminate in a manner which will permit connection to the burner assembly. A fuel line opening shall be plugged or capped to prevent entrance of foreign material prior to installation.

44.20 A coupling or union which is disconnected for service shall be located so that any oil dripping from the connection will not drip or run onto electrical parts.

44.21 A 1/8 inch (3.18 mm) iron pipe size or larger plugged tapping, accessible for test gauge connection, shall be furnished downstream from the last main line gas control for measuring gas pressure at the burner.

45 Valves and Regulators

45.1 Automatic safety shutoff valves – General

45.1.1 The pressure rating of a valve shall be not less than the maximum operating pressure of the fuel-burning device.

45.1.2 Safety shutoff valves shall be constructed so that they may not be restrained or blocked in the open position. Such valves shall close upon being de-energized regardless of the position of damper operating lever or reset handle.

45.1.3 An electrically operated safety shutoff valve shall not depend on electricity to shut off the fuel flow.

45.1.4 A pressure operated safety shutoff valve shall close upon failure of pressure.

45.1.5 A bypass to provide for minimum flame may be installed around a valve used to regulate fuel input only. A bypass shall not be installed around a safety shutoff valve or a combination input control and safety shutoff valve.

45.2 Oil valves

45.2.1 An automatic oil safety valve shall have a shut off time not to exceed that shown in Table 55.1 after being de-energized.

45.2.2 The oil fuel train of each assembly having an input in excess of 3 gph (11.4 L/h) shall be provided with two oil safety shut-off valves or one safety shut-off valve and a nozzle cut-off valve. The closing times of the shut-off valves shall not exceed the timings specified in 45.2.1. The pressure rating of the shut-off valves shall not be less than the maximum pump pressure.

45.2.3 A safety shut-off valve that is responsive to pressure variations in a hydraulic or pneumatic remote control system shall close upon failure of pressure in the control system.

45.3 Gas valves

45.3.1 Each main burner supply line shall be equipped with a safety shutoff valve or valves which will close, independent of external force and with sufficient closing force to provide tight shutoff under normal operating conditions. The following arrangements comply with this requirement:

a) Either two valves in series, one of which is a safety shutoff valve, or one safety shutoff valve of the type incorporating a proof of closure switch, when the maximum firing rate per combustion chamber does not exceed 2,500,000 Btu per hour (732 Kw). The two valve arrangement may be incorporated into a single control body;

b) Two safety shutoff valves in series, or one safety shutoff valve of the type incorporating a proof of closure switch, when the maximum firing rate per combustion chamber exceeds 2,500,000 Btu per hour but is not more than 5,000,000 Btu per hour (1.46 MW); or

c) Two safety shutoff valves in series, one of which is of the type incorporating a proof of closure switch when the maximum firing rate per combustion chamber exceeds 5,000,000 Btu per hour. Burners having a maximum firing rate per combustion chamber in excess of 12,500,000 Btu per hour and equipped to fire fuel gas having a specific gravity less than one shall also include a normally open 3/4 inch (19.1 mm) or larger electrically operated valve in a vent line located between the two safety shutoff valves.

Exception: If an automatic valve proving system is installed to verify that both safety shutoff valves are leak-free during each burner cycle and functions to prevent light-off in the event of a leak, a normally open vent valve is not required to be used.

45.3.2 Each pilot supply line shall be equipped with a safety shutoff valve. This may be incorporated into a main line combustion gas valve.

45.3.3 Gas safety shutoff valves shall shut off after being de-energized within the time limits specified in Table 55.1.

45.3.4 Means shall be provided to facilitate testing automatic gas valves for leakage when in the closed position.

45.3A Automatic valve proving systems

45.3A.1 When an automatic valve proving system is utilized, it shall comply with the requirements of 45.3A.2 – 45.3A.5, as applicable.

45.3A.1 added August 13, 2012

45.3A.2 Valve proving is to be verified by a pressure operated switch, or a pressure sensor and controller complying with the requirements of the Standard for Limit Controls, UL 353 or the requirements for protective controls in the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1, General Requirements, UL 60730-1. The pressure-operated switch shall be of the automatic reset type, suitable for use with the type of gas marked on the rating plate, and have an operating pressure range adequate to perform the valve proving check feature of the system.

45.3A.2 added August 13, 2012

45.3A.3 Automatic valves utilized with the operation of an automatic valve proving system shall be verified as having an opening time adequate to perform the valve proving check feature as specified in 45.3A.4 and shall comply, as applicable, with the time limits of Table 55.2.

45.3A.3 added August 13, 2012

45.3A.4 It shall be verified following assembly, that the valve opening time of the electric gas safety shutoff valves, as required by 45.3.1, is adequate to perform the valve proving check feature for the gas volume between the two valves.

45.3A.4 added August 13, 2012

45.3A.5 A bypass valve shall not be installed in parallel with the automatic safety shutoff valves for the purpose of filling or evacuating the main gas supply piping during the valve proving test, unless it can be verified, by test and/or a review of the wiring schematic of the unit, the bypass valve cannot be energized during a call for heat.

45.3A.5 added August 13, 2012

45.4 Manually operated valves – Oil

45.4.1 A manually-operated fuel-metering valve shall be provided with a means that may be set by the installer or manufacturer to restrict the maximum amount of fuel delivered to the burner to an amount which can be consumed as intended, or the means for adjustment shall be enclosed or shielded to discourage tampering after adjustment has been made by the installer. This does not apply to a burner intended only for commercial or industrial installations not open to the public.

45.4.2 A plug or rotating-disc type valve, employing the bearing surface of the plug or disc as the liquid seal to the exterior of the valve body, shall not be used in a fuel oil line.

45.4.3 A petcock or valve which, when open, will permit the discharge of fuel oil into the room shall not be used.

45.5 Manually operated valves – Gas

45.5.1 Manually operated main shutoff and pilot shutoff valves shall have an attached handle which is positioned parallel to the gas flow when the valve is in the open position. These valves shall be located so that they are accessible. These valves shall be stamped and/or marked for their specifically designed use (such as ″g″ for gas, or ″wog″ for water, oil, or gas), and they shall have indicated ON and OFF positions. These indications may be by means of a line on the valve stem which is parallel to the flow of gas when the valve is open and perpendicular to the flow of gas when the valve is closed. The valve shall also incorporate stops for both fully open and fully closed positions.

45.5.1 effective January 30, 2009

45.5.2 A manually operated main burner shutoff valve shall be installed in the line supplying all main burners of each gas device and shall be located upstream of main burner gas control and automatic safety shutoff valves. Another manually operated gas valve shall be installed in the gas line of the main burner, located downstream of all automatic safety shutoff valves to permit the testing of the safety shutoff valves for leakage.

45.5.3 A manually operated pilot shutoff valve shall be located in the gas supply line to the pilot burner(s).

45.6 Pressure regulators – Oil

45.6.1 A pressure-regulating valve shall incorporate a means of shielding or locking the adjustment to discourage tampering by unauthorized persons after being set. The valve shall be constructed so that the maximum pressure of oil at the maximum valve setting will not exceed the intended maximum pressure for the burner.

45.6.2 A nozzle shutoff valve of the automatic type shall close at a pressure above the minimum atomizing pressure of the burner.

45.6.3 A pressure-relief valve shall be connected into a fuel line in which pressure may build up in excess of that intended by the design, because of the closing of any valve in the assembly of the burner or when the oil is heated by a preheater.

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45.7 Pressure regulators – Gas

45.7.1 Spring or weight loaded regulators shall have springs or weights covered by a housing. A weight and lever type of regulator shall not be used.

45.7.2 The diaphragm housing of a gas pressure regulator shall be made so that a vent pipe may be connected. See Marking, 36.8, for tagging of vent line connection.

Exception: When the gas pressure regulator is provided with an integral leak limiting orifice, the vent pipe connection and marking of the connection need not be provided.

45.7.3 Except as indicated in 45.7.4, a gas pressure regulator(s) shall be furnished.

45.7.4 A burner or device may be furnished without a pressure regulator provided it is permanently marked to declare that a regulator capable of being adjusted to the equipment's designed burner manifold pressure shall be installed at the time of installation of the equipment. See 36.10.

46 Stuffing Boxes

46.1 If packing is used to prevent leakage of fuel oil around a shaft or stem, a stuffing box conforming to 46.2 – 46.11 shall be used if the construction is such that it is necessary to adjust or renew the packing to prevent leakage during usage or as wear occurs.

46.2 A stuffing box shall be provided with a removable, shouldered, unthreaded follower gland and with a nut, spring takeup, or equivalent means for adjusting the gland to maintain pressure on the packing as wear occurs.

46.3 A stuffing box for an automatically-operated stem shall be constructed to avoid binding of the stem.

46.4 If an adjustable stuffing box is used to seal an automatically-actuated stem of a safety device, it shall be such that any allowable adjustment of the packing take-up will not bind the stem sufficiently to prevent the device from functioning automatically. A gland shall be spring-loaded.

46.5 An automatic spring take-up for a gland shall employ a spring made of corrosion-resistant material or one coated to retard corrosion.

46.6 The physical characteristics of a take-up spring shall be such that it will advance the gland through not less than one-half its possible travel from its initial setting with the spring compressed.

46.7 At the advanced position of the gland, a take-up spring shall not require adjustment of the nut to prevent leakage from the stuffing box when tested under pressure of one and one-half times maximum rated pressure.

46.8 A stuffing-box gland shall be made of corrosion-resistant material. The assembly of parts shall be such as to result in compressing the packing against the stem when the stuffing box nut or yoke is tightened.

46.9 Before shipment, a stuffing box shall be fully packed with pliable packing material, the impregnation of which is not adversely affected by contact with fuel oil.

46.10 The structure shall be such as to permit repacking the stuffing box without requiring the assembly to be dismantled, and threads of a stem shall not enter the stuffing box recess.

46.11 A manually-operated stem shall not back out, nor shall threads of a stem enter a stuffing-box recess, when the stem is rotated or reciprocated in any allowable manner even though an adjustable packing nut or other take-up is disengaged.

47 Bleeds and Vents

47.1 A bleed line from a diaphragm valve and an atmospheric vent line from a gas-pressure regulator, pressure interlock switch or any other gas train component that requires atmospheric air pressure to balance a diaphragm, shall be provided with threaded pipe connection for venting in accordance with the manufacturers instructions. Unless the burners are equipped for constant-burning pilot only, the vent line of a regulator shall not vent into the combustion chamber. Bleed lines shall be not less than 1/4 inch (6.4 mm) outside diameter tubing.

47.2 Bleed lines from diaphragm control valves and vent lines from gas-pressure regulators that vent into the combustion chamber shall terminate in burner tips made of a metal having a melting point in excess of 1450°F (788°C). They shall be located so that the escaping gas will be readily ignited from the pilot flame and the heat liberated will not impair the operation of the thermal element. Bleed line burners shall be securely held so that the ports are in a fixed position relative to the pilot flame.

47.3 A vent line from a gas-pressure regulator shall not be connected into a common line with a bleed line from a gas-operated diaphragm or from a relief valve.

47.4 Atmospheric vent lines, when manifolded, shall be connected to a common vent line having a cross sectional area not less than the area of the largest vent line plus 50 percent of the areas of all the additional vent lines.

47.5 Gas vent lines with normally open, fully ported, electrically operated valves shall be sized in accordance with Table 47.1.

Table 47.1
Vent line sizing

Fuel line size, nominal pipe size, inches	Vent line size, nominal pipe size, inches
Up to 1-1/2	3/4
2	1
2-1/2	1-1/4
3	1-1/4
4	2
5	2
6	2-1/2
8	3

48 Gauges

48.1 A pressure gauge, when used, shall have a scale range of at least one and one-half times the maximum intended operating pressure of the burner and greater than the maximum operating pressure as well as the pressure obtained at the maximum setting of any relief or pressure-regulating valve included as part of the burner equipment.

48.2 A glass gauge or sight feed, the breakage of which will allow the discharge of fuel oil from the fuel supply system, shall not be used.

49 Ignition Systems – General

49.1 The electric igniter, pilot burner, and pilot and main burner flame-sensing devices shall be constructed and supported so that each will be fixed in its intended position.

49.2 The means for ignition shall be so designed and located as to avoid the collection of carbon and other material, or the dislocation, distortion, or burning of parts when the burner assembly is tested in accordance with these requirements.

49.3 The construction of a burner assembly shall be such that the igniter assembly may be readily withdrawn from and replaced in the burner assembly during servicing of the igniter assembly and burner assembly without resulting in:

a) Reduction of the clearances between bare current carrying parts, electrodes, and grounded metal parts;

b) Changes in the air gap at electrode tips;

c) Reduction of the spacings between the high potential cables and grounded metal parts; or

d) Changes in the position of the igniter or pilot relative to the area at which ignition is to be initiated.

50 Oil-Burning Devices

50.1 Except as indicated in 50.2, the lighting of main burner flame shall be accomplished by a pilot flame. An electric ignition system shall ignite only a pilot.

50.2 For an automatically ignited mechanical draft oil burner, having a maximum main flame hourly input in excess of 20 gph (75.7 L/h) the lighting of the main burner flame may be accomplished directly by an electric igniter if the burner is arranged to provide a guaranteed low fire start at a fuel input not exceeding 20 gph (75.7 L/h). The device shall carry the supplementary marking indicated in 36.24.

50.3 The high tension electric ignition system of an automatically-lighted oil burner shall be activated only before or simultaneously with the delivery of fuel to the ignition zone and shall remain active during the trial-for-ignition period. See 4.113.

51 Gas-Burning Devices

51.1 Except as indicated in 51.2, the lighting of the main burner flame shall be accomplished by a pilot flame. An electric ignition system shall ignite only a pilot.

51.2 For an automatically ignited mechanical draft gas burner having a maximum firing rate not greater than 5,000,000 Btu per hour per combustion chamber, the lighting of the main burner flame may be accomplished directly by an electric igniter if the burner, in conjunction with the appliance on which it is used, complies with Delayed Ignition – Test No. 10, 64.10.1 – 64.10.3. However, the maximum fuel input that is ignited directly by an electric igniter shall not exceed 2,500,000 Btu per hour. See 51.3.

51.3 If the maximum firing rate of a gas burner on which the main burner flame is lighted directly by an electric igniter exceeds 2,5000,000 Btu per hour per combustion chamber, the initial ignition input shall not exceed 2,500,000 Btu per hour. The ignition input shall be controlled by one or more of the following arrangements:

a) A low-fire start-up proved by an interlock arrangement;

b) A slow-opening gas valve arranged so that in 5 seconds after the valve is energized the fuel input rate to the burner does not exceed 2,500,000 Btu per hour; or

c) Staged fuel input by either a step-opening valve or an arrangement of two separate valves (see 45.1.5). The second stage input shall be delayed not less than 5 seconds from the energization of the first stage.

51.4 The ignition system for the main burner shall be activated before the delivery of fuel to the ignition zone and shall remain active during the main burner flame-establishing period. If means for ignition is cut off at the termination of the main burner flame-establishing period, the ignition (pilot and any pilot or main flame electric igniter) shall remain off for the duration of that firing cycle and for the purge period required upon attempting the next firing cycle in accordance with 55.3.

52 Electric High-Tension Ignition

52.1 Spark igniters

52.1.1 Current carrying parts, such as a bus bar, electrode, or terminals, shall be enclosed or insulated to provide protection against accidental contact.

52.1.2 If an adjustable air deflector or similar part is employed in the vicinity of bare conductors, the construction shall be such that the part may be securely fixed to maintain any spacing required to conform to 52.2.2.

52.1.3 The ignition system shall be subjected to the test specified in 31.2.1 and 31.2.2.

52.2 Electrode and bus bars

52.2.1 Bare electrodes and bus bars shall be self-supporting when in place.

52.2.2 An electrode or bus bar supporting an electrode shall be designed so that it may be fixed in its proper position, and will maintain the desired gap.

52.2.3 A setscrew shall not bear directly against an insulator. The design shall be such that an insulator is not likely to be damaged when tightening the securing means.

52.2.4 An electrode shall be prevented from rotating within its insulator, unless such rotation will not result in any change in spacing or alignment.

52.2.5 An electrode tip shall be of such design and material that extreme burning of its point will not result when the burner is tested in accordance with these requirements. A high-temperature alloy steel, or equivalent material, shall be used for the electrode tip.

52.2.6 An electrode slanting downward toward its insulator shall be provided with a drip loop, or the equivalent, to prevent oil running down the electrode from reaching the insulator.

52.3 Insulators

52.3.1 An insulator shall be made of ceramic insulating material or the equivalent, impervious to oil and moisture and cleanable by wiping. See 31.3.1 and 31.3.2 for the test method to confirm conformance with this clause.

52.3.2 An insulator shall provide a distance, as measured across the surface of the insulator, between the nearest point of bare current carrying parts and the nearest electrically grounded metal surface as indicated in Table 52.1.

Table 52.1
Spacing over surface of insulators

Secondary voltage of ignition transformer	Minimum surface distance over insulator, inches (mm)
Not more than 6,000	1 (25.4)
Not more than 10,000	1-1/2 (38.1)
Not more than 15,000	2 (50.8)

52.3.3 An insulator included in a proved gas pilot assembly to be energized by a transformer having a secondary voltage of not more than 6,000 need not conform to 52.3.2 and Table 52.1 if ignition is to be for combustible air-gas mixtures only within or adjacent to a pilot tip or nozzle.

52.3.4 An insulator shall be so located that no detrimental accumulations of carbon will form on it when the burner is tested in accordance with these requirements.

52.4 Leads

52.4.1 Ignition cable shall have a voltage rating equal to or greater than the rated secondary voltage of the ignition transformer. Each end of a high-tension lead shall be provided with a fixed loop, eyelet, or connector to facilitate and make sure adequate connection to the terminal. A high-tension lead or cable shall be run individually in a manner to avoid sharp bends.

52.5 Transformers

52.5.1 A transformer shall be mounted as closely as possible to the spark gap to avoid long leads. Its location shall be such that it will not be placed within 1 inch (25.4 mm) of the floor when the burner assembly is installed in accordance with the manufacturer's installation instructions unless that portion of the case within 1 inch (25.4 mm) of the floor is waterproof.

52.5.2 A spacing of at least 1/8 inch (3.2 mm) shall be provided between a transformer secondary terminal insulator and any adjacent metal part other than the transformer case.

52.5.3 The preceding requirements for electric high-tension ignition systems are based upon the use of ignition energy that is essentially sinusoidal. Other types of systems employing ignition energy that is not essentially sinusoidal may be considered. Among the factors taken into consideration in determining the acceptability of such systems are dielectric properties, electrical spacings, the true root-mean-square (rms) value and the peak voltage of the system, the average pulses, duration of the pulses, and duty cycles.

53 Gas Pilots

53.1 Except as indicated in 51.1, each main burner unit shall be equipped with a proved pilot to accomplish proper ignition of the main burner. If multiple burners are operated as a unit, a sufficient number of pilots shall be employed to accomplish the ignition of all main burners smoothly. The input to a pilot or the total input to all pilots being ignited simultaneously shall be in accordance with 64.10.1 and shall not exceed 5 percent of the maximum input of the main burner or total maximum input of all burners being operated as a unit for the following burners:

a) For an atmospheric natural draft gas burner; and

b) For any burner employing intermittent pilots.

53.2 If the input to a pilot or total input to all pilots being ignited simultaneously exceeds 400,000 Btu per hour the burner in conjunction with the appliance on which it is used shall comply with the Delayed Ignition – Test No. 10, 64.10.1 – 64.10.3.

53.3 A pilot burner shall be so located that fuel oil will not accumulate on or in it when the burner is firing or when the burner fails to ignite.

53.4 The gas supply pressure to the pilot or a group of pilots shall be regulated separately of the main burner gas regulator. The pilot-supply line shall be connected, or arranged to permit connection, upstream from all main burner valves and the main burner regulator.

53.5 Primary air openings and orifices shall be accessible for servicing.

53.6 A pilot burner, electric igniter, and pilot flame-sensing device shall be supported in such a manner that their position relative to each other and to the ports of the main burner or burners will remain fixed and means shall be provided to prevent the accidental incorrect assembly or mounting of any pilot burner in relation to the burner being served.

53.7 Clearance shall be provided for removal and replacement of the pilot burner without kinking the pilot gas tubing.

53.8 If a pilot burner supply line is taken from a horizontal line, the connection shall be made either at the side or top of the pipe. The pilot supply line shall be connected upstream of all main burner valves and regulators.

54 Control Applications

54.1 A safety-control circuit shall be two-wire, one side grounded, having a nominal voltage of 120. A safety control or protective device shall interrupt the ungrounded conductor.

54.2 It is the intent of the requirement in 54.1 that a short circuit or combination of short circuits to ground will not render a safety control or protective device inoperative. Safety control circuit arrangements other than described in 54.1 may be considered if they accomplish the intent of this requirement.

54.3 The control circuit shall be constructed so that a safety control or protective device cannot be rendered ineffective by short-circuit(s) to ground. Safety-control-circuit arrangements other than described in 54.1 shall provide equivalent protection.

54.4 The requirement of 54.1 does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

54.5 A control circuit shall be arranged so that it may be connected to a power supply branch circuit that can be protected against overcurrent at not more than the value appropriate for the rating of the electrical components included in the circuit.

54.6 All safety controls shall be accessible.

54.7 A safety control shall be supported in such a manner that it and its sensing element will remain in the intended position. It shall be possible to determine by observation or test whether or not each control is in its intended location.

54.8 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or allowing firing of the burner without the protection of each of the required safety controls.

54.9 Where so specified, safety shutdown may be provided either by employing manual reset type limit controls or it may be effected remotely by utilizing the manual reset feature of another control, such as the primary safety control. For systems where the reset feature is remote from the limit control, means shall be provided to indicate the limit control has operated when it causes safety shutdown.

54.10 A fuel-burning device not equipped to provide automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and following restoration of an interrupted power supply.

54.11 A fuel-burning device shall permit installation with a limit control(s) to prevent excessive pressure or temperature in the appliance being fired.

54.12 The control circuit of a burner intended for use with a limit control which functions to interrupt or reduce the delivery of fuel for combustion by opening an electrical circuit shall be arranged to permit the limit control to be wired into the circuit so as to effect the direct opening of that circuit, whether the switching mechanism is integral with the sensing element or remote from same.

54.13 The purpose of the requirement in 54.12 is to prevent interposing in the limit-control circuit other controls, the failure of which may result in a condition the limit control is intended to prevent. For this purpose, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the desired circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls, or to interrupt a multiphase circuit.

54.14 A limit control which functions by opening a switch shall directly interrupt the power supply to the safety shutoff valve(s) except when two safety shutoff valves are used in the main burner supply line, see 45.3.1. One of the valves may be controlled through a contactor of a type that complies with the requirements for use in a safety control circuit.

54.15 A fuel burning device circuit shall be arranged to prevent feedback by a motor capacitor, or similar device from energizing a fuel valve or ignition device.

55 Primary Safety Controls

55.1 Each assembly shall be provided with a primary safety control that will de-energize the main burner safety shutoff valve upon loss of flame at point of supervision.

55.2 Loss of flame at the point of supervision shall result in de-energization of the safety shutoff valve by the primary safety control and safety shutdown for the following burners:

a) Power burners and mechanical draft atmospheric gas burners having an input in excess of 2,500,000 Btu per hour (732 Kw) firing gas, in excess of 20 gph (75.7 L/h) firing oil;

b) Any type of burner equipped with a manually lighted continuous pilot; and

c) A burner employing direct electric ignition of main burner gas.

55.3 Following the loss of flame at the point of supervision and de-energization of the safety shutoff valve within the time interval specified in Table 55.2, the ignition means may be automatically reactivated for an attempt to restart the burner under the following conditions:

a) For a power burner or a mechanical draft burner having an input not exceeding 2,500,000 Btu per hour (732 Kw) firing gas, 20 gph (75.7 L/h) firing oil, after completion of the purge in accordance with 56.1.1 or 56.1.2; and

b) For any atmospheric natural draft gas burner after a 5 minute delay if the burner has unrestricted air passages or after a 90 second delay after opening of an automatic damper.

55.4 A primary safety control shall conform to the requirements of 55.5 – 55.9 and provide programming and monitor burner operation in accordance with Table 55.1 and Table 55.2 as appropriate.

Table 55.1
Required programming and timings based on maximum fuel input rating firing oil as a main fuel

Operation	Maximum input	
	Above 3 to 20 gph (above 11.4 to 75.7 L/h)	Above 20 gph (above 75.7 L/h)
Prepurge	Up to 7 gph (26.5 L/h) not required Over 7 gph required if oil pump operates independently of the burner. See 56.1.1	Four air changes at 60 percent damper opening and with proven airflow. See 56.1.2
Postpurge timing	Not Required	15 seconds minimum
Pilot type and flame establishing period	Interrupted, 10 seconds maximum if pilot used	Interrupted, Nos. 2 and 4 oil, 10 seconds maximum, Nos. 5 and 6 oil, 15 seconds maximum[a]
Main burner flame establishing period		
Ignited by pilot	15 seconds maximum[b]	10 seconds maximum
Direct ignition	15 seconds maximum Intermittent or interrupte[d]	Not permitted except for low fire start up to 20 gph, in which case 15 seconds maximum.[d]
Flame failure reaction time,[d]	4 seconds maximum	4 seconds maximum
Ignition by pilot	15 seconds maximum for inputs up to 7 gph	4 seconds maximum
Direct ignition,[c]	4 seconds maximum for inputs over 7 gph	
Safety shutoff valve closing time after de-energization	5 seconds maximum	1 second maximum
Action required on flame failure	One recycle permitted if flame failure response time does not exceed 4 seconds.	Safety shutdown required
Proven low fire start	Not Required	Required with direct ignition if total input exceeds 20 gph.
Combustion air proving	Required if fan is not mounted on burner motor shaft	Required
Action required on loss of combustion air	Safety shutdown except may recycle once. See 56.2.1.	Safety shutdown
Oil pressure supervision	Required if oil pump is remote from burner motor. See 57.3.	Required if oil pump is remote from burner motor. See 57.2.
Low atomizing media pressure supervision	Required unless atomization is accomplished by oil pump mounted on burner motor shaft. See 57.3.	Required. See 57.2
Oil temperature supervision	High and low temperature supervision required on preheated oil. Excessive temperature shall cause safety shutdown.	

[a] If it can be demonstrated by tests that a burner equipped to fire No. 5 or 6 oil needs more than 15 seconds for the main burner flame establishing period in order to avoid nuisance shutdown, the period may be extended to 30 seconds provided not more than 15 seconds of unburned fuel can be discharged during an attempt to establish the main flame.

[b] Use of pilot for igniting the main flame is optional for inputs of 20 gallons per hour or less. See 55.12.

[c] See 55.12.

[d] The flame-failure reaction time is to be considered the interval between the actual flame extinguishment and the time the safety shutoff device (such as an oil valve) is de-energized.

55.5 The operation of the primary safety control shall be such that after the end of the main burner flame establishing period the combustion detector is responsive only to the properties of main burner flame.

55.6 The control system for a burner assembly equipped with a pilot for ignition of main burner flame shall be arranged so that no gas can flow to the main burner or burner group operating as a unit unless the pilot is proved. See 53.1.

55.7 Pilot supervision by the primary safety control shall be only at the point where the pilot flame will effectively ignite the gas at the main burner or burner group with the pilot burning with any flame capable of actuating the safety control.

55.8 If a pilot is not proved, the gas to the pilot shall be automatically shut off and safety shutdown established. In the event of pilot extinguishment the gas to such pilots shall be shut off within the time interval specified in 55.15. A pilot, independently supervised, having an hourly input of 5000 Btu per hour or less, intended to light a larger pilot which is supervised in accordance with 55.6 and 55.15, is acceptable.

55.9 With respect to 55.1, for an oil burner having an input not exceeding 20 gph (75.7 L/h) and that is equipped to provide prepurge, on flame failure one additional attempt may be made to ignite the burner after a prepurge in accordance with 56.1.2. If flame is not established, safety shutdown shall occur.

55.10 With respect to 55.1, for an oil burner having an input in excess of 20 gph (75.7 L/h), on flame failure no additional attempts to relight the burner shall be made and safety shutdown shall occur.

55.11 When an automatically ignited pilot is used, the pilot flame shall be proved before the main fuel valve is energized. Fuel to the pilot shall be shut off and safety shutdown shall occur if the pilot flame is not proved.

55.12 Direct ignition of the main burner shall not be employed for inputs in excess of 20 gph (75.7 L/h).

Exception: Direct ignition may be used on a boiler assembly having an input in excess of 20 gph (75.7 L/h) if :

a) The initial ignition is accomplished at a input not exceeding 20 gph (75.7 L/h); and

b) The input is not increased until the main flame at the lower input has been established and proved.

55.13 If burner assemblies are designed for multiple installation in single devices, the automatic safety control mechanism of each burner assembly shall operate independently of the other, or equivalent safety features shall be provided so that in no case can any one burner operate unsafely.

55.14 With respect to 55.6, 55.8, and 55.13 for an atmospheric burner consisting of sections or groups of burners where each section or group is ignited by its own proved pilot and each pilot or main burner section or group is supervised by its own primary safety control, each section or group is to be considered as an individual burner. If a pilot is not proved during the trial for ignition or if a pilot flame is extinguished during the burner operation, safety shutdown of that particular section or group only needs to be effected and the operation of all other groups may continue unaffected, provided the appliance complies with combustion test requirements in 64.1.1 – 64.1.3 and Section 69.

55.15 The time required to prove an expanded pilot, the pilot flame-establishing period for intermittent and interrupted pilots, and the main burner flame-establishing period for a burner ignited by a pilot or directly by an electric igniter, shall be as indicated in Table 55.1 or 55.2, as applicable.

Table 55.2
Required programming and timings based on maximum fuel input rating firing gas as a main fuel

Operation	Maximum firing rate per combustion chamber		
	Above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732, 678 W)	**Above 2,500,000 Btuh (732,678 W) to 5,000,000 Btuh (1,465,356 W)**	**Above 5,000,000 Btuh (1,465,358 W) to 12,500,000 Btuh (3,663,389 W)**
Prepurge	Four air changes in 90 seconds with proven airflow, or at 60 percent damper opening, with both damper opening and airflow proven	Four air changes at 60 percent damper opening with both damper opening and airflow proven	Four air changes at 60 percent damper opening with both damper opening and airflow proven
Pilot type and flame establishing period	Intermittent or interrupted, 15 seconds maximum[c]	Interrupted, 10 seconds maximum	Interrupted, 10 seconds maximum
Main burner flame establishing period			
Ignited by pilot	15 seconds maximum	10 seconds maximum	10 seconds maximum
Direct ignition	4 seconds maximum	4 seconds maximum[a]	Not permitted
Flame failure reaction time[b]	4 seconds maximum	4 seconds maximum	4 seconds maximum
Safety shutoff valve closing time after de-energization	5 seconds maximum	1 second maximum	1 second maximum
Action required on flame failure	One recycle permitted	One recycle permitted	Safety shutdown required
Proven low fire start	Not required	Required	Required
Combustion air proving	Required	Required	Required
Action required on loss of combustion air	Safety shutdown except may recycle once. See 42.10	Safety shutdown except may recycle once. See 42.10	Safety shutdown
Gas pressure supervision	Not required	Low and high gas pressure switches required	Low and high gas pressure switches required

[a] Maximum fuel input at light off not to exceed 2,500,000 Btu per hour (732,678W). See 49.3.

[b] The flame-failure reaction time is to be considered, the interval between the actual flame extinguishment and the time the safety shutoff device (such as a gas valve) is de-energized.

[c] The pilot flame establishing period shall not exceed 4 seconds if the pilot input exceeds 400,000 Btu per hour (117 Kw). See 53.1.

55.16 Supervision of the main gas burner flame is not required on a burner equipped with an intermittent pilot that is supervised throughout the burner operating cycle in accordance with 64.7.2 and 64.8.1, provided the maximum firing rate per combustion chamber does not exceed the following:

a) 2,500,000 Btu per hour (732,678 W) for a mechanical draft burner; or

b) 5,000,000 Btu per hour (1,465,356 W) for an atmospheric burner.

55.17 Supervision of the main gas burner flame only shall begin at the end of the main burner flame-establishing period if:

a) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour (732,678 W) for a mechanical draft burner and 5,000,000 Btu per hour (1,465,356 W) for an atmospheric burner;

b) The burner assembly is equipped with an interrupted pilot or an electric igniter for ignition of the main burner gas; or

c) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour (732,678 W) and modulating or high-low firing is employed.

If the main burner flame is not proved, safety shutdown shall be established.

56 Purge and Combustion Air Monitoring Controls

56.1 General

56.1.1 A forced or induced draft burner assembly shall provide preignition purging for the combustion chamber, heat exchanger, and flue passages of the device to which the burner assembly is to be applied, immediately before ignition of an interrupted or intermittent pilot or before delivery of fuel to the main burner for direct ignition by an electric igniter, whichever is applicable. Purging shall continue for a sufficient time to make sure a minimum of four air changes of this volume. With the air flow proven and the air dampers proven to be open the air flow rate shall be at least equivalent of that provided for combustion at 60 percent of the rated high-fire input.

Exception: For a burner assembly having an input not exceeding that indicated below, as an option, the purging may be accomplished at a damper opening that provides at least four air changes in not more than 90 seconds.

Firing Oil as a Main Fuel	Firing Gas as a Main Fuel
In excess of 7 gph (26.5 L/h) but not exceeding 20 gph (75.7 L/h)	Above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732,678 W)

56.1.2 Purge periods at air flow rates not less than those indicated in (a) and (b) may be considered as providing purging in accordance with 56.1.1:

a) A purge period of 30 seconds, during which time air flow at a rate equivalent to that provided for combustion at rated, high-fire input of the burner assembly or device is obtained; and

b) A purge period of 60 seconds, during which time air flow at a rate equivalent to that provided for combustion at 60 percent of rated, high-fire input of the burner assembly or device is obtained.

56.1.3 A prepurge of a shorter time than specified in 56.2 is acceptable for a burner that is designated by a marking on the burner for use only on a specific appliance and it is determined that the shorter time provides at least four complete air changes for the combustion chamber, heat exchanger and the flue passages of the appliance. However, the purging shall be accomplished with the air flow at a rate not less than equivalent to that provided for combustion at 60 percent of the maximum rated high-fire input. During the purge the air flow and the damper position shall be proven.

56.1.4 With respect to 56.1.1 – 56.1.3 if there is a loss of air during the purge, a complete required purge of four air changes or the required period of purge shall be provided after reestablishment of air flow.

56.1.5 The requirement of air purging in 56.1.1 and 56.1.2 is based on flue gas recirculation not being present during the prepurge period. This may be accomplished by an FGR blower assembly being de-energized during purge or shutoff valve installed in the FGR ductwork.

56.1.6 Purging of the FGR system during preignition purging may be accomplished only when the direction of the purge airflow through the FGR system ductwork is from the combustion chamber to the flue stack.

56.1.7 The purging periods required by 56.1.1a and 56.1.2 shall either be provided as part of the primary safety control programming or by a separate device, arranged so that the ignition of the burner cannot be initiated if the device has failed in a manner that will not provide purging in accordance with 56.1.1 and 56.1.2.

56.1.8 A mechanical draft oil burner having an input in excess of 20 gph (75.7 L/h) shall provide a post-purge period of not less than 15 seconds.

56.1.9 An atmospheric or natural draft burner equipped with an automatically operated air shutter and/or draft damper which is closed or positioned so as to restrict the passage of air when the burner is not firing shall provide means to open such air shutters to the high-fire position and/or dampers for a period of at least 90 seconds immediately before each light-off cycle is initiated.

56.1.10 For convenient reference, the requirements for purge and action required on loss of combustion air are also included in Table 55.1.

56.2 Controls for oil burning assemblies

56.2.1 For an oil burning assembly having an input in excess of 20 gph (75.7 L/h), loss of combustion air shall result in safety shutdown. For an oil burning assembly having an input in excess of 3 gph (11.4 L/h) but less than 20 gph (75.7 L/h), on which the forced or induced draft fan that supplies combustion air is not integral with the burner motor shaft, loss of combustion air shall result in fuel shutoff to the burner.

57 Oil Atomization Control

57.1 A burner that uses a medium such as air or steam for atomizing the fuel oil, and in which the atomizing medium is obtained from a source separate from the assembly shall be provided with interlock means to shut off the delivery of fuel to the firing portion of the burner.

57.2 An oil burning assembly having an input rating in excess of 20 gph (75.7 L/h) shall employ a low oil pressure interlock switch that shall cause safety shutdown when the oil pressure falls below the predetermined limit.

Exception No. 1: A low pressure interlock is not required for rotary cup type burners.

Exception No. 2: A low pressure interlock switch is not required if the oil pump is secured directly on the burner motor shaft.

Exception No. 3: A low oil pressure interlock switch is not required if both the oil and atomizing medium are supplied to the burner from the same pump and an interlock switch is provided in accordance with 53.1.

57.3 An oil burning assembly having an input rating in excess of 3 gph (11.4 L/h) shall be provided with a low pressure interlock switch for the atomizing media that shall cause safety shutdown when the pressure falls below the predetermined limit.

Exception: A low pressure interlock switch is not required provided the air pump is secured directly on the burner motor shaft and the input does not exceed 20 gph (75.7 L/h).

57.4 With respect to 57.2 and 57.3, for convenient reference the requirements for pressure switches are also included in Table 55.1.

58 Oil Temperature Control

58.1 High and low temperature interlocks shall be provided for systems that fire preheated oil. An oil temperature in excess of the limit established by the burner manufacturer shall result in safety shutdown. If the oil temperature falls below the predetermined limit, the interlock shall operate to stop fuel delivery to the burner and allow circulation of the oil until the temperature increases to permit firing.

59 Gas Pressure Controls

59.1 A burner shall be equipped with low and high gas pressure switches if:

a) The maximum firing rate per combustion chamber exceeds 2,500,000 Btu (732,678 W) per hour; or

b) Regardless of the firing rate, the burner is equipped with an electric igniter for direct ignition of the main burner gas.

The switches shall cause a safety shutdown in the event the gas pressure varies by ±50 percent of the rated pressure downstream of the main burner regulator. The low gas pressure switch shall be located upstream of the safety shutoff valve or valves. The high gas pressure switch shall be located downstream of the safety shutoff valve or valves.

59.2 With respect to 59.1, the high gas pressure switch may be located downstream of the main burner regulator if it can be determined the burner is capable of operation at the intended pressure settings.

60 Interlocks

60.1 A control device provided as an interlock in the burner fuel supply-combustion air system, fuel supply-atomizing air system, or for a similar purpose shall comply with the requirements specified in the Standard for Limit Controls, UL 353.

61 Combination Gas-Oil Burners

61.1 A combination burner intended to burn only one fuel at a time shall be arranged so that the fuel not being fired will be shut off automatically when the burner for that fuel is not in firing position or is not intended to be fired.

61.2 A combination burner intended to burn only one fuel at a time, equipped to change automatically from one fuel to the other, shall be arranged so that the fuel being fired is shut off before the other fuel is delivered to the ignition zone. The ignition system for the fuel to be fired shall provide a predetermined trial-for-ignition period and shall be activated simultaneously with or before the initial delivery of the fuel to the ignition zone.

61.3 A burner intended to burn both gas and oil simultaneously shall be arranged so that the maximum operating input cannot exceed the maximum capacity of the burner as fired.

61.4 An automatically or remotely lighted combination burner shall be equipped so that no gas can flow to the main burner or burner group operating as a unit unless satisfactory ignition of the main gas burner is assured (proved pilot).

61.5 A combination gas-oil burner intended to burn one fuel at a time shall be provided with a fuel selector switch connected to the burner control circuit so that it permits firing only the selected fuel. For the purpose of changeover from one fuel to the other, the switch may be operated either manually or automatically, such as by the outside temperature. It's operation and marking shall be arranged in accordance with 61.6 – 61.8.

61.6 The fuel selector switch, when switched from one fuel to the other, shall be arranged to activate simultaneously and make effective all the required ignition devices, fuel control valves, interlocks and any other safety controls required for the selected fuel.

61.7 The fuel selector switch shall be arranged to operate in accordance with one of the following:

a) The fuel changeover can be affected only at the time the burner is shut down by an operating control;

b) If the fuel changeover can be effected at the time the burner is in operation and preignition purging is not specified for the newly selected fuel, the burner operation is to be interrupted for a sufficiently long time so that ignition of the newly selected fuel can not be effected by the previously fired fuel, as determined by fuel changeover test, 63.17.1 – 63.17.3; or

c) If the fuel changeover can be effected at the time the burner is in operation and preignition purge is specified for the newly selected fuel, the fuel changeover shall be accomplished only after a burner shut-down. The restart with the newly selected fuel shall provide all the required safety functions, including the preignition purge.

61.8 For a manual fuel selector switch, the switch position shall be clearly marked indicating the type of fuel and the off position. See 36.26.

PERFORMANCE

62 Test Installation

62.1 The burner is to be installed for test in an appliance of a size commensurate with the firing rate of the burner to be tested, except that a burner intended for application to a specific appliance may be tested as applied to that appliance or an appliance representative of the appliance for which the burner is designed.

62.2 All heating surfaces in contact with combustion products and the flue pipe of the appliance to be fired for the test are to be thoroughly cleaned before the combustion test is begun.

62.3 The burner is to be arranged for operation in accordance with the instructions furnished by the manufacturer. The burner is to be fired at a rate within the rating of the burner. A fire box, hearth, or the like, as recommended or furnished by the manufacturer, is to be provided.

62.4 The burner is to be fired with each of the lightest and heaviest grade of fuel for which the burner is rated and the air-fuel ratio adjusted in accordance with the manufacturer's instructions. The draft over fire is to be the value recommended by the manufacturer. Voltage is to be adjusted to the normal test voltage specified in Table 25.1.

63 Tests Firing Oil

63.1 Combustion – Test No. 1

63.1.1 Combustion shall be stable and complete at all firing rates over the operating range of the burner without excessive smoke and without causing the formation of excessive carbonization. The following is to occur:

a) Rate(s) shall be defined as the manufacturer's specified minimum and/or maximum input(s) for which the burner (or device) is intended to operate;

b) Actual test value(s) with the FGR system operative shall be ±2 percent of the specified value(s); and

c) Actual test value(s) without the FGR system operating shall not change to the extent that a deleterious affect on the combustion process is obtained.

63.1.2 The performance of a burner assembly or device during Test No. 1 and/or Test No. 2 shall be such that:

a) Automatic ignition is obtained on each cycle within the intended period of time;

b) Ignition is obtained at each cycle without backfire, flash, or ″puff;″

c) Stable combustion is obtained at all operating firing rates. Burner flames do not flash outside the heating appliance being fired;

d) The observed smoke at all firing rates during the prescribed tests does not exceed the following on the Shell-Bacharach scale with the Model RDC smokemeter or equivalent:

1) Number 1 spot for all mechanical draft burners having a maximum capacity not exceeding 7 gph (26.5 L/h) firing a distillate type fuel;

2) Number 2 spot for all vaporizing type burners firing a distillate type fuel and for mechanical draft burners having a maximum capacity in excess of 7 gph firing a distillate type fuel; and

3) Number 4 spot for all burners firing a residual type fuel.

e) The observed carbon monoxide concentration at all firing rates during the prescribed tests does not exceed 4/100 of 1 percent for burners firing a distillate fuel in a ″blue flame″ condition.

f) No excess amount of soot is deposited on surfaces of the heat exchanger, flue passages, or the flue pipe of the heating appliance fired for the test. Any tar or flocculent soot accumulation is deemed excessive;

g) Surfaces of the fire box, hearth, nozzles, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar;

h) No excess amount of carbon, soot, and tar has been deposited on burner surfaces. Any accumulation likely to be deleterious to the performance of the burner that continually increases as the test progresses, or that reduces the area of air openings in the burner or restricts fuel input, is to be deemed excessive;

i) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions; and

j) Flame stability as confirmed by both audible and visual inspection shall not be deleteriously affected with or without the FGR system operating.

63.2 Mechanical-atomizing burners – Test No. 2

63.2.1 The burner is to be fired until steady-state combustion conditions exist. Observations are to be made for each operating fire. For a modulating burner, these observations are to be made at minimum, intermediate, and maximum operating fires. The observed smoke is to be not more than that indicated on the Shell-Bacharach smoke scale with the Model RDC smokemeter or equivalent as specified in 63.1.2(d).

63.2.2 An automatically-lighted burner of the ″on″ and ″off″ type is to be fired intermittently, 10 minutes ″on″ and 10 minutes ″off.″

63.2.3 An automatically-lighted modulating-burner is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off.

63.2.4 During the test period, daily observations and recordings are to be made of the draft on each operating fire, ignition, and combustion characteristics, combustion chamber conditions, and any abnormal performance.

63.2.5 The fuel-burning rate, draft over fire, smoke, CO_2 and NO_x on each operating fire are to be observed and recorded at the beginning of the test, after each 50 hours of operation thereafter, and at the end of the test.

63.2.6 The duration of these tests is to be that required to obtain conclusive performance data. If excess deposits of tar or unburned carbon are found on the firing head, additional fire testing may be required which should not exceed 250 hours.

63.2.7 Following Test No. 2 the total electrical input and the electrical input of each component, except those having a pilot duty rating, are to be measured.

63.3 Combustion air failure test – Test No. 3

63.3.1 A mechanical draft burner not provided with a combustion air interlock shall operate in accordance with the requirements specified in 63.3.3 or 63.3.4 during interruption and upon restoration of the combustion-air supply.

63.3.2 The initial conditions for the test are to be as for Test No. 1. While the burner is being fired at any operating fire, the fan supplying air for combustion is to be stopped, that is, by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off in accordance with 63.3.3.

63.3.3 If the main burner flame is extinguished following interruption of the air supply, the fuel is to be shut off due to the inherent design of the burner or by action of a safety control within the safety control timing period specified in Table 55.1. The burner is to require manual restart to fire the burner upon restoration of the air supply, or an automatically-lighted burner may restart automatically upon restoration of the air supply provided the intended automatic reignition is obtained.

63.3.4 If combustion is continued following interruption of the air supply, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the combustion air supply is to be restored and the burner ignited if the flame has been extinguished. The performance of the burner is to be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the air supply, the combustion, if maintained, is to be such that the burner flame does not produce smoke in excess of that indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 63.1.2(d);

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test;

c) Combustion is stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash or ″puff;″ and

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

63.4 FGR fan failure test – Test No. 4

63.4.1 A mechanical draft burner shall operate in accordance with the requirements specified in 63.4.3 or 63.4.4 during interruption and upon restoration of the recirculating flue gas fan assembly.

63.4.2 The initial conditions for the test are to be as for Test No. 1. While the burner is being fired at any operating fire, the fan supplying recirculated flue gases is to be stopped, that is, by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off in accordance with 63.4.3 or combustion, if continued, is to be in accordance with 63.4.4.

63.4.3 If the main burner flame is extinguished following interruption of the air supply, the fuel is to be shut off due to the inherent design of the burner or by action of a safety control within the safety control timing period specified in Table 55.1. The burner is to require manual restart to fire the burner upon restoration of the FGR fan motor, or an automatically-lighted burner may restart automatically upon restoration of the FGR fan motor provided the intended automatic reignition is obtained.

63.4.4 If combustion is continued following interruption of the FGR fan motor, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the FGR fan motor is to be restored and the burner ignited if the flame has been extinguished. The performance of the burner is to be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the FGR fan motor, the combustion, if maintained, is to be such that the burner flame does not produce smoke in excess of that indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 63.1.2(d);

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test;

c) Combustion is stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash or ″puff;″ and

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

63.5 Interruption of atomization test – Test No. 5

63.5.1 A mechanical atomizing burner employing air, steam, or a mechanical device for atomizing fuel shall be arranged to shut off the delivery of fuel for combustion upon interruption of the atomizing media or the operation of the mechanical device.

63.5.2 The initial conditions for the test are to be as for Test No. 1. While the burner is being fired at any operating fire, the atomizing media or operation of the mechanical device is to be interrupted, that is, by disconnecting from the electrical circuit only the motor driving a device providing the atomizing means, by disconnecting any flexible coupling or removing any belt needed to drive such device, or by stopping the flow of an atomizing media furnished by a source other than the burner. Fuel to the main burner flame is to be shut off due to the inherent design of the burner or by action of the safety control timing period specified in Table 55.1. The burner is to require manual restart upon restoration of the atomizing means, or an automatically lighted burner may restart upon restoration of the atomizing means provided the intended automatic reignition is obtained.

63.6 Undervoltage test – Test No. 6

63.6.1 A burner shall operate in accordance with the requirements specified in 63.6.2 when tested at an undervoltage as specified in Table 25.1.

63.6.2 The initial conditions for test are to be as for Test No. 1, except that the test voltage shall be regulated to maintain the appropriate undervoltage, as specified in Table 25.1. The performance of the burner shall be such that:

a) Ignition of the main burner flame is effected without backfire, flash, or ″puff;″

b) Flames are not expelled from the burner or the heating appliance being fired for the test;

c) Combustion is complete and stable;

d) Flames at all allowable firing rates do not produce smoke in excess of that indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 63.1.2(d); and

e) The burner is capable of operation without interruption.

63.7 Power interruption test – Test No. 7

63.7.1 A power-operated burner shall operate in accordance with the requirements of 63.7.3, during interruption and upon restoration of the power supply.

63.7.2 The initial conditions for test are to be as for Test No. 1. While the burner is being fired at any operating fire, the power supply is to be interrupted. The power is then to be restored after being interrupted for any period of time. Fuel to the main burner is to be shut off immediately in accordance with 63.7.3.

63.7.3 If the main burner flame is extinguished immediately following interruption of the power supply, the oil shall be automatically shut off due to the inherent design of the burner or by action of a safety control. The burner shall require manual restart to fire the burner upon restoration of the power supply, or an automatically-lighted burner may restart automatically upon restoration of the power supply provided the intended automatic reignition is obtained.

63.7.4 If combustion is continued following interruption of the power supply, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the power supply is to be restored and the burner ignited if the flame has been extinguished. The performance of the burner is to be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the power supply, the combustion, if maintained, is to be such that the burner flame does not produce smoke in excess of that indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 63.1.2(d);

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test;

c) Combustion is stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash or ″puff;″ and

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

63.8 Ignition tests, electric high-tension reduced voltage – cold oil – Test No. 8

63.8.1 A high-tension ignition system for an automatically- or remotely-lighted burner shall effect the intended ignition of the fuel as introduced into the ignition zone when a voltage equivalent to 70 percent of normal test voltage is impressed on the primary circuit of the ignition system, the combustion air supply and burner are at room temperature and the temperature of the oil supplied to the burner is reduced to the value specified in 63.8.3.

63.8.2 The burner, arranged and installed as for Test No. 1, is to be tested after it has been subjected to the Combustion Test, except that the test voltages are as indicated in 63.8.3. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of oil fuel being used for the test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but not less than 1/8 inch (3.2 mm), if the burner is to employ an ″Interchangeable″ transformer. The temperature of the oil as supplied to any parts of the burner, except those located downstream from the preheater, is it to be 35 ±5°F (1.7 ±3°C). If a burner is equipped with a preheater, the temperature of the oil at the inlet to the preheater is to be not less than 20°F (11°C) above the pour point of the test fuel.

63.8.3 Except as indicated in 63.8.4, the voltage of the power supply to the ignition system is to be regulated to 70 percent of normal test voltage, and the voltage of the power supply to the primary safety control is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of normal test voltage for direct current.

63.8.4 If the burner is equipped with a primary safety control that can be connected only for interrupted ignition, the voltage of the power supply to both the ignition system and primary safety control shall be regulated to the minimum voltage necessary to initiate a trial for ignition.

63.8.5 The burner and ignition circuits are to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. If the burner is to employ an ″Interchangeable″ transformer, the appropriate ″Interchangeable″ test transformer is to be applied to the burner and five additional trials for ignition are to be made. During each trial, ignition is to be effected so that no flame is to be expelled from the burner or the heating appliance being fired for the test.

63.8.6 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes, during which period stable combustion is to be maintained.

63.9 Combustion detectors – Test No. 9

63.9.1 The combustion detector of a primary safety control that is capable of detecting the presence of ignition spark shall be so positioned that the combustion detector shall sense only the presence or absence of flame.

63.9.2 The test is to be made in conjunction with Test No. 1. Before a test is begun, a minimum pilot condition shall be established with the safety control operating at the appropriate overvoltage as specified in Table 25.1. The minimum signal strength, current or voltage, capable of permitting the flame relay to remain energized shall be recorded. The fuel supply to the pilot, if provided, is then to be shut off and the voltage reduced to normal test voltage. Five trials are to be made to determine that ignition spark, or a reflection of the spark from any part of the burner or appliance cannot be detected by the combustion detector at a value greater than 50 percent of the recorded signal strength capable of pulling in and holding in the flame relay.

63.10 Ignition test, gas reduced voltage – Test No. 10

63.10.1 A pilot flame for an automatically- or remotely-lighted burner shall effect ignition of the fuel as introduced into the ignition zone in accordance with the requirements of 63.10.4 when the voltage of the power supply to the burner is 85 percent of rated voltage for alternating current and 80 percent of rated voltage for direct current, and the temperature of the oil supplied to the burner is reduced to the value specified in 63.10.2.

63.10.2 The burner is to be arranged and installed as for Test No. 1. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum recommended in the manufacturer's instructions. The temperature of the oil supplied to any parts of the burner, except those located downstream from the preheater is to be 35 ±5°F (1.7 ±3°C). If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at room temperature.

63.10.3 The voltage of the power supply to the burner is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of rated voltage for direct current.

63.10.4 The burner is to be energized and allowed to remain energized for the design trial-for-ignition period. Five trials are to be made. During each trial, ignition shall be effected so that no flame is expelled from the burner or the heating appliance being fired for the test.

63.10.5 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes, during which period stable combustion is to be maintained.

63.11 Pilot supervision – Test No. 11

63.11.1 Pilot supervision by a safety control shall be only at a point where the pilot flame will effectively ignite the oil at the main burner or burner group when the gas supply to the pilot is reduced so the flame is just sufficient to actuate the primary safety control.

63.11.2 Tests to determine conformance with 63.11.1 are to be made in conjunction with Test No. 1. Initially the trial to ignite the main burner fuel is to be made with the fuel to the pilot regulated to produce a pilot of the minimum size which can be detected by the combustion detector of the primary safety control. The pilot flame size is then to be increased in small increments up to the maximum pilot size and trials to ignite the main burner fuel are to be made with each pilot size. At least five trials to ignite the main burner fuel shall be made with the minimum pilot and with any other size pilot which appears to be critical.

63.12 Flame failure response – Test No. 12

63.12.1 A burner shall not provide a false indication of pilot or main flame due to the atomizing media, refractory glow or the recirculated flue gases.

63.12.2 The test is to be made in conjunction with Test No. 1. Before the test is begun, the fuel supply to the pilot is to be regulated to provide the minimum pilot flame required to actuate the primary safety control. During the initial start up the main manual fuel shutoff valve is to be closed and after the pilot flame is supervised, the pilot fuel supply is to be shut off by the manual valve. The primary safety control shall actuate to de-energize the pilot safety valve.

63.12.3 As a continuation of this test and providing the safety control responded to shut off the pilot safety valve, the burner assembly shall be operated at the high-fire rate for at least 15 minutes after which time the fuel to the main burner shall then be shut off by action of a manual valve. The primary safety control shall actuate to de-energize the main fuel safety valve.

63.13 Pilot stability – Test No. 13

63.13.1 A pilot flame shall not become extinguished unintentionally when the main burner or burners are turned on or off in the intended manner, either manually or by automatic controls.

63.13.2 Observations are to be made in conjunction with Test No. 1 or Test No. 2.

63.14 Ignition test, gas-electric – Test No. 14

63.14.1 A burner equipped with a gas-electric ignition system shall not ignite when a trial-for-ignition is made with no gas available, with the combustion air supplied at room temperature, and with the oil at the intended operating temperature. This requirement does not apply to a burner equipped with a proved pilot or a control which prevents a trial-for-ignition when no gas is available.

63.14.2 The burner is to be arranged and installed as for Test No. 1. The oil-temperature control for a burner intended to burn preheated oil is to be set for the maximum recommended in the manufacturer's instruction. The oil supplied to any parts of the burner, except those located downstream from a preheater, is to be at room temperature. If a burner is equipped with a preheater, the temperature of the oil at the outlet of a preheater is to be the maximum recommended in the manufacturer's instructions for the grade of fuel being used for the test.

63.14.3 The voltage of the power supply to the burner is to be regulated to 110 percent of normal test voltage. The gas supply to the ignition system is to be shut off. The burner is to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. No ignition of oil is to occur.

63.15 Ignition test, gas-electric high-tension reduced voltage – cold oil – Test No. 15

63.15.1 A gas-electric high-tension ignition system for an automatically- or remotely-lighted burner shall ignite the pilot immediately upon admission of pilot gas with a voltage equivalent to 70 percent of normal test voltage in the primary circuit of the ignition system. The pilot shall effect ignition of the oil fuel as introduced into the ignition zone when the combustion air is supplied at room temperature and the temperature of the oil supplied to the burner is reduced to the value specified in 63.15.1.

63.15.2 The burner is to be tested after it has been subjected to the Combustion – Test No. 1, except that the test voltage is to be as indicated in 63.15.3. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of oil fuel being used for the test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but a gap is to be not less than 1/16 inch (1.6 mm). The temperature of the oil as supplied to any parts of the burner, except those located downstream from a preheater, is to be 35 ±5°F (1.7 ±3°C). If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be not less than 20°F (11°C) above the pour point of the test fuel.

63.15.3 Except as indicated in 63.15.4, the voltage of the power supply to the ignition system is to be regulated to 70 percent of rated voltage, and the voltage of the power supply to the safety control circuits is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of rated voltage for direct current.

63.15.4 If the burner is equipped with a primary safety control that can be connected only for interrupted ignition, the voltage of the power supply to both the ignition system and primary safety control is to be regulated to the minimum voltage necessary to initiate a trial for ignition.

63.15.5 The burner and ignition circuits are to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. If the burner is to employ an ″Interchangeable″ transformer, the appropriate ″Interchangeable″ test transformer is to be applied to the burner, and five additional trials-for-ignition are to be made. During each trial, ignition shall be effected so that no flame is expelled from the burner or the heating appliance being fired for the test.

63.15.6 Following the last trial for ignition and as a continuation thereof, the burner is to be allowed to fire at high-fire rate for at least 15 minutes, during which period stable combustion is to be maintained.

63.15.7 A gas-electric high-tension ignition system shall conform also to 63.11.1 – 63.13.2.

63.16 Ignition test, multiple-atomizer burner – Test No. 16

63.16.1 An automatically-lighted-atomizing burner equipped with multiple atomizers, jets, or nozzles shall be so constructed that the atomized oil delivered for combustion by each will be ignited by the flame at each other atomizer when tested in accordance with 63.16.2 and 63.16.3. No incomplete ignition or combustion shall be obtained when the fuel delivered by any one or more atomizers is interrupted during an ignition or firing cycle.

63.16.2 The initial conditions for test are to be as for Test No. 1. If more than one igniter is provided, all but one igniter is to be deactivated unless all igniters become ineffective when one is deactivated. The burner is to be energized to fire in accordance with its designed sequence of operation. Five trials-for-ignition are to be made. If more than one igniter capable of functioning independently of the others is provided, the test is to be repeated with each additional igniter in turn activated while all others are deactivated. During each trial, ignition of the fuel as introduced into the ignition zone by each atomizer shall be effected as intended, no flame shall be expelled from the burner or the heating appliance being fired for the test, and stable combustion shall be maintained.

63.16.3 As a continuation of the test described in 63.16.2, the burner is to be shut off and all igniters activated. One atomizer is to be prevented from delivering fuel for combustion. The burner is to be energized to fire in accordance with its intended sequence of operation. Five trials-for-ignition are to be made. The test is to be repeated with each other atomizer being blocked one at a time with two or more atomizers blocked at one time until all combinations, including one or more blocked atomizers, are tried. No ignition of the oil as introduced into the ignition or combustion zone is acceptable performance, provided the burner is shut off by its safety control within the intended period; but if any ignition occurs, such ignition shall be effected as intended, no flame shall be expelled from the burner or the heating appliance being fired for the test, and stable combustion shall be obtained.

63.16.4 During this test multiple burners with more than one igniter capable of functioning independently shall light as intended when all but one igniter is deactivated; the automatically-lighted multiple burner delivering fuel through more than one nozzle shall be equipped with an igniter capable of providing the intended ignition and combustion when the nozzle of one burner adjacent to the igniter is plugged, and with the initial plugged nozzle relieved and any other one nozzle plugged, the intended ignition from the other nozzle shall occur.

63.17 Fuel changeover test – Test No. 17

63.17.1 A combination gas-oil burner intended to burn only one fuel at a time that does not provide preignition purge as part of its operating sequence, shall be subjected to tests in accordance with 63.17.2 and 63.17.3 to determine that upon fuel changeover the ignition of the new fuel is not affected by the previously fired fuel and the ignition takes place without any risk of fire or explosion.

63.17.2 The initial conditions for the test shall be as specified for Combustion – Test No. 1. The burner shall be started firing one fuel and operated on that fuel through a complete firing cycle until stable burner flame is observed. The burner is then to be changed over to the other fuel as rapidly as possible, following the instructions provided with the burner. The burner is to be observed for ignition and continued burning until the flame stabilizes. The fuel changeover is then to be repeated to the original fuel.

63.17.3 The ignition of both fuels shall be affected smoothly by the intended ignition means without any backfire, flashback or burning of the flame outside of the combustion chamber.

64 Tests Firing Gas

64.1 Combustion – Test No. 1

64.1.1 Combustion shall be complete in the space provided by the device or, if a burner assembly in the space recommended by the manufacturer, and no carbon monoxide in concentration in excess of 4/100 of 1 percent shall be present in air free samples of the flue gases taken over the full operating range of the burner assembly. The following is to occur:

a) Rate(s) shall be defined as the manufacturer's specified minimum and/or maximum input(s) for which the burner (or device) is intended to operate;

b) Actual test value(s) with the FGR system operative shall be ±2 percent of the specified value(s); and

c) Actual test value(s) without the FGR system operating shall not change to the extent that a deleterious affect on the combustion process is obtained.

64.1.2 Complete and stable combustion shall be maintained at the minimum rate of firing or during any sudden change in the gas firing rate between maximum and minimum rates. Ignition shall be accomplished safely.

64.1.3 The performance of a burner assembly or device during shall be such that:

a) Ignition is obtained on each cycle within the expected safe period of time;

b) Ignition is obtained at each cycle without flash of flame outside the heating devices being fired and without damage to parts of the device;

c) Stable fires are obtained at all operating firing rates;

d) No soot has been deposited on surfaces of the heat exchanger, flue passages, or vent connector of the heating device fired for the test;

e) Surfaces of the fire box, hearth, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar;

f) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions; and

g) Flame stability as confirmed by both audible and visual inspection shall not be deleteriously affected with or without the FGR system operating.

64.2 Endurance – Test No. 2

64.2.1 The burner is to be fired until steady-state combustion conditions exist. Observations are to be made for each operating fire. For a modulating burner, these observations are to be made at minimum, intermediate, and maximum operating fires. The observed carbon monoxide concentration on an air-free sample is not to exceed 4/100 of 1 percent.

64.2.2 A burner assembly of the ″on″ and ″off″ type is to be fired 10 minutes ″on″ and 10 minutes ″off″ for intermittent firing tests.

64.2.3 A modulating burner assembly is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off for intermittent firing tests.

64.2.4 During test periods, observations and recordings are to be made of the draft on each operating rate, ignition, and combustion characteristics, combustion-chamber conditions, and any unnatural performance.

64.2.5 The fuel burning rate, draft over fire, CO_2, NO_x, and any CO are to be observed and recorded for each operating fire. For an atmospheric burner consisting of sections or groups of burners that can be operated as individual burners (see 55.14), tests are to be conducted with different combinations of burner sections or groups operating at a time.

64.2.6 The duration of these tests is to be that required to obtain conclusive performance data.

64.3 Combustion air failure – Test No. 3

64.3.1 A mechanical-draft burner assembly or device shall not operate unsafely during interruption and upon restoration of the combustion air supply, as determined by test in accordance with 64.3.2 and 64.3.3.

64.3.2 The initial conditions for the test to determine conformance to the preceding are to be as for Test No. 1. While the burner assembly or device is being fired at any operating rate, the fan supplying air for combustion is to be stopped, that is, by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off in accordance with 64.3.3.

64.3.3 The fuel shall be shut off due to the inherent design of the burner assembly or by action of a control before any conditions develop that may cause a risk of fire or explosion. For an automatically lighted burner assembly whose maximum rated input does not exceed 2,500,000 Btu per hour (732 kW) the light off may be accomplished automatically upon restoration of the air supply after completion of the purge in accordance with 56.1.1 – 56.1.4. For a manually lighted burner and for an automatically lighted burner whose maximum rated input is in excess of 2,500,000 Btu per hour a manual reset shall be necessary to restart the burner after restoration of the air supply.

64.4 FGR fan failure test – Test No. 4

64.4.1 A mechanical draft burner assembly or device shall not operate unsafely during interruption and upon restoration of the recirculating flue gas fan assembly.

64.4.2 The initial conditions for the test to determine conformance to the preceding are to be as for Test No. 1. While the burner assembly or device is being fired at any operating rate, the fan supplying recirculated flue gases is to be stopped, that is, by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off in accordance with 64.4.3 or combustion, if continued, is to be in accordance with 64.4.4.

64.4.3 The fuel is to be shut off due to the inherent design of the burner assembly or by action of a safety control within a safe period. The burner assembly is to require manual restart to fire the burner assembly upon restoration of the FGR fan motor, or an automatically lighted burner assembly may restart automatically upon restoration of the FGR fan motor provided safety automatic reignition is obtained.

64.4.4 If combustion is continued following interruption of the FGR fan motor, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the FGR fan motor is to be restored and the burner ignited if the flame has been extinguished. The performance of the burner is to be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the FGR fan motor, the combustion, if maintained, is to be such that the burner flame does not produce a carbon monoxide concentration in excess of that indicated in 64.1.1.

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test;

c) Combustion is stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash or ″puff;″ and

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

64.5 Undervoltage – Test No. 5

64.5.1 A burner assembly or device shall operate in accordance with these requirements when tested at an undervoltage as specified in Table 25.1.

64.5.2 The initial conditions for test are to be as for Test No. 1. The voltage of the power supply to the burner assembly or device is to be regulated to maintain the minimum voltage specified in Table 25.1 and the burner assembly ignited and fired at high fire in the intended manner until steady-state conditions are attained.

64.5.3 The performance of the burner or device shall be such that:

a) Ignition of the main burner flame is effected safely during the five ignition trials;

b) Flames do not flash outside the device being fired nor damage appliance parts;

c) Combustion is complete and stable;

d) The concentration of carbon monoxide in an air free sample of the flue gas taken at the high-fire rate does not exceed 4/100 of 1 percent; and

e) The burner is capable of operation without interruption.

64.6 Power interruption – Test No. 6

64.6.1 A power operated burner assembly or device shall not operate unsafely upon interruption of the power supply. Upon restoration of the power supply, the burner assembly or device shall require manual restart or shall safely resume normal operation automatically.

64.6.2 The initial conditions for test to determine conformance to the preceding are to be as for Test No. 1. The test may be conducted during the course of the combustion test. While the burner assembly or device is being fired at any operating rate, the power supply is to be interrupted. The power is then restored after being interrupted for any period of time. The gas safety valve(s) shall be de-energized and fuel to the main burner shall be shut off within the time limit specified in 26.2.

64.6.3 The fuel is to be automatically shut off due to the inherent design of the burner assembly or by action of a safety control. In such case, the burner assembly is to require manual restart to fire the burner assembly upon restoration of the power supply, or an automatically lighted burner assembly may restart automatically upon restoration of the power supply provided safe automatic reignition is obtained.

64.7 Pilot supervision – Test No. 7

64.7.1 Pilot supervision by a safety control shall be only at a point where the pilot flame will effectively ignite the fuel at the main burner or burner group with the pilot burning with any flame capable of actuating the primary safety control.

64.7.2 Test to determine conformance with the preceding is to be made in conjunction with Test No. 1. Before a test is begun, the gas supply to the pilot is to be regulated to provide any flame which will actuate the primary safety control. At least five trials are to be made for each pilot flame tested.

64.7.3 The combustion detector of a primary safety control which is capable of detecting the presence of ignition spark shall be so positioned that the combustion detector shall respond to flame properties only. At the rated voltage, the signal strength due to an ignition spark shall be not more than 50 percent of the signal strength required to hold in the flame relay at 110 percent of rated voltage.

64.7.4 The test to determine conformance with the preceding is to be made in conjunction with Test No. 1. Before a test is begun, the gas supply to the pilot is to be shut off. Five trials are to be made to determine that ignition spark, or reflection from any part of the burner or device capable of reflecting the spark, will not result in a signal strength in excess of that specified. Each trial shall extend for the designed pilot flame establishing period.

64.8 Ignition, gas-electric high tension – Test No. 8

64.8.1 A gas-electric high tension ignition system, arranged for initially igniting a gas pilot, shall ignite the pilot upon admission of pilot gas in accordance with 64.8.3 – 64.8.5. The pilot, in turn, shall effect ignition of the main burner fuel as introduced into the ignition zone.

64.8.2 An electric high tension ignition system arranged for ignition of main burner gas directly shall effect the ignition when tested in accordance with 64.8.3– 64.8.5. See also 64.10.1 – 64.10.3.

64.8.3 The burner assembly or device, arranged and installed as for Test No. 1 is to be tested for conformance to the preceding after it has been subjected to the combustion test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but a gap is to be not less than 1/16 inch (1.59 mm).

64.8.4 The voltage of the power supply to the ignition system is to be regulated to 70 percent of rated voltage, and the voltage of the power supply to the safety control circuit is to be regulated to 85 percent of rated voltage for alternating current equipped and 80 percent of rated voltage for direct current equipment.

64.8.5 The burner assembly or device and ignition circuits are to be energized. Five trials are to be made. If the burner assembly or device is to employ an interchangeable transformer, the appropriate interchangeable test transformer is to be applied to the burner assembly or device and five additional trials for ignition are to be made. During each trial, ignition is to be effected safely and no flame is to flash outside the device being fired.

64.9 Ignition, multiple burner – Test No. 9

64.9.1 An assembly employing multiple burners which are automatically lighted shall be designed so that, when tested in accordance with 64.9.2 and 64.9.3, the fuel delivered for combustion by each will be ignited by the flame at each other. Furthermore, no unsafe ignition or combustion shall be obtained when the fuel delivered by any one or more burners is interrupted during an ignition or firing cycle.

64.9.2 The initial conditions for test to determine conformance to 64.9.1 are to be as for Test No. 1. If more than one igniter capable of functioning independently of the others is provided, all but one igniter is to be deactivated. The burner assembly or device is to be energized to fire in accordance with its designed sequence of operation. Five trials for ignition are to be made. The test is to be repeated with each additional igniter in turn activated while all others are deactivated. During each trial, ignition of the fuel as introduced into the ignition zone by each burner is to be effected safely, no flame is to flash outside the device being fired, and stable combustion is to be maintained.

64.9.3 The initial conditions for this test are to be as for Test No. 1. The burner assembly or device is to be energized to fire in accordance with its design sequence of operation. Five attempts to initiate firing are to be made for each test. The port(s) of one burner is to be plugged and the assembly energized for firing. The test is to be repeated with any other burner(s) plugged. During each test, fuel introduced into the ignition zone is to be safely ignited, no flame is to flash outside the device being fired, and stable combustion is to be obtained.

64.9.4 During this test multiple burners with more than one igniter capable of functioning independently shall light safely when all but one igniter is deactivated; an automatically lighted multiple burner delivering main gas fuel through the ports of more than one orifice shall be equipped with an igniter capable of providing safe ignition when the orifice of one burner adjacent to the igniter is plugged; and with the initial plugged orifice unplugged and any other one burner orifice plugged. Safe ignition of all gases from the other burner ports shall occur.

64.10 Delayed ignition – Test No. 10

64.10.1 For an appliance that is arranged for ignition of the main burner gas directly by an electric igniter, or on which the input of the pilot exceeds 400,000 Btu per hour (117,228 W), delay of the ignition shall not result in flashback of flame to the outside of the appliance or any damage to the appliance and the connected vent system when tested in accordance with 64.10.2 and 64.10.3.

64.10.2 The appliance shall be arranged as specified for Combustion – Test No. 1 – except the power to the electric igniter is to be connected through a switching device so that energization can be delayed for a controlled period of time. The tests are to be conducted with both the control system and the igniter energized at the rated voltage.

64.10.3 Ignition of the main burner or pilot, whichever is applicable, is to be delayed initially for 1 second from the time the gas valve is energized. The test is then to be repeated with the delay period successively increased by 1 second, up to the maximum flame establishing period of the primary safety control that is employed. The ignition of the main burner or pilot shall be in accordance with 64.10.1 for each of the trials.

PART III – BOILER ASSEMBLIES

CONSTRUCTION

65 Assembly

65.1 A boiler assembly shall be factory-built as a group assembly and shall include all the essential components necessary for its normal function when installed as intended. A boiler assembly may be shipped as two or more major subassemblies. The boiler assembly shall be constructed, equipped, inspected, tested, and marked in accordance with the 1995 ANSI/ASME Boiler and Pressure Vessel Code. BPVC 1995 Code Cases: Boilers and Pressure Vessels Interfiled; Supplements 1 – 3, 1995; Supplements 4 – 7, 1996; Supplements 8 – 11, 1997; Supplements 12 –, 1998 (Boiler and Pressure Vessel Codes), Section I, Power Boilers or Section IV, Heating Boilers, whichever is appropriate.

65.2 A boiler assembly, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. See 65.3. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the intended installation or operation of the boiler assembly, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other, without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

65.3 To be in accordance with 65.2, major subassemblies of a boiler assembly are deemed to be the burner and the heat exchanger sections of a cast iron sectional boiler including its base, combustion chamber, casing, and safety controls. A wiring harness may be packaged with one of the major subassemblies.

65.4 A radiation shield or baffle employed to prevent excessive temperature shall be assembled as part of the boiler assembly; or be part of a subassembly that must be attached to the boiler assembly for its normal operation; or be designed so that the boiler assembly cannot be assembled for operation without first attaching a required shield or baffle in its proper position.

65.5 A boiler assembly shall be such that, for any normal installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to prevent unsafe temperatures is not required.

65.6 A boiler assembly shall afford convenient operation by the user of those parts requiring attention or manipulation in normal usage.

65.7 An external door, providing access into the combustion chamber of a boiler assembly intended for installation with a clearance of less than 24 inches (610 mm) from the face of or 48 inches (1.22 m) above the door, shall be self-closing.

65.8 A burner shall be secured so it will not twist, slide, or drop out of position.

66 Accessibility for Servicing

66.1 A boiler assembly shall be built to allow cleaning of parts such as heating surfaces in contact with combustion products, and oil strainers, without major dismantling of the boiler assembly or removal of parts required by 65.2 to be factory-assembled.

66.2 The removal of access panels, burners, caps, plugs, or the like, specifically designed to permit ready removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 66.1.

66.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the boiler assembly is installed as recommended by the manufacturer. The disposition of parts in the assembly removed for normal care shall be such that their restoration, following removal, will not necessitate their realignment to secure their proper relationship with other parts of the assembly. Special facilities required for normal care to be done by the operator shall accompany the boiler assembly to the user.

67 Casing

67.1 The outer casing or jacket shall be made of steel or equivalent material, braced, reinforced or formed so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel at least 0.020 inch (0.51 mm) (No. 24 MSG) thick if uncoated, or 0.023 inch (0.58 mm) (No. 24 GSG) if galvanized, or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

67.2 Access panels that need to be removed for normal service and accessibility shall be constructed to permit removal and replacement repeatedly without causing damage or impairing any required insulating value.

67.3 A removable panel through which air is drawn for combustion shall be so constructed as to prevent it from being attached in a manner that may cause unsafe performance of the boiler assembly.

67.4 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same boiler when interchange may allow unsafe operation of the boiler assembly.

67.5 The casing of a boiler assembly for installation on combustible flooring shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor.

68 Radiation Shields or Liners

68.1 A radiation shield or liner shall be so constructed, formed, and supported as to ensure proper positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the boiler assembly is tested in accordance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the boiler assembly is tested under these requirements.

68.2 Thermal insulation which is not adequately self-supporting shall be applied to solid surfaces in a manner so as to prevent sagging. The insulating value of the material shall be unimpaired when the boiler assembly is tested under these requirements.

68.3 An adhesive for attaching insulating material shall retain its adhesive qualities at any temperature the adhesive may attain when the unit is tested under these requirements and at 0°F (minus 17.8°C).

69 Combustion Chamber

69.1 A combustion chamber and flueway shall be constructed of cast iron, sheet steel, or of a material equivalent in mechanical properties and corrosion resistance. Plain carbon sheet steel, if used, shall be at least 0.042 inch (1.07 mm) (No. 18 MSG) thick.

69.2 Combustion chamber or fire box lining material, if used, shall be durable, adequately held in place, and accessible for replacement with equivalent lining material.

70 Baffles

70.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be constructed and disposed in a manner to provide for reasonable life and shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI 1010 hot-rolled sheet steel having a minimum thickness of 0.042 inch (1.07 mm) (No. 18 MSG) unless its deterioration will not cause excessive temperatures when the boiler assembly is tested in accordance with these requirements.

70.2 A flue baffle shall be accessible for cleaning. A flue baffle which is removable for cleaning shall be such as to facilitate its removal and permit replacement only in a safe position.

71 Flue Collar

71.1 A flue collar shall be constructed and arranged to permit the secure attachment of the chimney connector to the boiler assembly.

72 Flue Dampers, Draft Regulator, and Draft Hoods

72.1 An adjustable flue damper shall be equipped with minimum and maximum operating stops. The minimum operating stop for such damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

72.2 An automatically operated flue damper shall be designed to maintain a safe damper opening at all times and be arranged to prevent starting of the burner unless the damper is in a safe position for starting.

72.3 An automatically operated flue damper shall be counterbalanced to assume an open position in the event of breakage or failure of its operating means. Operating parts shall be located or shielded to avoid interference with their movement and to prevent injury to the operator in case of breakage.

72.4 A fuel-burning assembly to be equipped with a barometric draft regulator shall be designed so as not to require the regulator to be installed in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

72.5 A device to be equipped with a barometric draft regulator or draft hood shall be designed so as not to require the regulator or draft hood to be installed in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator or draft hood and the combustion air supply.

72.6 For gas burning appliances, a draft hood or draft regulator shall be furnished with each device equipped with an atmospheric or natural-draft burner, except a device for outdoor use only and having a venting system supplied as part of the assembly or when a sealed combustion system is employed.

72.7 For gas burning appliances, a draft hood shall comply with the applicable construction provisions of the Standard for Listing Requirements for Draft Hoods, Fifth Edition, ANSI /IAS/A.G.A. Z21.13-1990.

72.8 A double swing barometric draft regulator, if used, shall incorporate means which will act to cause the gas supply to be shut off in the event flue gas spillage continues for a duration exceeding 60 seconds.

72.9 An adjustable flue damper shall not be used in connection with a device equipped with a draft hood or draft regulator.

73 Controls

73.1 Application

73.1.1 Safety controls shall conform with the requirements in Control Applications, Section 54.

73.2 Operating controls

73.2.1 A boiler assembly shall be provided with operating controls that regulate the fuel supply so as not to exceed the rated operating temperature or pressure as specified in 73.2.2 – 73.2.4.

73.2.2 A steam boiler shall be provided with at least one steam pressure actuated control that will shut off fuel supply to the burner when the steam pressure in the boiler reaches a preset maximum operating pressure. This requirement does not preclude the use of additional operating controls, if required.

73.2.3 A water boiler shall be provided with at least one temperature actuated control to shut off the fuel supply to the burner when the temperature of the water in the boiler reaches a preset operating temperature. This requirement does not preclude the use of additional operating controls, if required.

73.2.4 If a boiler assembly equipped with an operating control that only regulates the fuel input between high and low values of steam pressure or water temperature, it shall be provided with an additional operating control that is set to shut off the fuel at a pressure or temperature value below the set point of the limit control.

73.2.5 An operating control need not be factory-installed provided the wiring diagram and instructions furnished with the boiler indicate that an operating control of an appropriate type and setting is to be furnished by the installer. See 37.4.

73.3 Limit controls

73.3.1 A boiler shall be provided with limit controls that operate to shut off fuel and cause safety shutdown in case of a low water condition and excessive temperature or excessive pressure, as specified in 73.3.2 – 73.3.5 and 73.7.1. The limit controls shall be in addition to any operating controls specified in 73.2.1 – 73.2.5.

73.3.2 With respect to 73.3.2, safety shutdown may be provided either by employing manual reset type limit controls or it may be effected remotely by utilizing the manual reset feature of another control, such as the primary safety control. For systems where the reset feature is remote from the limit control, means shall be provided to indicate the limit control has operated when it causes safety shutdown.

73.3.3 Fixed-setting hot-water temperature limit controls shall be marked with the operating temperature, and steam-pressure controls shall be marked with the operating pressure of their fixed points. Adjustable setting hot-water temperature limit controls shall have their temperature range marked, and steam-pressure controls shall have their pressure range marked.

73.3.4 Except as permitted in 54.13, a limit control that functions to interrupt or reduce the delivery of fuel for combustion by opening an electrical circuit shall be so arranged as to effect the direct opening of that circuit, whether the switching mechanism is integral with or remote from the sensing element.

73.3.5 The purpose of the requirement in 73.3.4 is to avoid interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to prevent. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the safety circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls or to interrupt a multiphase circuit.

73.3.6 The limit control for a boiler for alcove or closet installation shall be factory-located on the assembly or its location shall be factory-predetermined.

73.4 Primary safety control

73.4.1 A primary safety control having timings and programming as indicated in Primary Safety Controls, Section 55, shall be provided.

73.5 Liquid level limit controls

73.5.1 A water boiler shall be provided with at least one low water cut-off or combination low water cut-off and water feed control that operates to open the burner circuit and cause safety shutdown before the water falls below the lowest permissible level as specified in 73.5.2.

Exception: A water tube or coil type boiler that requires forced water circulation to guard against excessive temperatures (see 73.7.1), may employ a water flow sensing device instead of a low water cut-off.

73.5.2 Low pressure and high pressure steam boilers shall be provided with at least two low water cut-offs or combination low water cut-off and water feed controls. Both controls shall be wired electrically so that operation of either control causes fuel cut-off to the burner before the water level falls below the lowest visible part of the gage glass. However, one control shall be set to operate at a lower water level than the other. The control set lower shall cause safety shutdown, requiring a manual reset to restore burner operation.

Exception: A boiler that does not exceed any of the following limits may be provided with only one low water cut-off:

a) Maximum working pressure – 100 psig (689.5 kPa);

b) Maximum inside diameter of shell– 16 inches (406.4 mm);

c) Maximum heating surface – 20 square feet (1.86 m^2); or

d) Gross volume, exclusive of casing and insulation – 5 cubic feet (0.142 m^2). See 73.5.3.

73.5.3 With reference to the exception to 73.5.2, the gross volume is considered to be the volume of a rectangular or cylindrical enclosure into which all the pressure parts of the boiler could be fitted in their final assembly including gas passages that are integral with the assembled pressure parts. Projecting nozzles or fittings need not be considered in this volume.

73.5.4 With respect to 73.5.1 and 73.5.2, safety shutdown may occur simultaneously with the operation of the low water cut-off to shut down the burner or it may incorporate a time delay. The time delay for safety shutdown shall not exceed the boiler manufacturer's recommended time or 90 seconds, whichever is less.

73.6 Pressure limit controls

73.6.1 Each low pressure and high pressure steam boiler shall be provided with a pressure operated control that operates to shut off all fuel to the burner and cause safety shutdown in case of excessive steam pressure in the boiler. The control settings shall be in accordance with 73.6.2 and 73.6.3, as appropriate.

73.6.2 The maximum setting of a limit control on a low-pressure steam boiler shall limit the steam pressure in the boiler to 15 psig (103 kPa). On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop. Such a boiler is marked with ASME Code Symbol ″H″.

73.6.3 The limit control for a high pressure steam boiler shall limit the steam pressure in the boiler to the maximum allowable working pressure of the boiler. On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop. Such a boiler is marked with ASME Code Symbol ″S″.

73.7 Temperature limit controls

73.7.1 A water boiler shall be provided with at least one temperature-operated limit control that operates to shut off all fuel to the burner and cause safety shutdown before the water temperature in the boiler exceeds the maximum rated operating temperature. For a low pressure hot water boiler safety shutdown shall occur before the water temperature in the boiler exceeds 250°F (121°C).

73.8 Safety shut-off valves

73.8.1 Safety shutoff valves shall conform with the requirements in 45.1.1 – 45.3.2.

74 Installation of External Controls and Fittings

74.1 If a low water cutoff is installed external to a low pressure or a high pressure steam boiler utilizing a water column, the connecting piping and fittings to the column shall not be smaller than 1-inch NPS and no shutoff valves of any type shall be placed in the piping between the boiler and the cutoff. A cross or equivalent fitting shall be used in the piping connections at every right angle to facilitate cleaning and inspection.

74.2 A low water cutoff that embodies a separate chamber shall incorporate a vertical drainpipe and a blowoff valve not smaller than 3/4-inch NPS, located at the lowest point of the chamber or water-equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the low water cutoff can be tested for operation.

74.3 A low water cutoff or a combination cutoff and water feed control for a low pressure steam boiler may be installed in the tapped openings provided for attachment of a water gage glass directly to the boiler. For such installation, the connections shall be made with nonferrous ″T″ or ″Y″ fittings for the low water cutoff connections. The ends of any nipples used shall be hollowed to full size of the internal diameter.

74.4 For a hot water heating boiler, the low water cutoff may be installed external to the boiler. Under low water conditions, the chamber in which the cutoff is located shall drain so as to maintain the same water level as in the boiler, and if flow occurs in the chamber, it will be in the upward direction.

74.5 A water feed control, when used, shall be constructed and installed so that the water inlet valve cannot feed water into the boiler through a float chamber of a low water cutoff or through the connections of such float chamber.

74.6 A steam pressure limit control shall be installed on the boiler without any shutoff valve between the limit control and the boiler.

74.7 Each steam pressure limit control shall be protected with a siphon or equivalent means of maintaining a water seal between the steam and the inlet to the control. The size of the siphon shall not be less than 1/4-inch NPS. Tubing of adequate temperature and pressure rating and of equivalent inside diameter may be substituted for pipe.

74.8 If a steam pressure limit control that incorporates a mercury switch is mounted on a siphon, the loop of the siphon shall be in a plane that is 90 degrees (1.57 rad) from the plane of the mercury switch.

74.9 The steam pressure connections to the steam pressure limit control shall not be:

a) Smaller than 1/4-inch NPS, if the pipe is of nonferrous material;

b) Smaller than 1/2-inch NPS, for ferrous materials up to 5 feet (1.52 m) in length; or

c) More than 1-inch NPS for ferrous materials over 5 feet in length. Tubing of adequate temperature and pressure rating and of equivalent internal diameter may be substituted for pipe.

PERFORMANCE

75 General

75.1 Performance shall be determined on the boiler assembly as described in this Section and Section 23.

75.2 A boiler assembly shall meet the applicable requirements when tested as described herein. An assembly of a type not described specifically herein is to be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed herein that an assembly will not continue to meet the requirements in normal usage so as to assure continued safe performance, such supplementary tests shall be conducted as deemed necessary to assure safe service.

75.3 A boiler assembly is to be tested normally as suitable for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than indicated in Table 75.1. Such a boiler assembly is categorized under Form II, Form III, or Form IV, depending on its physical size and/or operating flue gas temperature as noted in Table 75.1. At the option of the manufacturer, a boiler assembly operating at not more than 1000°F (537°C) flue gas temperature may be tested as suitable for installation on combustible floors and when so tested is categorized under Form IIa or Form IIIa, depending on its physical size.

Table 75.1
Standard clearances

Type of Boiler	Minimum clearance, inches (mm)					
	A	B	C	D	D	F
	Above	Front	Chimney/vent Connector	Rear	Sides	Below
Form XIII	6 (152)	18 (457)	6 (152)	6 (152)	6 (152)	NC
Form II	6 (152)	24 (610)	18 (457)	6 (152)	6 (152)	NC
Form IIa	6 (152)	24 (610)	18 (457)	6 (152)	6 (152)	C
Form III	18 (457)	48 (1219)	18 (457)	18 (457)	18 (457)	NC
Form IIIa	18 (457)	48 (1219)	18 (457)	18 (457)	18 (457)	C
Form IV	48 (1219)	96 (2438)	36 (914)	36 (914)	36 (914)	NC
Form IVa	48 (1219)	96 (2438)	36 (914)	36 (914)	36 (914)	C

Where:

C – Combustible.

NC – Noncombustible.

Form XII – Water walled types - hot water boilers, low pressure steam boilers, not larger than 100 cubic feet (2.8 m^3) in size excluding burner – equipped with draft hood.

Form II – Water walled types - hot water boilers, low pressure steam boilers, not larger than 100 cubic feet (2.8 m^3) in size excluding burner – not equipped with draft hood.

Form IIa – Warm Air Furnace, horizontal forced, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner and installed at zero below clearance – not equipped with draft hood. And, same as Form II boilers except installed on combustible flooring.

Form III – Low Heat Industrial Device, Floor mounted type furnaces and heaters and not classified under Forms I (furnaces) or XI (furnaces and heaters) and, hot water boilers and steam boilers operating at not more than 1000°F (537°C) flue gas temperature not classified under Form II or XII.

Form IIIa – Same as Form III except installed on combustible flooring.

Form IV – Medium Heat Industrial Devices, steam boilers operating in excess of 1000°F (537°C) flue gas temperature.

Form IVa – Same as Form IV except installed on combustible flooring.

75.4 At the further option of the manufacturer, a boiler assembly may be tested with clearances less than those indicated in Table 75.1. A boiler assembly of the type categorized under Forms II and IIa, see Table 75.1, equipped with an integral limit control may be tested as suitable for installation in an alcove or closet.

75.5 If a boiler assembly is to be tested in a partial enclosure at clearances less than those designated as standard in Table 75.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are to be at least 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 75.1, the connector arrangement is to be as specified in 76.2.2 and Figure 76.2. Except for those modifications of the enclosure and as otherwise provided herein, tests are to be conducted in the manner described for standard clearances.

75.6 The minimum standard clearances designated in Table 75.1 are based on the boiler assembly being installed in a room that is large compared to the size of the assembly. All clearances designated in Table 75.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

75.7 The maximum temperature of flue gases during the continuous operation temperature test no. 3, at the maximum input recommended by the manufacturer shall not be in excess of the following:

Type of device	Maximum temperature rise above ambient	
	Degree F	Degree C
Devices equipped with draft hoods and appliances intended for connection to a Type B gas vent	400	204.4
Other appliances	850	454.4

The maximum temperatures specified above are for the purpose of obtaining safe temperatures on combustible construction in proximity of the chimney or vent connector when the indicated clearances are maintained. Only devices equipped with draft hoods or appliances without draft hoods that exhibit a negative pressure of the flue gases (see 75.8) are suitable for connection to a Type B gas vent. All other devices are suitable only for connection to a chimney.

75.8 With respect to 75.7, determination that the flue gases in the vent pipe are at a negative pressure are to be made in the center within the vent pipe, 6 inches (152 mm) downstream from the connection of the vent pipe to the flue gas outlet of the appliance. The vent pipe is to be connected in accordance with 76.2. The pressure of the flue gases shall be negative at all permitted inputs of the appliance.

75.9 Additional performance requirements are specified in 68.1, 68.2, and 68.3.

76 Test Installation for Standard Clearances

76.1 Enclosure

76.1.1 A boiler assembly is to be placed in a partial enclosure in the as-received condition, as described in 76.1.2 – 76.1.5. Except as permitted by 75.3, the distance from the back, side, and top of the assembly and from the chimney connector to the walls and ceiling of the enclosure is to be as indicated in Table 75.1. If one side of the assembly may create a higher wall temperature than the other, that side of the assembly is to be directly opposite one wall. A boiler assembly categorized under Forms IV and IVa need not be placed in a partial enclosure unless it is to be tested at clearances less than those designated as standard in Table 75.1.

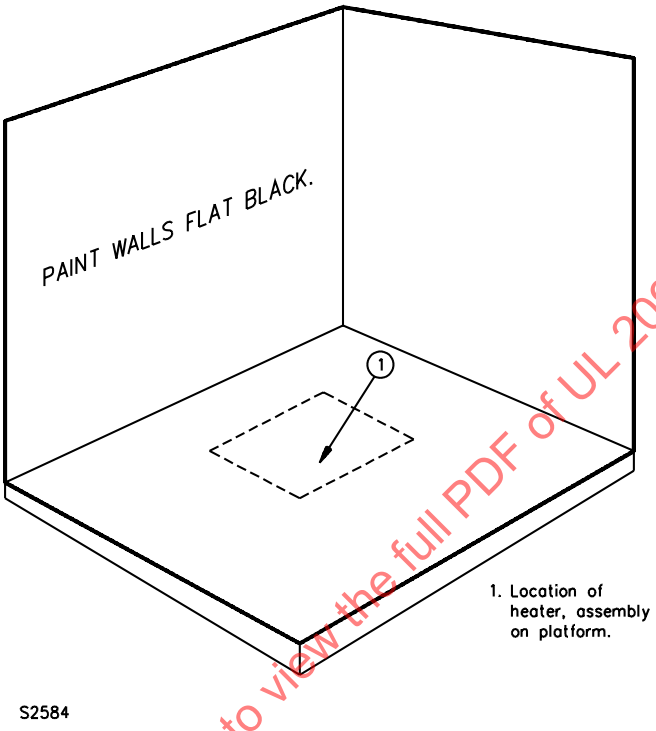
76.1.2 As an alternative to 76.1.1, when tested at clearances designated as standard in Table 75.1, the partial test enclosure may be eliminated and thermocouples attached to the outer casing panels as specified by 24.5.1 – 24.5.6. The temperature at points on external surfaces of the appliance, except within 9 inches (229 mm) of the flue collar or any inspection or relief opening, shall not exceed the values specified in Table 27.1.

76.1.3 The boiler assembly is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the boiler assembly the minimum allowable distance above the floor.

76.1.4 The partial enclosure is to be formed by two walls of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. See Figure 76.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to be such as to obtain the minimum clearance above the boiler assembly specified in Table 27.1 and in accordance with 75.3. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the boiler assembly. Except as permitted by 75.3, the walls are to be the minimum distance specified in Table 27.1 from the side and back

of the boiler assembly, except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 76.1.11.

Figure 76.1
Enclosure for standard clearances



76.1.5 If the boiler is intended for direct installation on combustible flooring, the floor beneath the boiler assembly is to be 1 inch (25.4 mm) white-pine flooring covered with one thickness of building paper, and then by 3/4 inch (19.1 mm) thick plywood, unpainted or finished with a clear sealer.

76.1.6 If the boiler is intended to be insulated in service, it may be tested with the covering furnished by the manufacturer as standard equipment. If the boiler covering is not furnished as part of the boiler assembly, the assembly may be tested with plastic magnesia or equivalent insulation 1-1/2 inches (38.1 mm) thick.

76.1.7 If the boiler covering is not furnished by the manufacturer or if the covering is furnished by the manufacturer but not factory assembled on the boiler, the manufacturer is to specify such covering as is specified in 76.1.6 or the manner in which the separately packaged factory furnished covering is to be installed. This information is to be furnished in conjunction with the clearance information to appear on the boiler assembly. Such information should also be included with the instructions furnished with the boiler assembly.

76.1.8 The limit control, if furnished separately for mounting in the field, is to be located as specified in the installation instructions furnished with the boiler assembly.

76.1.9 The inlet air temperature is to be measured by a thermocouple, not heavier than 24 AWG (0.21 mm^2), shielded from direct radiation and located centrally 24 inches (610 mm) in front of the boiler assembly and 24 inches above the floor of the test enclosure.

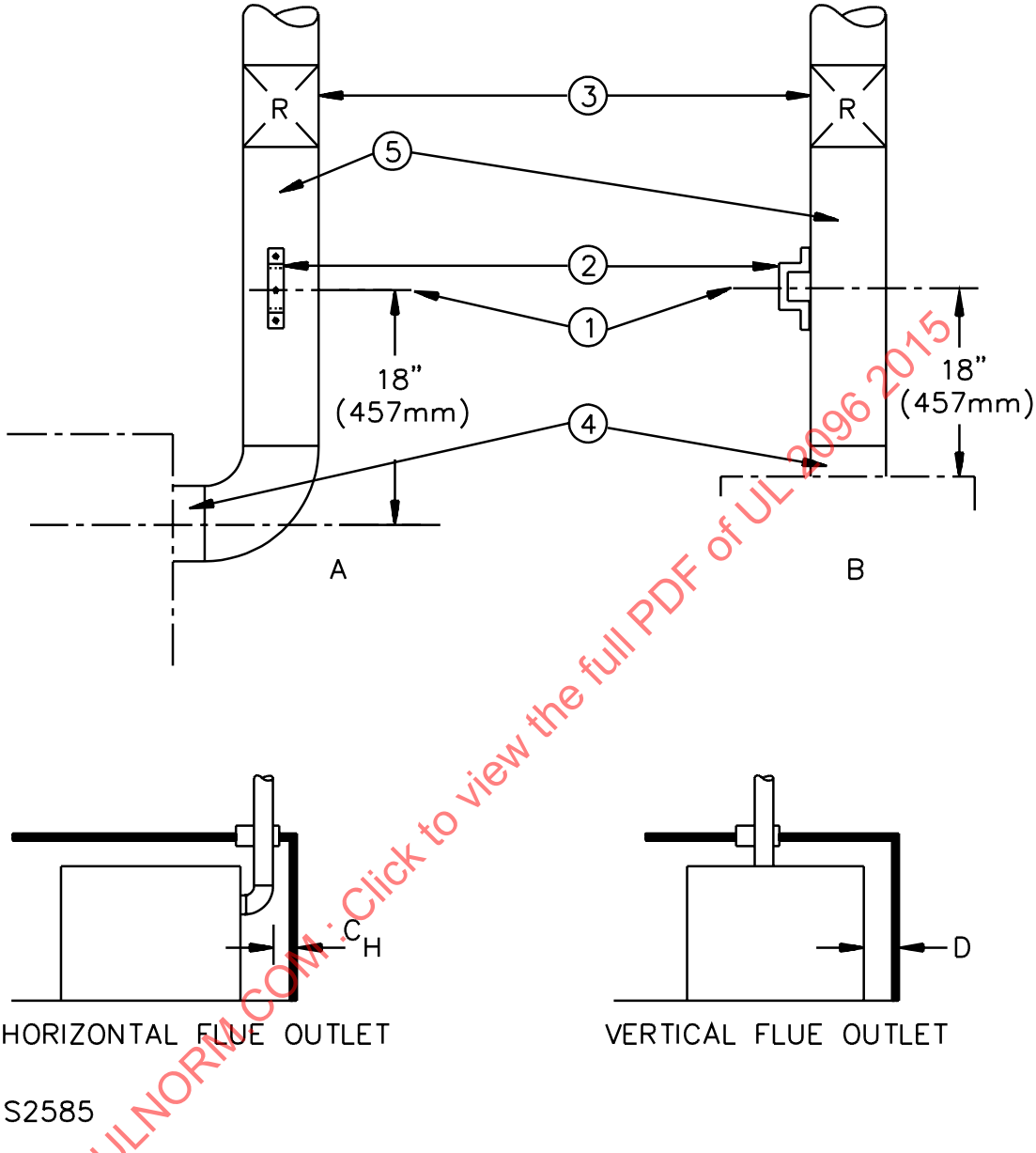
76.1.10 The water temperature in a boiler is to be measured by a thermocouple located so that the water temperature 1 inch (25.4 mm) below the outlet connection of a hot-water boiler and 1 inch below the surface of the water in a steam boiler may be determined.

76.1.11 Steam pressure is to be measured by a commercial steam gauge of appropriate range.

76.2 Chimney connector

76.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the boiler. Galvanized stovepipe not heavier than 0.023 inch (0.58 mm) (No. 24 GSG) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure, directly connected to and extended vertically above a vertical flue outlet, and connected to a horizontal flue outlet by using a 90-degree sheet metal elbow at the bottom of the vertical section. See Figure 76.2.

Figure 76.2
Chimney connectors clearance test



1. Centerline of thermocouple.

2. Support bracket.

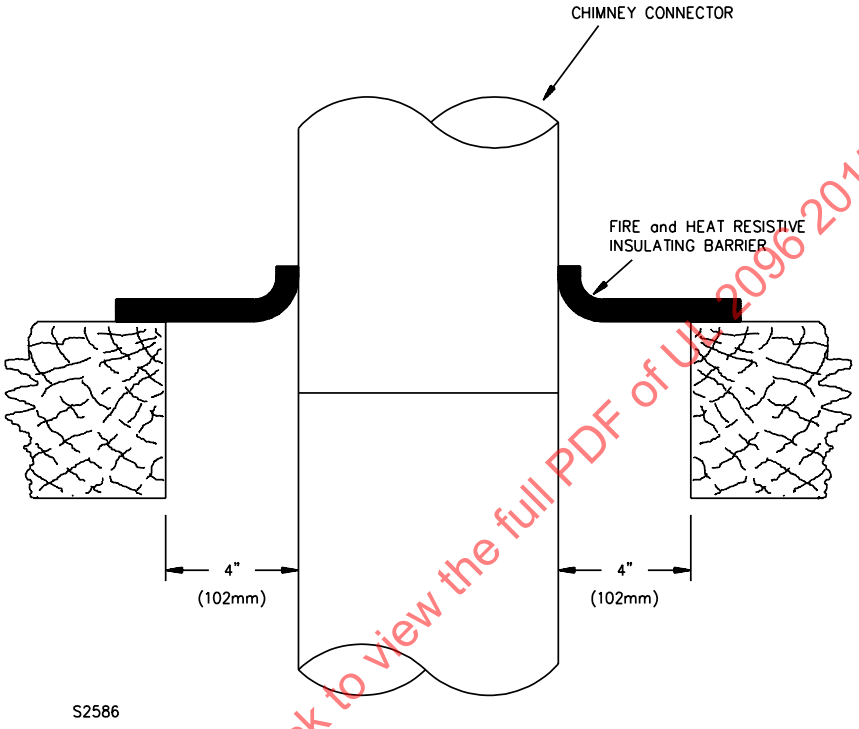
3. Draft Regulator.

4. Flue collar.

5. Chimney connector, same nominal diameter as flue collar.

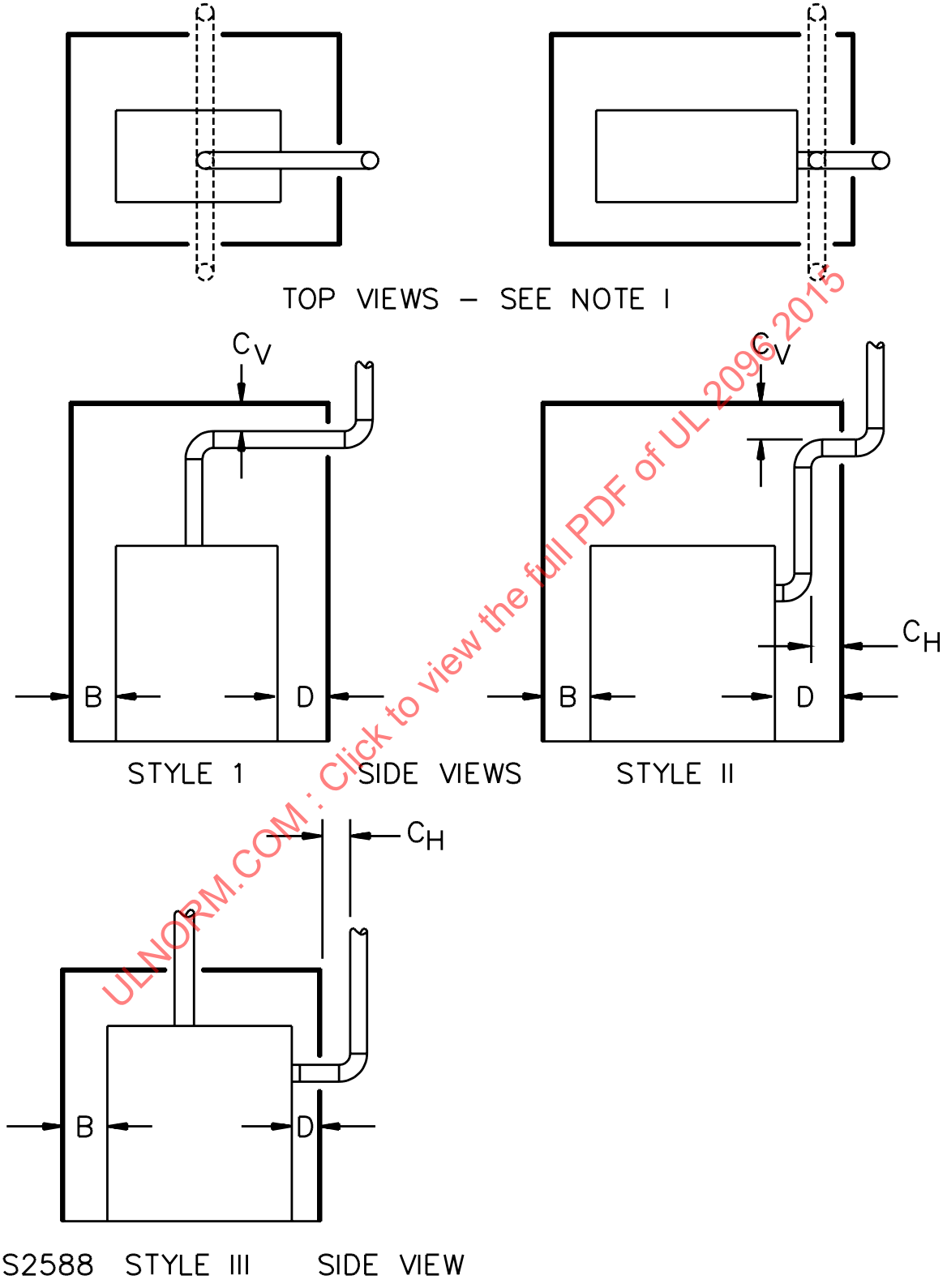
76.2.2 For a boiler assembly tested in a partial enclosure (see Figure 76.1) at clearances less than those designated as standard in Table 75.1, the clearances from the chimney connector are to be not less than 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 75.1, the chimney connector arrangement is to be as specified in 76.2.3 and Figure 76.3.

Figure 76.3
Sealing of annulus around chimney connector



76.2.3 A boiler assembly with vertical flue outlets is to be tested with two chimney connector arrangements, Styles I and III, and a boiler assembly with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III as indicated in Figure 76.4, unless the manufacturer elects to specify the minimum clearance from the boiler assembly as that obtained when tested with the chimney connector arranged in accordance with Style I or II only.

Figure 76.4
Chimney alternate arrangement



76.2.4 Where the chimney connector pierces the enclosure, an opening 8 inches (203 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 76.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50.8 mm) from the outer edge of the annulus.

76.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2 of Figure 76.2.

76.2.6 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 76.2.

76.2.7 Any built-in draft regulator included as part of the boiler assembly is to be fixed in the position allowing maximum draft.

76.2.8 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

77 Initial Test Conditions

77.1 The boiler assembly is to be set up for test in the appropriate enclosure and manner described in Test Installation for Standard Clearances, Section 76.

77.2 Unless otherwise specified in the describing the tests, boiler assemblies are to be tested at the test voltages indicated in Table 25.1.

77.3 The boiler assembly is to be fired at its rated input, with each type of fuel for which the boiler is rated:

a) Rate(s) shall be defined as the manufacturer's specified minimum and/or maximum input(s) for which the burner (or device) is intended to operate;

b) Actual test value(s) without the FGR system operative shall be ±2 percent of the specified value(s); and

c) Actual test value(s) with the FGR system operating shall not change to the extent that a deleterious affect on the combustion process is obtained.

77.4 The input, air-fuel ratio, and other operating conditions are to be in accordance with the manufacturer's instructions.

77.5 All heating surfaces in contact with combustion products and the vent pipe of the device to be fired for the test are to be thoroughly cleaned before the combustion test is begun.

77.6 Tests are to be conducted at normal fuel pressures.

77.7 The limit control is to be bypassed to permit continued operation when required by a test. During test, the temperature or pressure within the boiler is to be not greater than its rated temperature or pressure, but not less than the appropriate value given below:

a) 200°F (93.3°C) in a low pressure hot-water boiler;

b) 12 psi (82.74 kPa) in a low pressure steam boiler;

c) 95 percent of maximum rated temperature in a high pressure water boiler; or

d) 95 percent of rated working pressure in a high pressure steam boiler.

77.8 The water level in the boiler is to be maintained at normal level. The boiler is to be fired for the temperature test until equilibrium temperatures are attained.

78 Combustion – Test No. 1

78.1 When tested at steady state conditions as described in 78.2:

a) The observed smoke at all firing rates during the prescribed tests does not exceed the following on the Shell-Bacharach scale with the Model RDC smokemeter or equivalent:

1) Number 1 spot for all mechanical draft burners having a maximum capacity not exceeding 7 gph (26.5 L/h) firing a distillate type fuel;

2) Number 2 spot for all vaporizing type burners firing a distillate type fuel and for mechanical draft burners having a maximum capacity in excess of 7 gph firing a distillate type fuel; or

3) Number 4 spot for all burners firing a residual type fuel.

b) Firing gas, combustion shall be complete in the space provided by the device and no carbon monoxide in concentration in excess of 4/100 of 1 percent shall be present in air free samples of the flue gases taken over the full operating range of the assembly;

c) Ignition is obtained on each cycle within the expected safe period of time;

d) Ignition is obtained at each cycle without flash of flame outside the heating devices being fired and without damage to parts of the device;

e) Stable fires are obtained at all operating firing rates;

f) No soot has been deposited on surfaces of the heat exchanger, flue passages, or vent connector of the heating device fired for the test;

g) Surfaces of the fire box, hearth, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar;

h) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions; and

i) Flame stability as confirmed by both audible and visual inspection shall not be deleteriously affected with or without the FGR system operating.

78.2 For the test specified in 78.1 the device is to be installed and adjusted in accordance with the manufacturer's instructions, and fired at rated input and operated until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established. The current input to the assembly is to be measured during this test.

78.3 Complete and stable combustion shall be maintained at the minimum rate of firing or during any sudden change in the gas firing rate between maximum and minimum rates. Ignition shall be accomplished safely.

78.4 A boiler shall be capable of functioning uniformly and reliably at the maximum input recommended by the manufacturer without a loss of heat to the chimney in excess of 25 percent of the heat input to the device.

79 Limit Control Cutout – Test No. 2

79.1 The limit control for a low-pressure boiler when adjusted to its maximum setting allowed by a fixed stop shall function when the temperature of the water in a hot-water heating boiler is not more than 250°F (121°C) and when the pressure in a steam heating boiler is not more than 15 psi (103 kPa), when the boiler assembly is tested as described herein. The limit control for a high-pressure boiler shall function when the pressure in a steam boiler is not more than the designed working pressure of the boiler, or when the water temperature in a hot-water boiler is not more than the temperature of saturated steam at the designed working pressure of the boiler, when the boiler assembly is tested as described herein.

79.2 The boiler is to be filled to the intended level with water. A steam or a hot-water boiler is to be provided with a pressure-relief valve.

79.3 The limit control, if adjustable, is to be adjusted to the highest temperature or pressure setting, as applicable. Any modulating type operating control provided to regulate the fuel input between high and low fire values is to be bypassed to permit the appliance to operate on high fire. The on-off type operating control, set to cut out at a value below the set point of the limit control, is also to be bypassed during this test.

79.4 The water temperature obtained in a hot-water boiler is to be measured as described in 76.1.10. The inlet and outlet water valves are to be adjusted so that hot water passes the thermocouple bead during the test.

79.5 A slow-closing valve is to be placed in the steam outlet line of a steam boiler.

79.6 The boiler is to be fired at rated input and the water or steam valves adjusted to raise the temperature or pressure until the limit control functions. Neither the maximum water temperature in the boiler nor the pressure is to exceed the values indicated in 73.6.2 and 73.7.1.

79.7 Following the test in 79.6, the boiler is allowed to be filled to the intended level with water. The boiler is to be fired at any input, a feed water device, if provided is to be disconnected, and the boiler drain valve opened. Firing is to continue until the low water control operates to de-energize the burner.

79.8 The water level in the boiler upon interruption of the burner circuit is to be the lowest safe permissible water level established by the manufacturer.

80 Continuous Operation Temperatures– Test No. 3

80.1 When a boiler assembly is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to impair intended operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage if such damage to the material or part may cause the boiler assembly to introduce a risk of fire, electric shock, or injury to persons. The temperature rises at specific points shall be not greater than those specified in Table 27.1, unless otherwise indicated. Water temperature or steam pressure shall not be excessive.

80.2 Motors shall not exceed the temperature rises indicated in Table 27.1 when tested as described herein.

80.3 During this test, the temperature rises above inlet air temperature shall not exceed the values specified in Table 27.1. See 27.1.

80.4 Each limit control is to be bypassed to permit continued operation during this test.

80.5 The boiler is to be fired at rated input. For boilers designed for hot-water use only, the feed-water inlet is to be throttled during the test until the water temperature at the outlet of the boiler has reached the value determined in accordance with 79.6, but not less than 200°F (93°C). The feed water is then to be supplied at such a rate as to maintain the temperature at the boiler outlet within ±5°F (±2.8°C) of the specified value. A steam boiler is to be maintained at the pressure allowed by the limit control, but not less than 14 psi (97 kPa), and the feed water is to be supplied to maintain a relatively constant water level in the gauge glass. If the temperature of the boiler assembly components or the test enclosure would be affected during the test by the feed-water temperature, the temperature of feed water measured at the inlet to the boiler is to be maintained 20°F (11.1°C) below the outlet-water temperature for hot-water boilers and not less than 180°F (82°C) for steam boilers. Boilers suitable for either hot water or steam are to be tested as steam boilers.

80.6 Firing of the boiler is to be continued until equilibrium temperatures are attained, as evidenced by no changes in temperature rises for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

81 Low Water Cutoff – Test No. 4

81.1 A boiler equipped with a low water cutoff control or controls for compliance with 73.5.1 and 73.5.2 shall be subjected to tests to determine that the low water condition in the boiler results in burner shutdown and safety shutdown in accordance with 81.2 – 81.5.

81.2 The test is to be started with the normal water level in the boiler and the burner firing at any convenient input. Any water feed to the boiler is to be turned off during the test. The boiler water is then to be drained slowly until the burner is shut off by the action of the low water cutoff control. If the boiler is a hot water heating boiler that is provided with a single low water cutoff control, the draining of the water is to be discontinued and it is to be determined that the burner operation cannot be restored without a manual reset (see 81.4 and 81.5). If the boiler is provided with a second low water cutoff control and the control that operated is of an automatic reset type, the test is to be continued in accordance with 81.3.

81.3 After operation of the automatic reset type low water cutoff, it is to be electrically bypassed so that operation of the burner is resumed. The draining of the boiler water is to be continued until the second low water cutoff operates to shut down the burner. At that point the draining is to be discontinued and it is to be determined that operation of the burner cannot be resumed without a manual restart. See 81.4 and 81.5.

81.4 With respect to 81.2 and 81.3, determination that a burner operation cannot be resumed without a manual reset can be made by increasing the water level in the boiler or by observing that the control whose action provided safety shutdown has operated and requires a manual reset.

81.5 If any of the controls whose operation is being tested in accordance with 81.2– 81.4 includes a time delay feature, it shall be determined that the time delay from burner shutdown to safety shutdown shall be in compliance with 73.5.2. The burner shutdown by the control that causes safety shutdown has to occur before the water level falls below the lowest level permitted by 73.5.1.

PART IV – FURNACES AND HEATERS

CONSTRUCTION

82 Assembly

82.1 Except as permitted by 45.7.2 and 87.2.3, each device shall be factory built to include all the components necessary for its normal function when installed as intended. It may be furnished as two separate components, one component consisting of the burner assembly and the other consisting of the furnace or heater assembly. The burner assembly shall include the primary safety control. The furnace or heater shall include all the other parts constituting the complete gas-fired device.

82.2 A device, if not manufactured as an assembly, shall consist of as few subassemblies as practicable. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding or similar tasks by the installer, except to the extent described in 39.7 and 82.3. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe operation of the device, shall be designed and marked so that they may readily be incorporated into the final assembly in their correct relationship.

82.3 Cutting or drilling which is required for the attachment of a return or supply plenum, an optional filter rack, or to cut a return air opening in the furnace casing is deemed to conform to 82.2. If a return air opening is to be cut in the casing panel by the installer, instructions and a template shall be furnished with the furnace, or the corners of the opening shall be embossed or be in knockout form.

82.4 A radiation shield or baffle employed to prevent excessive temperature shall be assembled as part of the device; or be part of a subassembly that must be attached to the device for its normal operation; or be designed so that the device cannot be assembled for operation without first attaching the required shield or baffle in its proper position.

82.5 Each device shall afford convenient operation by the user of those parts requiring attention or manipulation by him in normal usage.

82.6 Any adjustable part shall be provided with a locking device.

82.7 Opening in perforated or expanded metal panels, provided over combustion-air, circulating-air, or vent-relief openings shall not be less than 1.8 inch (45.7 mm) diameter. If the openings in such panels are other than circular in shape, they shall be of such size that will permit entrance of a No. 20 drill.

82.8 A suspended device shall be constructed to prevent the dropping of incandescent particles from the unit.

82.9 A suspended device shall be equipped with hangers or brackets to support the unit.

82.10 Furnaces for space heating shall not allow the products of combustion to become mixed with the circulating air.

83 Accessibility

83.1 All flue gas passageways or heating surfaces shall be accessible for inspection and cleaning without major dismantling and without removal of controls.

83.2 Provision shall be made to permit observation of each pilot and main burner flame during adjustment and under operating conditions.

83.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the device is installed as recommended by the manufacturer. The arrangement of parts in an assembly removed for normal care shall be such that their restoration, following removal, will not necessitate realignment to secure their proper relationship with other parts of the assembly. Special tools that may be required for normal care to be done by the operator shall be supplied with the device.

83.4 Heads and nuts of bolts which must be removed to permit the removal of cleanout plates shall not be placed where they will be in contact with flue gases.