UL 795

STANDARD FOR SAFETY

Commercial-Industrial Gas Heating Equipment

UL Standard for Safety for Commercial-Industrial Gas Heating Equipment, UL 795

Eighth Edition, Dated December 2, 2016

Summary of Topics

This revision of UL 795 dated September 29, 2020 includes editorial corrections to an equation in paragraph 56.1.5 and a table reference in paragraph 43.2. The revisions published on September 1, 2020 which included changes in requirements for gas vent valve and lines in paragraphs 26.9 and 34.5 are still identified.

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.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated March 27, 2020 and June 5, 2020.

No Text on This Page

DECEMBER 2, 2016
(Title Page Reprinted: September 29, 2020)

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UL 795

Standard for Commercial-Industrial Gas Heating Equipment

First Edition – November, 1952
Second Edition – October, 1964
Third Edition – April, 1973
Fourth Edition – June, 1994
Fifth Edition – July, 1999
Sixth Edition – October, 2006
Seventh Edition – April, 2011

Eighth Edition

December 2, 2016

This UL Standard for Safety consists of the Eighth Edition including revisions through September 29, 2020.

The Department of Defense (DoD) has adopted UL 795 on January 27, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to factory-built gas appliances having inputs of more than 400,000 Btu per hour, per individual combustion chamber which require flame failure and other precautions and which are intended primarily for commercial and industrial installation. The appliances covered by these requirements are comfort heating furnaces, heaters and gas-fired boiler assemblies except watertube boilers having outputs of 10,000 pounds of steam per hour or more.

1.2 These requirements also apply to all high pressure steam and high temperature water gas-fired boiler assemblies regardless of Btu per hour input.

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

1.4 Additional installation and operation requirements are available for central-heating gas appliances, floor furnaces, room heaters, unit heaters, and water heaters as defined by the National Fuel Gas Code, NFPA 54, and by the Liquefied Petroleum Gas Code, NFPA 58, as applicable.

2 Glossary

2.1 For the purposes of this Standard the following definitions apply.

2.2 AIR HEATER – An indirect fired vented appliance intended to supply heated air for space heating and other purposes, but not intended for permanent installation.

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

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

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

2.6 APPLIANCE FLUE – The flue passages within an appliance.

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

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

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

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

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

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

2.13 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).

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

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

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

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

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

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

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

2.21 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, and warm air ducts, means 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 though flameproofed, fire retardant treated, or plastered.

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

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

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

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

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

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

2.28 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.

2.29 CONTROL, HIGH LIMIT – A protective (safety) control that is responsive to changes in pressure, temperature, liquid level, or flow. It is to be set beyond the intended operating range of the controlled equipment to limit its operation. This control may be electrical or mechanical in nature.

2.30 CONTROL, OPERATING LIMIT – A limit control to start fuel input according to demand and to stop fuel input on satisfaction of demand. An operating limit control may be electrical or mechanical in nature.

2.31 CONTROL, PROTECTIVE (SAFETY) – Automatic controls and interlocks (including relays, switches, and other auxiliary equipment used in conjunction with a safety control circuit) which are intended to prevent operation of the controlled equipment under conditions not anticipated by the design. A control intended to prevent the risk of electric shock, fire, or injury to persons during abnormal operation of the appliance. An example would be a water temperature limit control. A protective control always provides Type 2 action. (See 2.93).

2.32 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 timings, as required, in proper sequence, for purging, flame establishing periods 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.

2.33 DAMPER – A valve or plate for regulating draft or flow of the 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 or vent connector.

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

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

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

2.37 DRAFT REGULATOR, BAROMETRIC – A device which functions to maintain a desired draft by automatically reducing the chimney draft to the desired value.

2.38 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 peak) or direct current and supplied by a primary battery or by a standard Class 2 transformer or other suitable transforming device, or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer. 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) Isolated Limited Secondary Circuit – A circuit of limited energy derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes (VA) and open-circuit secondary voltage rating not exceeding 1000 volts.

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

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

2.40 FLAME SAFEGUARD – See Control, Primary Safety, 2.31.

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

2.42 FLUE GASES – Combustion products and excess air.

2.43 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.

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

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

2.46 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.

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

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

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

2.50 HEAT EXCHANGER, DIRECT – A heat exchanger in which heat generated in the combustion chamber of the device is transferred direct through walls of the heat exchanger 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-transfer device.

2.51 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. It is an indirect heat-transfer device.

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

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

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

2.55 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.

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

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

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

2.59 LINER – See Radiation Shield, 2.84.

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

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

2.62 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 characteristic.

2.63 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.

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

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

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

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

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

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

2.67 NORMAL CARE – 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.

2.68 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.

2.69 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.

2.70 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.

2.71 PILOT, CONTINUOUS – A pilot that burns without turn-down throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

2.72 PILOT, EXPANDING – A pilot that burns throughout the entire time the burner assembly is in service, whether the main burner is firing or not. Upon a call for heat, the pilot is automatically expanded so as to reliably ignite the main burner. This pilot may be turned down automatically at the end of main burner flame-establishing period.

2.73 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.

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

2.75 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.

2.76 PILOT, PROVED – A pilot flame supervised by a primary safety control.

2.77 PLENUM – An air compartment, part of a distributing 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.

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

2.79 PRESSURE CUT-OUT – A pressure sensing control intended to keep a pressure below or above one particular value during abnormal operating conditions and which has no provisions for setting by the user.

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

2.81 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.

2.82 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.

2.83 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.

2.84 RADIATION SHIELD – A separate panel or panels interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

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

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

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

2.88 SAFETY CONTROL – See Control, Safety, 2.31.

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

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

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

2.92 TOOLS, SPECIAL – Those tools that are not available on the open retail market.

2.93 TYPE 2 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have been declared and tested to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

2.94 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.

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

2.96 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.

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

2.98 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.

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

2.100 ZERO GOVERNOR – A regulating device which is normally adjusted to deliver gas at atmospheric pressure within its flow rating.

3 Units of Measurement

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

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Components

5.1 Except as indicated in 5.2, a component of a product covered by this standard shall comply with the requirements for that component. See the individual sections of this Standard for component requirements.

5.2 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.

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

5.4 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.

CONSTRUCTION – MECHANICAL

6 General

6.1 The requirements of 23.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

6.2 Moving parts such as fan blades, blower wheels, pulleys, belts, etc., which may cause injury shall be enclosed or guarded.

6.3 If the removal of doors or 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).

6.4 The distance from an opening in a required guard or enclosure to the moving part mentioned in 6.3 shall be in accordance with the following table, 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.

Minor dimensions of opening, inches[a]	Minimum distance from opening to moving part, inches
1/4	1/2
3/8	1-1/2
1/2	2-1/2
3/4	4-1/2
1	6-1/2
1-1/2	10-1/2
2	14-1/2
Over 2	30

[a] Openings less than 1/4 inch are not to be considered.

6.5 A moving part is not to be considered when judging compliance with 6.3 and 6.4 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

6.6 Parts that may come in contact with the operator's hand during normal adjustment or servicing shall be free from sharp projections or edges and projecting screw ends.

7 Corrosion Protection

7.1 Iron and steel parts shall be protected against corrosion by painting, galvanizing, plating or other equivalent means when malfunctioning of such unprotected part results 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 contact 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. See 50.4.

8 General Components and Devices

8.1 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

8.2 Thermoplastic wiring material shall comply with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

8.3 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62.

8.4 Fittings for conduit and/or metal clad cable shall comply with the Standard for Conduit, Tubing, Cable Fittings, UL 514B.

8.5 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9 for Class K).

8.6 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

8.7 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

8.8 Terminal Blocks shall comply with the Standard for Terminal Blocks, UL 1059.

8.9 Electrical (Junction) boxes shall comply with the Standard for Metallic Outlet Boxes, UL 514A or the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C, as applicable.

8.10 Attachment-plug receptacles intended for general use as a convenience receptacle on the equipment shall be of the grounding type, and shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

CONSTRUCTION – ELECTRICAL

9 General

9.1 Fuel confining parts, or operating parts if failure of the part will allow excess leakage of fuel, unintended operation, or restrict a safety device from functioning, shall be of sufficient strength, durability, and resistance to fire. 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.

9.2 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 reduce the risk of contact with water from humidifiers.

9.3 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.

10 Servicing and Adjustment

10.1 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; operating manual switches;

c) Adjusting air-flow dampers.

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

10.2 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 are:

a) Not located in front, in the direction of access of the mechanism; and

b) Are not located within 6 inches on any side or behind the mechanism, unless guarded.

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

10.4 Components in a low-voltage circuit are to comply with the requirements of 10.3 in their relation to uninsulated live parts in a high-voltage circuit and to moving parts.

11 Electrical Enclosures

11.1 Uninsulated high-voltage parts shall be enclosed or guarded to reduce the likelihood of unintentional contact by persons during normal use of the equipment. This applies also to such parts located in a compartment into which access is required for normal care of the equipment, such as resetting controls, replacing filters, lubrication, cleaning, and the like.

11.2 Sheet metal complying with Table 11.1 and Table 11.2 whichever applies, meets the requirement for the individual enclosure of electrical components.

Table 11.1
Minimum thickness of sheet metal for enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b] in inches (cm)		Maximum length[c] in inches (cm)		Maximum width[b] in inches (cm)		Maximum length in inches (cm)		Uncoated (MSG)		Metal coated (GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d]	(0.51)	0.023[d]	(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[d]	(0.66)	0.029[d]	(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		0.032	(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	(104.1)	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)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	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	0.126

Table 11.1 Continued on Next Page

Table 11.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)		
Maximum width[b] in inches (cm)		Maximum length[c] in inches (cm)		Maximum width[b] in inches (cm)		Maximum length in inches (cm)		Uncoated (MSG)	Metal coated (GSG)	
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)	(10)	(3.20)

[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, e.g. 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 limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

[d] Sheet metal for an enclosure intended for outdoor use shall comply with 60.7 and 60.8.

Table 11.2
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 (mm) (AWG)	
Maximum width[b] in inches (cm)		Maximum length[c] in inches (cm)		Maximum width[b] in inches (cm)		Maximum length in inches (cm)			
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.7)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.2)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.4)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.4)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.4)	Not limited		60.0	(152.4)	Not limited		0.095	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.9)	Not limited		0.122	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(6)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)	

[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

Table 11.2 Continued on Next Page

Table 11.2 Continued

Without supporting frame[a]		With supporting frame or equivalent reinforcing[a]		
Maximum width[b] in inches (cm)	Maximum length[c] in inches (cm)	Maximum width[b] in inches (cm)	Maximum length in inches (cm)	Minimum thickness inches (mm) (AWG)
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, e.g. 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 limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide. [d] Sheet metal for an enclosure intended for outdoor use shall comply with 60.7 and 60.8.				

11.3 Among the factors taken into consideration when evaluating an enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging according to the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. An enclosure complying with the requirements of the Standard for Industrial Control Panels, UL 508A, would be considered to comply with the requirements of (a) – (f).

11.4 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 11.1 or Table 11.2 whichever applies, may be employed.

11.5 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 11.1.

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 11.1 for the maximum dimensions of the cabinet enclosure.

g) The part is not subject to unintentional contact by persons.

11.6 The requirements of 11.5 apply only to parts of high-voltage circuits as defined by 2.38.

11.7 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, ANSI/NFPA 70.

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

11.9 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.813 mm) if uncoated steel, No. 20 MSG, not less than 0.034 inch (0.864 mm) if galvanized steel, No. 20 GSG, and not less than 0.045 inch (1.14 mm) if nonferrous.

11.10 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. 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.

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

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

11.13 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.

11.14 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 (0.356 mm) for steel or 0.019 inch (0.483 mm) for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimension; and

b) 0.027 inch (0.686 mm) steel or 0.032 inch (0.813 mm) nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimension.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

11.15 The enclosure shall reduce the risk of 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.

11.16 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.

11.17 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 11.15.

11.18 A junction box which is formed in part 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 (12.7 mm) wide to enter.

b) An opening between the box and motor frame having no dimension exceeding 1/2 inch does not permit the entrance of a 13/64 inch (5.16 mm) diameter rod.

11.19 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 Figure 11.1, cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe, as illustrated in Figure 11.2, 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 (19.1 mm) diameter rod is acceptable under the conditions described in Figure 11.3.

Figure 11.1

Probe for uninsulated live metal parts

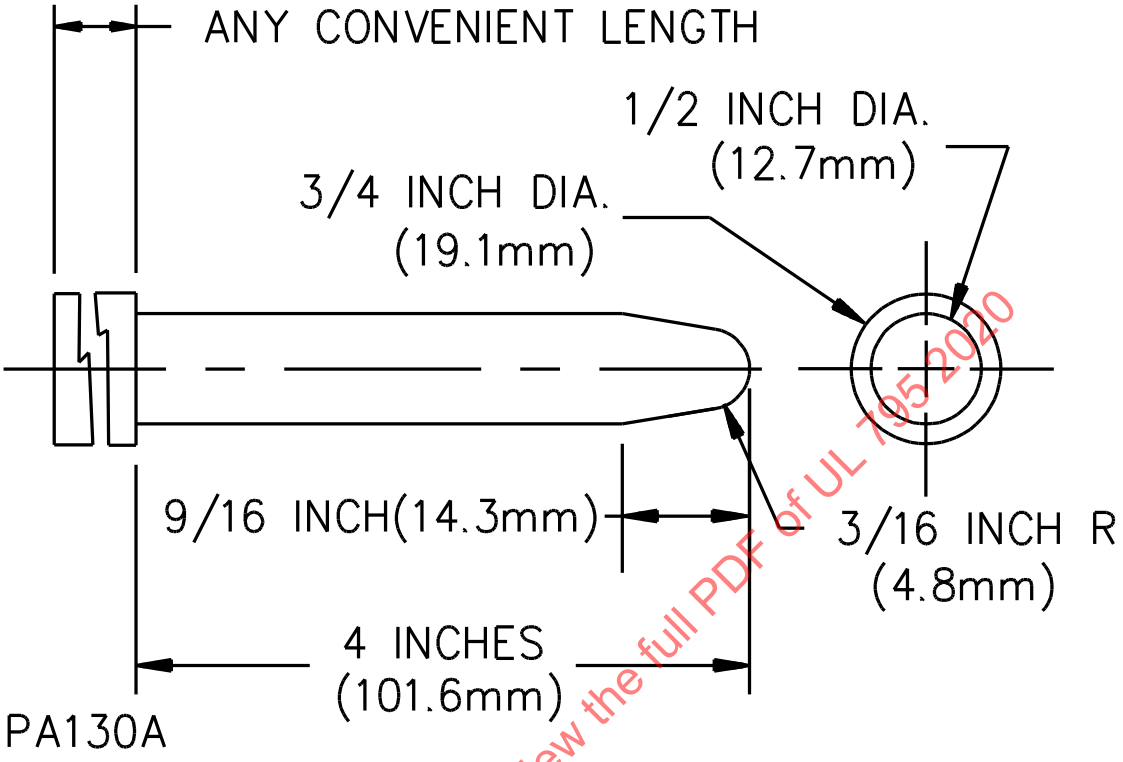


Figure 11.2

Probe for enamel insulated wire

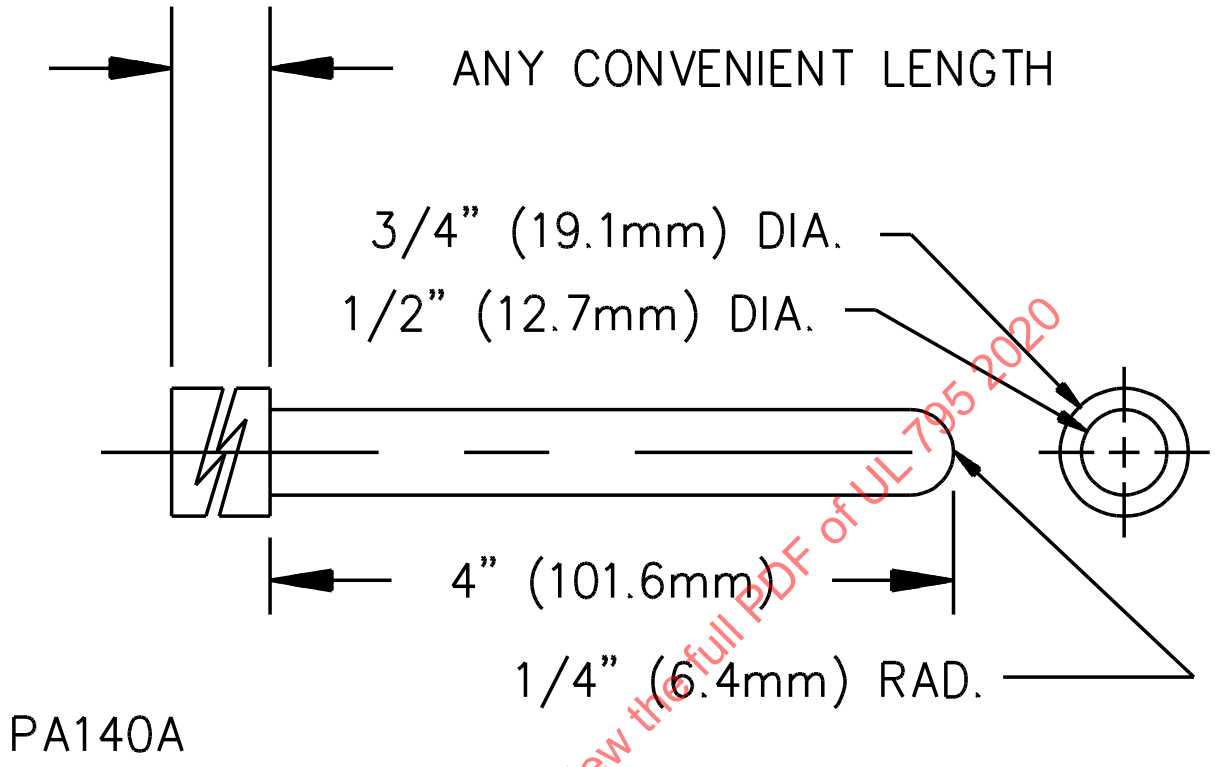
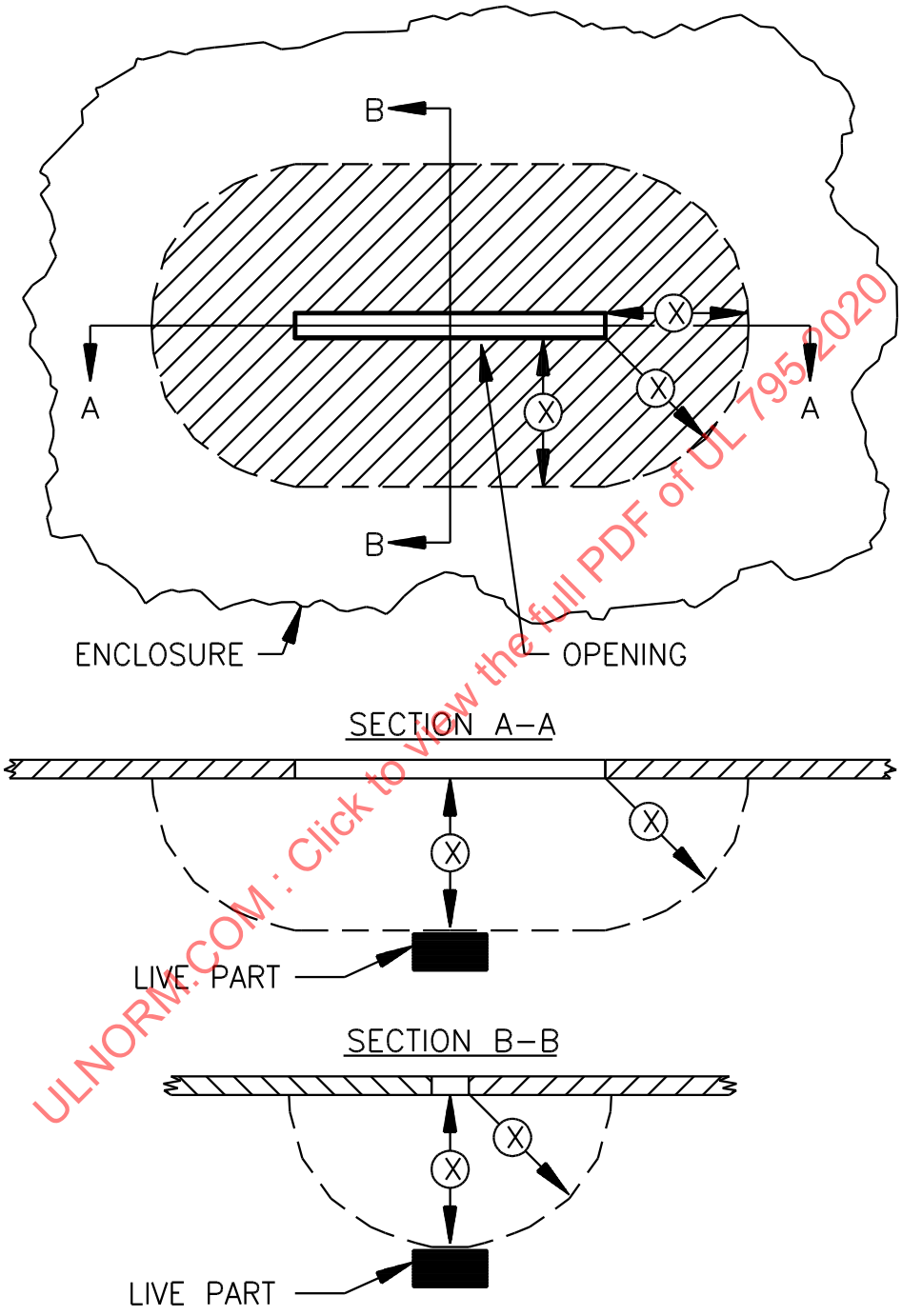


Figure 11.3

Opening in enclosure



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

a) Less than X inches from the perimeter of the opening, as well as

b) Within the volume generated by projecting the perimeter X inches 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 four inches.

11.20 During the examination for conformance with the requirements in 11.19, a part of the enclosure, including air filters, which may be removed without the use of tools is to be removed.

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

11.22 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 moving parts or uninsulated live parts.

11.23 The assembly shall be so arranged that an overcurrent protective device, such as a fuse, whose normal functioning requires renewal, can be replaced and manual reset devices can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device.

11.24 A required protective device shall be wholly inaccessible from outside the appliance 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 appliance enclosure.

11.25 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 (3.57 mm) at any setting or position of the dial, knob, etc.

11.26 A fuseholder shall be so designed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (101.6 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 similar material employed for this purpose shall be not less than 0.028 inch (0.711 mm) in thickness.

11.27 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, except as indicated in 11.28.

11.28 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.

11.29 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.

11.30 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 it is considered to be suitable means for holding the door in place as required in 11.29.

11.31 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (6.35 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angel 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.

11.32 Stripes 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 (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

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

12 Field Wiring Connections

12.1 As used in the following a wiring terminal is considered to be a terminal to which power supply or control circuit connections will be made in the field when the unit is installed.

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

12.3 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.

12.4 The connections are to 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 such use, may serve as a cover. A knockout for connection of a field wiring system to a field wiring compartment shall accommodate conduit of the trade size determined by applying Table 12.1.

Table 12.1
Trade size of conduit in inches

Wire size		Number of wires				
		2	3	4	5	6
AWG	(mm^2)					
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	(21.2)	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
MCM						
250	(127)	2	2-1/2	2-1/2	3	3
300	(152)	2	2-1/2	3	3	3-1/2

Table 12.1 Continued on Next Page

Table 12.1 Continued

Wire size		Number of wires				
		2	3	4	5	6
350	(177)	2-1/2	2-1/2	3	3-1/2	3-1/2
400	(203)	2-1/2	3	3	3-1/2	4
500	(253)	3	3	3-1/2	4	4

NOTE – This table is based on the assumption that all conductors will be of the same size and there will be no more than 6 conductors in the conduit. If more than 6 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 areas of the wires, based on the cross-sectional area of Type THW wire.

12.5 The wiring of the equipment may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the equipment to the wiring system specified in 12.2. 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 reduce the risk of loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, ANSI/NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the equipment 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 (19.1 mm) trade size, or the fittings for the conduit are identified as providing grounding.

12.6 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 11.2. 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.

Table 12.2
Size of junction boxes

Size of conductor, AWG	Free space within box for each conductor, cubic inches
16 or smaller	1.5
14	2.0
12	2.25
10	2.5
8	3.0

12.7 The limitations in 12.6 do not apply to terminal housings supplied with motors, nor to boxes or enclosures which contain terminals for electrical connections.

12.8 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, ANSI/NFPA 70, corresponding to the marked rating of the assembly shall be provided.

12.9 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 electric shock.

12.10 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 terminal or result in damage to the lead from sharp edges. Leads shall be tested in accordance with the Strain Relief Test in Section 58.

12.11 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 inherent overheating, protective device.

12.12 At terminals, stranded conductors shall be restrained 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. Open slot-type connectors shall not be used unless they are designed to prevent 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 (0.711 mm).

12.13 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.

12.14 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 12.19, 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.

12.15 A wire binding screw at a high-voltage wiring terminal for field connection shall be not 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.

12.16 A terminal plate for a wire binding screw shall be of metal not less than 0.030 inch (0.762 mm) in thickness for a 14 AWG or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG; and in either case there shall be not less than two full threads in the metal.

12.17 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.

12.18 A wire binding screw shall thread only into metal.

12.19 Field wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be restrained 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 method.

12.20 Conductors intended for connection to a grounded neutral line shall be identified, i.e., 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 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.

12.21 A box or enclosure included as part of the assembly and in which a branch circuit supplying power to the furnace 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.

13 Internal Wiring

13.1 The wiring of high-voltage and safety control circuits shall conform to the requirements in this Section.

13.2 Wiring shall be accomplished 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).

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

13.4 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, i.e., 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.

13.5 Except as permitted by 13.17 and 13.18 conductors shall be:

a) Enclosed within conduit that complies with the Standard for Flexible Metal Conduit, UL 1 or the Standard for Electrical Rigid Metal Conduit – Steel, UL 6, as applicable, electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel, UL 797 or the Standard for Extruded Insulating Tubing, UL 224, metal raceway electrical enclosure;

b) Within a metal-clad cable that complies with the Standard for Metal Clad Cable, UL 1569; or

c) Exposed Run Tray Cable, Type TC-ER, that complies with the requirements for Power and Control Tray Cable, UL 1277 or, for applications not exceeding 150 volts and/or 5 amps, Exposed Run Instrumentation Tray Cable, Type ITC-ER, that complies with the requirements of the Standard for Instrumentation Tray Cable, UL 2250. The cable utilized shall:

1) Comply with the crush and impact requirements of the Standard for Metal Clad Cable, UL 1569;

2) Be secured and supported at intervals not exceeding 6 feet (1.8 m).

3) Have voltage and temperature ratings suitable for the intended application.

13.6 Group A of Table 13.1 includes some wiring materials suitable for use if enclosed as indicated in the preceding paragraph.

Table 13.1
Typical wiring materials

Group	Type of wire, cord, cable, or wiring material	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	FFH-2, MTW, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFHH-3, RH, RHH, RHW, SF-2, SFF-2, T, TF, TFF, TFN, TFFN, THW, THW-MTW, THWN, TW, XHHW, or thermoplastic appliance wiring material.	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.4)	3/64	(1.2)
		6	(13.3)	4/64	(1.6)
		4	(21.2)	4/64	(1.6)
		3	(26.7)	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	(107.2)	5/64	(2.0)
B	S, SE, SJ, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, or appliance wiring material with thermoplastic or neoprene insulation	18	(0.82)	4/64	(1.6)
		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	(8.4)	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 8.4 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, and flammability.

13.7 Flexible metal conduit, if used, shall be not smaller than 3/8 inch electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads, considered under other Standards.

13.8 If flexible metal conduit is used, it shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (30.5 cm) on each side of every junction box except for lengths not over 36 inches (91 cm) where flexibility is necessary.

13.9 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered if bushing or loosening of the connection may result in any hazardous condition.

13.10 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.

13.11 Splicing devices, such as fixture type splicing connectors, pressure wire connectors, and the like, may be employed if they have insulation suitable for the voltage to which they are subjected. In determining if splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat resistant and moisture resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge does not meet the intent of the requirement.

13.12 A splice is to be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials, may be employed.

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

13.14 At all points where conduit or metal-clad cable terminates the conductors 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 cable and the connector or clamp shall be of such design that the insulating bushing or its equivalent will be visible for inspection.

13.15 The design of a wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and 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.

13.16 All wiring shall be supported and routed to reduce the risk of damage due to sharp edges or moving parts.

13.17 Internal 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 13.5.

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

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

13.18 Cords or wiring material as referenced in Group B, Table 13.1 may be employed if the wiring is enclosed by a furnace casing 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 device 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 (12.7 mm) in diameter larger than the object that will be installed through the opening.

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

e) Where combustible material other than electrical insulation is located within the compartment the wiring is separated from such material and the material has self-extinguishing characteristics. An air filter may be employed within the enclosure.

13.19 With reference to 13.18(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.

13.20 In applying the requirement of 13.18, an opening which is always intended to be connected to an air duct may be considered as closed.

13.21 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 shall have smooth, rounded 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.

13.22 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.

13.23 To provide an unbushed opening in sheet metal usually requires rolling and/or extrusion of the metal around the opening, or the insertion of a grommet conforming to 13.21.

13.24 Except as indicated in the following paragraph, conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected, 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.

13.25 Conductors that conform to the following are considered to meet the intent of the requirements without test:

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

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 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.

14 Separation of Circuits

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

14.2 Segregation of insulated conductors as required above may be accomplished by clamping, routing, or equivalent means which promotes permanent separation from insulated or uninsulated live parts of a different circuit.

14.3 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.

c) Any uninsulated live parts whose short-circuiting may result in operation of the product in a manner that involves 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 Type T or equivalent conductors are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

14.4 Segregation of field installed conductors from other 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 circuit. If 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 the above paragraph that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current carrying parts connected to a different circuit is to be investigated. To determine if a device complies with the requirements of the above paragraph, it is to be wired as it would be in service and in doing so 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.

14.5 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 of suitable insulating material and be held in place.

14.6 A metal barrier shall have a thickness at least as great as that required by Table 11.1, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.711 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.

14.7 Openings in a barrier for the passage of conductors shall be not larger than 1/4 inch (6.3 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.

15 Mounting of Components

15.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to restrain it from turning, except as noted in the following paragraphs.

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

a) The switch is to be 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 to be reduced below the required values if the switch rotates.

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

15.3 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 restrained from turning if rotation cannot reduce spacings below the required values.

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

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

15.6 Control equipment located within the plenum or return air compartment of a furnace shall be so designed, enclosed, and/or protected that dense smoke will not be generated or flame emitted under any conditions likely to occur in service.

16 Motors and Motor Overcurrent or Overload Protection

16.1 All motors shall be protected by an integral thermal protector or by overcurrent protective devices, or combinations thereof.

16.2 "Overcurrent protective devices" as referred to in 16.1 means overcurrent protective devices conforming to the requirements of the National Electrical Code, ANSI/NFPA 70, as follows:

a) A separate overcurrent device which 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 a marked service factor not less than 1.15, 125 percent;

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

3) All other motors, 115 percent.

Each winding of a multispeed motor is to 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, 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 temperature rise not over 40°C (72°F), 140 percent; and

3) All other motors, 130 percent.

16.3 An integral thermal protective device is to comply with the requirements in the Standard for Thermally Protected Motors, UL 1004-3.

16.4 Separate overcurrent devices, except when included as part of a magnetic motor controller(s), 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 operation of the equipment in a manner that involves a risk of fire, electric shock, or injury to persons.

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

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

b) Thermal protectors, combinations of thermal protectors and overcurrent devices, or other recognized 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-phasing conditions. This marking may be paper sticker or decal, or may be on an attached wiring diagram.

16.6 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 this requirement; provided it is determined that the motor will not overheat under actual conditions of use.

16.7 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 actual conditions of use, except that such impedance protection is not to be recognized where the motors are installed in compartments handling air for circulation to the conditioned space.

16.8 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.

16.9 Motors shall not exceed the temperature rises indicated in Table 48.1 when tested as described herein.

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

16.11 In no case shall interruption of the circuit to a motor by the overcurrent or overtemperature protective device result in operation of the equipment in a manner that involves a risk of fire, electric shock, or injury to persons or discharge of fuel that may result in a risk of fire or injury to persons.

16.12 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 improper operation of the equipment.

16.13 A motor included in an attic, horizontal, or suspended furnace shall be of the totally enclosed construction if not wholly enclosed within the furnace casing.

16.14 In determining compliance with 16.13, when a totally enclosed motor is to be provided, no openings are permitted in portions of the motor frame exterior to the device, i.e., openings may be in the shaft end of face mounted oil-burner motors in combination gas-oil burners, bolted flush to the blower housing of a gun type burner, but not in other portions of the motor frame.

16.15 A motor shall have no openings permitting a drop of liquid, or a particle falling vertically onto the motor, to enter the motor as applied to the assembly.

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

16.17 Motors having openings in the enclosure or frame shall be installed or shielded to reduce the risk of particles falling out of the motor on to combustible material within or under the assembly.

16.18 The requirement in 16.17 will necessitate the use of a barrier of noncombustible 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 device 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

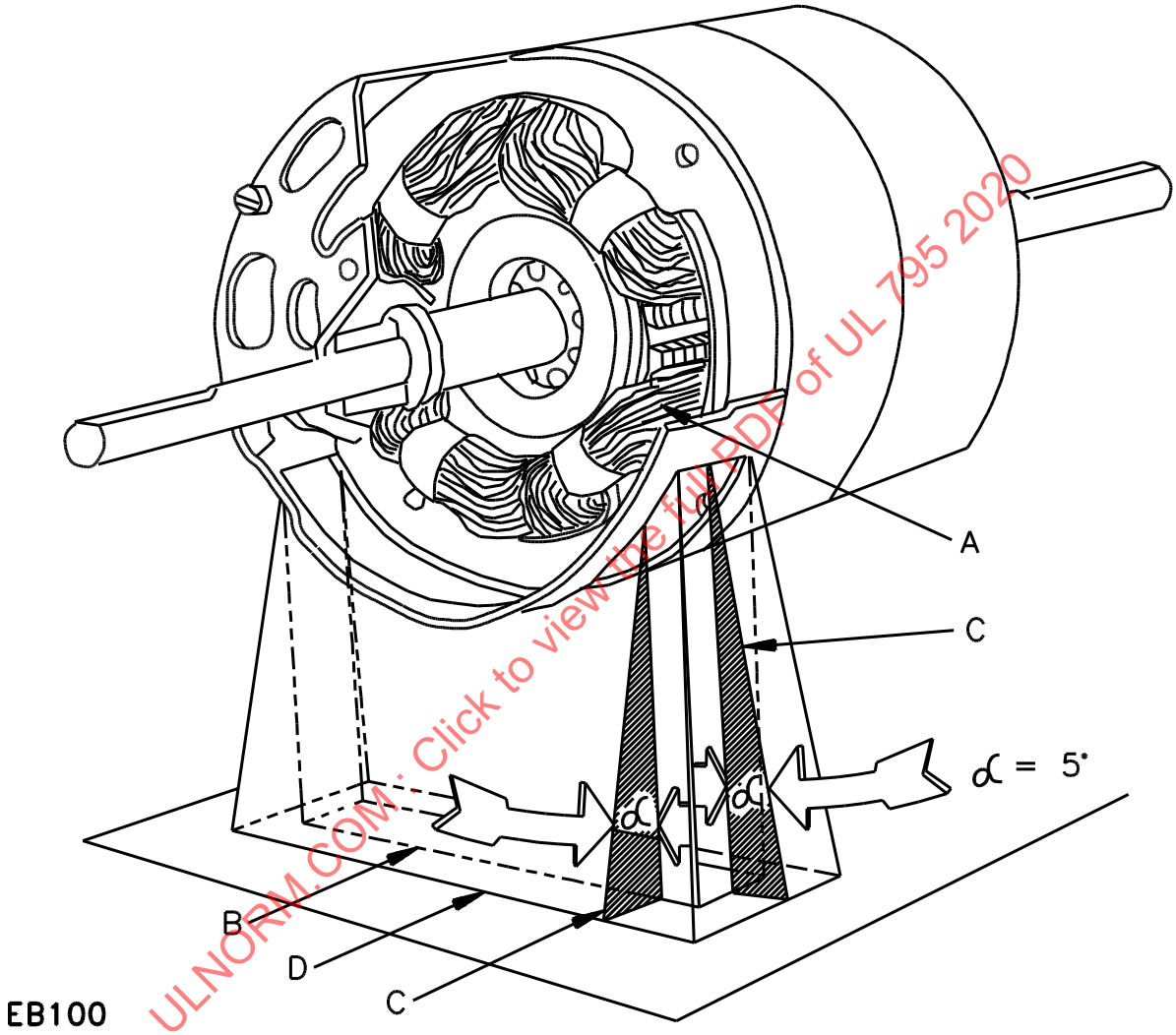
4) Capacitor shorted, permanent split capacitor type; or

c) The motor is provided with a thermal motor protector, i.e., a protective device that is sensitive to temperature and current, that will reduce the risk of the temperature of the motor windings from becoming more than 257° F (125° C) under the maximum load under 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.

16.19 The barrier mentioned in 16.18 shall be horizontal, shall be located as indicated in Figure 16.1 and shall have an area not less than that described in that illustration. Openings for drainage, ventilation, etc., 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 16.1

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

a) Tangent to the motor winding;

b) Five degrees from the vertical; and

c) 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.

17 Overcurrent Protection of High-Voltage Control-Circuit Conductors

17.1 General

17.1.1 For the purpose of these requirements, 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 equipment. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the equipment, see Overcurrent Protection of Transformers, Section 18, for additional requirements.

17.1.2 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 equipment. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the equipment. See 67.11.

17.2 Tapped high-voltage control circuits

17.2.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the product from the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 17.2.3 and 17.3.

17.2.2 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, ANSI/NFPA 70.

17.2.3 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 17.1.

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 50.9.

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 requirements specified in Overcurrent Protection of Transformers, Section 18; and

b) The rating of the device does not exceed the applicable value specified in Table 17.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 17.1
Overcurrent protective device rating for control circuit conductors

Tapped control-circuit conductor size, AWG (mm^2)	Maximum rating of overcurrent protective device, amperes			
	Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
	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	b	b	c	c

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of the National Electrical Code, ANSI/NFPA 70.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of the National Electrical Code, ANSI/NFPA 70.

17.3 Overcurrent-protective devices

17.3.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 17.2.3, shall be provided as part of the equipment. If a fuse is used, the equipment shall be marked in accordance with 67.9.

Exception: The overcurrent device, or devices, need not be provided as part of the equipment if, based on the marked rating of the equipment, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in Table 17.1.

17.3.2 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 17.2.3; 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 acceptable fuses are Class CC, G, H, J, K, L, R, or T cartridge fuses and a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the equipment, 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 50.1. If the supplementary device used is a fuse, the equipment shall be marked in accordance with 67.10.

18 Overcurrent Protection of Transformers

18.1 High-voltage transformers

18.1.1 A transformer, other than as described in 18.3.1 and 18.3.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 18.2.1;

b) Be protected by an overcurrent device, or devices, in accordance with the requirements in 18.2.3; or

c) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 52.

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.

18.2 Thermal protection

18.2.1 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 51.

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 52.

18.2.2 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 – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

18.2.3 If a high-voltage transformer is protected by an overcurrent device or devices, such protection shall comply with the requirements specified in 18.2.4, 18.2.5, and 18.4.1 – 18.4.3.

18.2.4 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 18.1 for the primary. See 18.2.5 and 18.4.1.

Table 18.1
Rating of transformer overcurrent protective devices

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 a standard rating of fuse or circuit breaker, the next higher 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.

18.2.5 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 18.1 for the secondary.

18.3 Low-voltage transformers

18.3.1 Except as specified in 18.3.2, 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 18.4.1.

18.3.2 A transformer that directly supplies a Class 2 circuit [see 2.38(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).

18.4 Overcurrent protective devices

18.4.1 Overcurrent protection in the primary circuit of a transformer, as described in 18.2.4 and 18.3.1, need not be provided as part of the equipment if, based on the marked rating of the equipment, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in 18.2.5 or 18.3.1, as applicable.

18.4.2 Overcurrent protection in the secondary circuit of a transformer, as required by 18.2.5, shall be provided as part of the equipment. If a fuse is used, the equipment shall be marked in accordance with 67.9.

18.4.3 A required transformer overcurrent-protective device provided as part of the equipment shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 18.2.5 – 18.3.1, 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 intended for branch-circuit protection. Examples of fuses are Class CC, G, H, J, K, L, R, or T cartridge fuses and a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the unit, 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 50.1. The equipment shall be marked in accordance with 67.10.

19 Switches and Controllers

19.1 Except as indicated in 19.2, 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.

19.2 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 any one of the motors. Also, a controller is not required for an assembly that conforms to 19.9.

19.3 A single controller may control more than one motor if the controller is suitable for the combined load. The assembly is to be marked in accordance with 46.1.7 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

19.4 A controller or switch shall be rated for the load which it controls.

19.5 The load controlled is to include any load external to the assembly for which connections in the controller or switch circuit are provided.

19.6 A controller, which 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.

19.7 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 failure. The endurance test is to be of a duration equivalent to that required for the overload device and at an equivalent rate.

19.8 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.

19.9 If the marked maximum fuse size of the device does not exceed the maximum size rated 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 anticipated conditions of service that might be encountered.

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

19.11 As applicable, switches shall comply with the Standard for Enclosed and Dead Front Switches, UL 98, the Standard for General-Use Snap Switches, UL 20 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

19.12 Controllers shall comply with the following, as applicable:

a) The Standard for Industrial Control Equipment, UL 508;

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1;

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2.

20 Capacitors

20.1 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 not permit the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 20.2 and 20.3, the container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.5 mm), No. 24 MSG.

20.2 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 burner and if such a box, case, or the like, is acceptable for the enclosure of current-carrying parts.

20.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead-metal parts by moisture-resistant insulation not less than 0.028 inch (0.711 mm) thick, except as indicated in 15.4. Otherwise, it shall be separated from dead-metal parts by spacings in accordance with Table 22.1.

20.4 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 50.

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 50.1 but not less than the current established by dividing the circuit voltage by the impedance of the other components(s).

20.5 Capacitors shall comply with the Standard for Capacitors, UL 810.

21 Electrical Insulating Material

21.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold molded composition, or other material acceptable for the particular application.

21.2 Ordinary vulcanized fiber may be used for the 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, electric shock, or injury to persons. Plastic materials may serve as the sole support of uninsulated live parts, if found to have the mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric withstand, and other properties needed for the application.

22 Spacings – High-Voltage Circuits

22.1 Except as noted in paragraphs below, 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 specified in Table 22.1.

Table 22.1
Spacings

Ratings		Minimum spacing in inches		
Volt-amperes	Volts	Through air	Over surface	To enclosure[c]
0 – 2000	0 – 300[a]	1/8[b]	1/4	1/4
More than 2000	0 – 150	1/8[b]	1/4	1/2
	151 – 300	1/4	3/8	1/2
	301 – 600	3/8	1/2	1/2

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

[b] The spacings between field wiring terminals of opposite polarity, of between a field wiring terminal and ground, shall be not less than 1/4 inch.

[c] Includes fittings for conduit or metal clad cable.

22.2 The through-air and over-surface spacings at an individual component part are to be evaluated on the basis of the total volt-ampere consumption of the load or loads that the component controls. However, the spacing from the component to the enclosure shall be evaluated on the basis of the total load on all components in the enclosure. For example, the through-air and over-surface spacing at a component that controls only a motor is evaluated on the basis of the volt-amperes of the motor. A component that controls loads in addition to the motor is similarly evaluated on the basis of the sum of the volt-amperes of the loads so controlled; however, a component that independently controls separate loads is evaluated on the basis

of the volt-amperes of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

22.3 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 (6.4 mm) where 3/8 inch (9.5 mm) is specified.

22.4 The spacing requirements in Table 22.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component that is evaluated on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead or enclosures, are to be those indicated in Table 22.1.

22.5 The spacings titled To Enclosure in Table 22.1 are not to be applied to an individual enclosure of a component part within an outer enclosure or cabinet.

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

22.7 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 (0.711 mm) thick; however, a liner or barrier not less than 0.013 inch (0.33 mm) thick 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.

22.8 Material having a lesser thickness may be used if it has insulating, mechanical, and flammability properties equivalent to those of the materials specified in 22.7.

23 Spacings – Low-Voltage Circuits

23.1 The spacings for low-voltage electrical components which are installed in a circuit which includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in risk of fire, electric shock, or injury to persons shall comply with the requirements of this standard.

23.2 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 22.4.

23.3 Spacing shall be not less than 1/4 inch (6.4 mm) 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.

23.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the 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.

23.5 The spacings in low-voltage circuitry that do not contain devices such as those indicated in 23.4 are not specified.

23.6 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 transformer device of 30 volts or less.

23.7 Two or more transformer devices supplying circuits classified as Class 2, low-voltage circuits provided as a part of the equipment 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.

24 Accessibility of Uninsulated Live Parts

24.1 An uninsulated high-voltage live part and moving parts shall be located, guarded, or enclosed so as to minimize accidental contact by personnel performing service functions which may have to be performed with the equipment energized.

24.2 Accessibility and the reduction of risk of electric shock and injury to person may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 24.1.

a) The components are located with respect to the access opening in the outer cabinet so that the farthest component in the control assembly is not more than 14 inches (35.6 cm) 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 are located not closer than 6 inches 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 bonded 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.

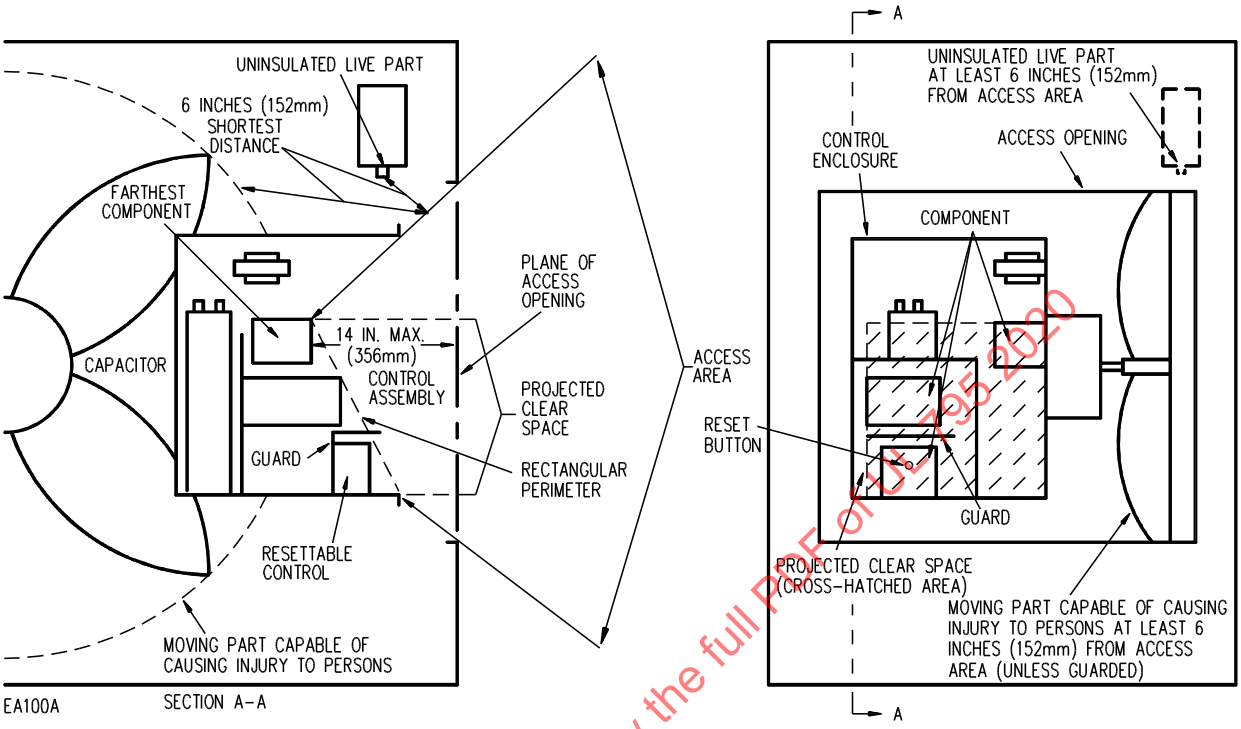
c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet, within the access area, is completely free of obstructions, including wiring.

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 there is unimpeded access to these components through the access opening in the outer cabinet and so that they are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Figure 24.1

Accessibility and protection



24.3 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) Terminals and splices with suitable insulation;

f) Insulated wire.

25 Bonding For Grounding

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

25.2 Except as indicated in 25.3, 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 are likely to be contacted by the user or serviceman.

25.3 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, etc., 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.

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.

25.4 If a component, such as a switch, is 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.

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

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

25.7 A separate bonding conductor shall be of material suitable 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 to 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.

25.8 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 (454.4°C). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

25.9 A connection that depends upon the clamping action exerted by rubber or similar materials shall comply with 25.11 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.

25.10 If bonding depends on screw threads, two or more screws, or two full threads of a single screw, are to engage the metal.

25.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by (a) and (b), it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 25.1, 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 50.

Table 25.1
Duration of current flow, bonding conductor test

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

25.12 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 25.13, the size of the conductor or strap shall be in accordance with Table 25.2.

Table 25.2
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	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

25.13 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 or components within the enclosure.

25.14 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.

25.15 All exposed dead metal parts requiring grounding shall be electrically connected to an equipment grounding terminal(s) or lead(s).

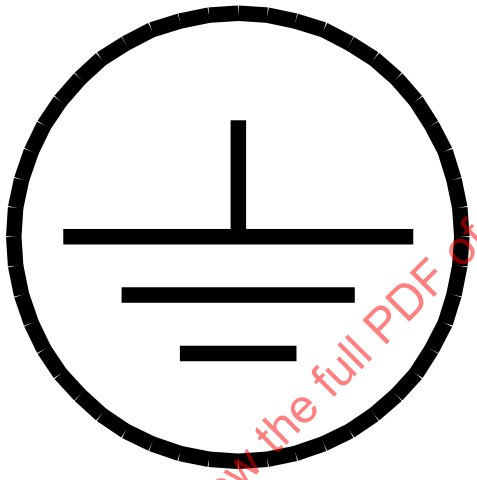
25.16 The equipment grounding terminal or lead shall be located in the field wiring compartment and shall be suitable for connection of an equipment grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70, for the rating of the power supply circuit to be connected.

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

25.18 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"; the letters "G", "GR"; a grounding symbol such as Figure 25.1; 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.

Figure 25.1

Grounding symbol



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

25.20 Grounding and bonding equipment used to comply with this Section and other applicable requirements of this Standard shall comply with the Standard for Grounding and Bonding Equipment, UL 467.

CONSTRUCTION – BURNER ASSEMBLIES

26 General

26.1 Each gas burner assembly employed in the gas-fired appliance covered by these requirements shall be constructed and tested in accordance with the Standard for Commercial-Industrial Gas Burners, UL 295.

26.2 With respect to 26.1, a burner assembly equal to or less than 400,000 Btuh (117,228 W), used on a gas-fired high pressure steam or high temperature water boiler assembly, shall comply with the requirements specified for burner assemblies rated above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732,678 W) in the Standard for Commercial-Industrial Gas Burners, UL 295.

26.3 When the gas burner is installed on the appliance, all safety controls shall be readily accessible.

26.4 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 that each control is in its intended location.

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

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

26.7 As applicable, clearance shall be provided for removal and replacement of the pilot burner without kinking the pilot gas tubing.

26.8 A burner assembly shall be secured so that it will not twist, slide, or drop out of its correct position.

26.9 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 performs a valve proving system sequence on both safety shutoff valves during each burner cycle and functions to prevent light-off in the event of a detectable leak, a normally open vent valve is not required to be used.

27 Combination Gas-Oil Burner Assemblies

27.1 A combination burner assembly designed 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 assembly for that fuel is not in firing position or is not intended to be fired.

27.2 A combination burner assembly designed 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 ignition cycle which shall be initiated before the delivery of main burner fuel to the ignition zone.

27.3 A burner designed to burn both gas and oil simultaneously shall be regulated so that the total input to the burner does not exceed the maximum for which the burner is designed.

27.4 The gas burner portion of the gas-oil burner assembly shall be constructed and tested in accordance with the Standard for Commercial-Industrial Gas Burners, UL 295.

27.5 The oil burner portion of the gas-oil burner assembly shall be constructed and tested in accordance with the Standard for Oil Burners, UL 296.

CONSTRUCTION – BOILERS, FURNACES AND HEATERS

28 General

28.1 Except as permitted by 28.2, 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 boiler, furnace, or heater assembly. The burner assembly shall include the primary safety control. The boiler, furnace, or heater shall include all the other parts constituting the complete gas-fired device.

28.2 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 below and in 28.3. 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.

Exception: Burner piping components such as the main automatic gas shutoff valve, main manual gas shutoff valve, pressure regulator, and the like, 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.

28.3 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 28.2. 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.

28.4 A radiation shield or baffle employed to reduce the risk of unintended temperatures 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.

28.5 Each device shall afford convenient operation by the user of those parts requiring attention or manipulation by him in normal usage.

28.6 Any adjustable part shall be provided with a locking device.

28.7 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.

28.8 Boilers shall bear evidence that they comply with the applicable section of the ASME Boiler and Pressure Vessel Code:

Section I – Power Boilers, 1992 Edition and Addenda thereto.

Section IV – Low-Pressure Heating Boilers, 1992 Edition and Addenda thereto.

28.9 A suspended device shall be constructed to reduce the risk of incandescent particles dropping from the unit.

28.10 A suspended device shall be equipped with hangers or brackets to support the unit.

28.11 Furnaces for space heating shall not allow the products of combustion to become mixed with the circulating air.

29 Accessibility

29.1 All flue gas passageways or heating surfaces of gas-fired devices shall be accessible for inspection and cleaning without major dismantling and without removal of controls.

29.2 Provision shall be made for observation of each pilot and main burner flame during adjustment and under operating conditions.

29.3 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.

29.4 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.

30 Baffles

30.1 Flue baffles shall be removable for cleaning or shall be designed so that they cannot be dislodged or distorted during cleaning. Flue baffles which are removable for cleaning shall be designed so as to assure their replacement in the correct position.

31 Limit Controls

31.1 General

31.1.1 The application of all controls and the requirements for combustion-air and primary safety controls shall be in accordance with Sections 26 – 27 of these requirements.

31.1.2 Except as indicated below, 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.

Exception: 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, one of the valves may be controlled through a contactor of a type that complies with the electrical spacings and endurance requirements of the Standard for Limit Controls, UL 353.

31.1.3 A boiler equipped with an operating control that only regulates the fuel input between high and low values of steam pressure or water temperature, shall be provided with an additional operating limit control that is set to shut off the fuel at a pressure or temperature value below the set point of the high limit control.

31.1.4 The purpose of the requirement in 31.1.2 is to reduce the risk of interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to preclude. 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.

31.1.5 A limit control that operates to shut off fuel in case of low water condition, unintended (high) temperature or unintended (high) pressure shall cause safety shutdown (see 2.89) so that a manual reset is required to restore the burner operation. See 31.1.6.

Exception: The operation of a high temperature limit control on a warm air central furnace or a unit heater as a result of unintended outlet air temperature need not result in safety shutdown. The burner operation can be resumed automatically when the outlet air temperature decreases below the limits specified in 31.5.1.

31.1.6 With respect to 31.1.5 safety shutdown may be provided either by employing manual reset type limit controls or it may be effected by utilizing the manual reset feature of another control on the boiler, such as the primary safety control. For systems where the reset feature is separate from the limit control, means shall be provided to indicate that the limit control has caused safety shutdown.

31.1.7 The operating limit control, as specified by 31.3.1(a) and 31.4.1(a), need not be factory-installed provided the wiring diagram and instructions furnished with the appliance indicate that an operating control of an appropriate type and setting is to be furnished by the installer. See instruction requirement of 68.3.

31.2 Liquid level limit controls – boilers

31.2.1 Fixed-setting hot-water and warm air 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 and warm air temperature limit controls shall have their temperature range marked, and steam-pressure controls shall have their pressure range marked.

31.2.2 A hot water heating boiler shall be provided with at least one low water cutoff or combination low water cutoff and water feed control that operates to open the burner circuit and cause safety shutdown before the water falls below the lowest permissible level recommended by the manufacturer.

Exception: A water tube or coil type boiler that requires forced water circulation to guard against unintended temperatures may employ a water flow sensing device instead of a low water cutoff.

31.2.3 A low pressure and a high pressure steam boiler shall be provided with at least two low water cutoffs or combination low water cutoff and water feed controls. Both controls shall be wired electrically so that operation of either control causes fuel cutoff to the burner before the water level falls below the lowest visible part of the gage glass. However, one shall be set to operate at a lower water level than the other. The control that is 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 (690 kPa).

b) Maximum inside diameter of shell – 16 inches (406 mm).

c) Maximum heating surface – 20 square feet (1.86 m^2).

d) Gross volume, exclusive of casing and insulation – 5 cubic feet (0.142 m^3). See 31.2.4.

31.2.4 The gross volume mentioned in 31.2.3 is intended to include gas passages that are integral with the assembled pressure parts. For the purpose of these requirements, the 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. Projecting nozzles or fittings need not be considered in this volume.

31.2.5 With respect to 31.2.2 and 31.2.3, safety shutdown may occur simultaneously with the operation of the low water cutoff 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.

31.2.6 A liquid level limit control shall comply with the Standard for Limit Controls, UL 353 or the requirements for protective controls in the Standard for Automatic Electrical Controls – Part 1, General Requirements, UL 60730-1.

31.3 Pressure limit controls – boilers

31.3.1 A steam boiler shall be equipped with two factory installed limit controls, as follows:

a) One pressure actuated limit control to shut off the fuel supply to the burner when the steam pressure in the boiler reaches a preset operating pressure.

b) One pressure actuated limit control to shut off all fuel to the burner and cause safety shutdown, requiring a manual reset to restore burner operation, in case of unintended steam pressure in the boiler. The control settings shall be in accordance with 31.3.2 and 31.3.3, as appropriate.

31.3.2 The maximum setting of a limit control on a low-pressure steam boiler shall limit the steam pressure in the boiler to 15.0 psig (103 kPa) or less. On a control having an adjustable setpoint this maximum setting shall be limited by a fixed stop. Such a boiler is marked with ASME Code Symbol "H".

31.3.3 The limit control for a high pressure steam boiler shall be set so that the steam pressure in the boiler will not exceed 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 stamped with the ASME Code Symbol "S".

31.3.4 The requirements of this Section do not preclude the use of additional operating controls, if required by the manufacturer.

31.3.5 An electro-mechanical limit control shall comply with the Standard for Limit Controls, UL 353 or the requirements for pressure cut-outs in the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6 and a maximum drift of five percent and an initial deviation value not exceeding five percent.

31.3.6 An electronic limit control with switched outputs that only relies on hardware circuitry to limit the pressure within the limits specified in 31.3.1 – 31.3.3 shall be investigated to the requirements of:

a) The Standard for Limit Controls, UL 353; or

b) Type 2 Protective Control requirements per the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

An electronic limit control shall have a maximum drift of five percent and an initial deviation value not exceeding five percent.

31.3.7 An electronic limit control that relies on software to limit the pressure within the limits specified in 31.3.1 – 31.3.3 shall be investigated to the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998 and the Standard for Limit Controls, UL 353 or software Class C in accordance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

31.4 Temperature limit controls – boilers

31.4.1 A hot water boiler shall be equipped with two factory installed limit controls, as follows:

a) One temperature actuated limit 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 limit control can be an automatically reset type; and

b) One temperature actuated limit control that operates to shut off all fuel to the burner and causes safety shutdown before the water temperature in the boiler exceeds the maximum rated operating temperature. For a hot water boiler safety shutdown shall occur before the water temperature in the boiler exceeds 250°F (121°C). This limit control shall be a manually reset type.

31.4.2 The requirements of this section do not preclude the use of additional temperature regulating controls, if required by the manufacturer.

31.4.3 An electro-mechanical limit control shall comply with the Standard for Limit Controls, UL 353 or the requirements for protective electrical controls in the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. The limit control shall have a maximum drift of five percent or 10°F (5.6°C), whichever is less and an initial deviation value not exceeding 5°F (2.8°C).

31.4.4 An electronic limit control with switched outputs that only relies on hardware circuitry to limit the temperature within the limits specified in 31.4.1 and 31.5.1 shall be investigated to the requirements of:

a) The Standard for Limit Controls, UL 353; or

b) Type 2 Protective Control requirements per the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

An electronic limit control shall have a maximum drift of five percent or 10°F (5.6°C), whichever is less and an initial deviation value not exceeding 5°F (2.8°C).

31.4.5 An electronic limit control that relies on software to limit the temperature with the limits specified in Sections 31.4 and 31.5 shall be investigated to the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998 and Standard for Limit Controls, UL 353 or software Class C in accordance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

31.5 Temperature limit controls – warm air furnaces and heaters

31.5.1 A suspended warm air heater having a horizontal outlet in the bottom shall be provided with a limit control that at its maximum fixed stop setting does not permit outlet air temperature higher than 200°F (93.3°C). All other types of heaters, including unit heaters and central furnaces shall be provided with a limit control that at its maximum fixed stop setting limits the outlet air temperature to 250°F (121.1°C) or less.

31.5.2 A downflow or a horizontal furnace or heater shall be provided with a limit control that operates to shut off the burner in case of reverse air flow.

31.5.3 The limit controls required by 31.5.1 and 31.5.2 shall comply with 31.4.3 – 31.4.5.

32 Installation of External Controls and Fittings on Boilers

32.1 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 shut-off valves of any type shall be placed in the piping between the boiler and the low water cutoff. A cross or equivalent fitting shall be used in the piping connections at every right angle to facilitate cleaning and inspection.

32.2 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.

32.3 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 cut-off connections. The ends of any nipples used shall be hollowed to full size of the internal diameter.

32.4 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 shall be in the upward direction.

32.5 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.

32.6 A steam pressure limit control shall be installed on the boiler without any shutoff valve between the limit control and the boiler.

32.7 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 be not less than 1/4-inch NPS. Tubing of adequate temperature and pressure rating and with an inside diameter at least equal to standard pipe size may be substituted for pipe.

32.8 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.

32.9 The steam pressure connections to the steam pressure limit control shall be not smaller than:

a) 1/4-inch NPS, when the pipe is of nonferrous material;

b) 1/2-inch NPS for ferrous materials up to 5 feet (1.5 m) in length; or

c) 1-inch NPS for ferrous materials over 5 feet (1.5 m) in length.

Tubing of adequate temperature and pressure rating and with an inside diameter at least equivalent to standard pipe sizes may be substituted for pipe.

33 Flue Dampers, Draft Regulators, and Draft Hoods

33.1 An adjustable flue damper shall be equipped with suitably located 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.

33.2 An automatically operated flue damper shall be designed to maintain a safe damper opening at all times and be arranged to reduce the risk of starting the burner assembly unless the damper is in an intended position for starting.

33.3 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 reduce the risk of interference with their movement and to reduce the likelihood of injury to the operator in case of breakage.

33.4 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.

33.5 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.

33.6 A draft hood shall comply with the applicable construction provisions of the Standard for Draft Hoods, ANSI Z21.12.

33.7 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.

33.8 An adjustable flue damper shall not be used in connection with a device equipped with a draft hood or draft regulator.

34 Bleeds and Vents

34.1 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.

34.2 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.

34.3 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.

34.4 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.

34.5 Gas vent lines with normally open, fully ported, electrically operated valves, as applicable to 26.9, shall be sized in accordance with Table 34.1.

Table 34.1
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

35 Bases

35.1 The base of a furnace shall be constructed to support the furnace as intended. A subbase, if furnished as a separate assembly, shall be arranged for attachment to the furnace in the intended position only and in a manner that will establish and maintain the intended position of the furnace with respect to the subbase.

35.2 The base of a furnace shall be constructed of metal or fabricated of other noncombustible material in a manner to provide equivalent strength and durability. The assembly shall be constructed so that there will be no open passages in the floor through which flame or hot gases from a fire originating in the space below the floor can travel to the room above when the furnace is installed.

35.3 The base and subbase of a downflow furnace intended for installation on combustible floor shall be constructed to establish and maintain not less than the required clearance between vertical surfaces of the plenum or duct to be attached thereto and the floor construction. A spacer shall extend at least 3 inches (76.2 mm) below the upper surface of the floor on which the furnace is to be installed. The use of spacers in the form of separate blocks, and the like, is not considered to comply with this requirement.

36 Heating Surfaces and Combustion Chambers

36.1 Heating surfaces shall be constructed of cast iron, sheet steel, or other material determined to comply with this requirement. The temperature of the metal shall not exceed the limits specified in Table 48.1, when the device is operated under the conditions of the applicable tests in the Temperature Tests, Section 48. Sheet steel, if used, shall maintain strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to AISI 1010 hot rolled sheet steel having a minimum thickness of 0.053 inch (1.3 mm).

36.2 Joints in heating surfaces shall be welded, brazed, or be made by a machined slip joint, or by machining, bolting or riveting. A joint shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

36.3 Combustion-chamber (fire-box) lining, if used, shall be durable, securely held in place, and accessible for replacement with equivalent material.

37 Radiation Shields

37.1 A radiation shield or liner shall be so constructed, formed, and supported to maintain its intended positioning and to resist distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause temperatures in excess of those specified in Table 48.1 when the product is tested as specified in Temperature Tests, Section 48. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the device is tested as specified in the Temperature Tests, Section 48.

38 Materials in Air Handling Compartments

38.1 Materials in a compartment handling air for circulation through a duct system shall not have a flame spread rating over 25 nor a smoke developed rating over 50 when tested in accordance with the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723. This requirement does not apply to the following:

a) Air filters, drive belts, wire insulation, and paint as applied for corrosion protection.

b) Gaskets forming air or water seals between metal parts.

c) Miscellaneous small parts such as refrigerant line bushings or insulating bushings, resilient or vibration mounts, wire ties, clamps, labels, and the like.

d) An adhesive which, when tested in combination with the specific insulating material, complies with the requirement.

e) Molded or formed components made of polymeric materials (not liners) in such quantity that the total surface area of such materials in the compartment does not exceed 10 square feet (0.9 m^2). See 38.7.

38.2 Exposed unimpregnated asbestos material shall not be used in an air handling compartment. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

38.3 The supporting surface to be used in the test for adhesives as specified in the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723, is to be of asbestos cement board or metal. Other materials requiring support may be supported using metal rods or bars or 2 inch (50.8 mm) hexagonal mesh-wire with metal bars or rods.

38.4 Thermal or acoustic insulating material shall be securely positioned if loosening may reduce or block air flow to cause temperatures or pressures in excess of those acceptable during testing as specified in Temperature Tests, Section 48, or if loosening will result in reduction of electrical spacings below the required values, short-circuiting, or grounding. Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air such as by butting edges of insulation against bulkheads.

38.5 A mechanical fastener for each square foot of exposed surface is considered to securely position insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Rigid or semirigid sheets of insulating material may not require fastening to the extent needed for less rigid material or protection of leading edges if the material possesses inherent resistance to damage.

38.6 An adhesive required for securing insulation shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the performance requirements of this Standard and at zero fahrenheit, minus 20 degrees fahrenheit for outdoor-use equipment.

38.7 Polymeric materials exempted by the 38.1(e) shall not have a flame spread rating exceeding 25 or shall comply with the requirements specified in Section 57, Flame Test.

39 Casings

39.1 An outer casing or jacket shall be made of steel or other suitable material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.0254 inch (0.645 mm), and all surfaces shall be protected against corrosion.

39.2 Sheet iron or steel, used for casings to confine circulating air shall not be less than 0.032 inch (0.813 mm) thick.

39.3 Access panels as need be removed for normal service and accessibility shall be designed to permit ready removal and replacement repeatedly without causing damage or impairing any required insulating value.

39.4 A removable panel through which air is drawn for combustion shall be so designed as to restrain it from being attached in a manner that may cause improper performance of the device.

39.5 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same device when interchange may allow improper operation of the device.

39.6 The casing of a device 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; except an opening intended to be always connected to a circulating air-distribution duct may be permitted.

39.7 The casing of a forced air type device shall have no uncovered openings communicating with the circulating air compartments unless such openings are intended to be always connected to a circulating air distribution duct.

39.8 The device shall be designed so that the negative pressure created by an air circulating fan cannot affect the combustion air supply or draw products of combustion into the circulating air. Separate doors for burner assembly and air circulating fan compartments may be provided.

39.9 Connection between the heat exchanger and the casing which encloses circulating air shall be constructed to reduce the risk of combustion products leaking into the circulating air.

39.10 An access opening to a return-air compartment shall be completely covered with a tightfitting, readily removable door or panel.

39.11 A central furnace shall be designed for the attachment of warm air outlet and cold air return ducts.

40 Fuel Lines and Components

40.1 Fuel piping and fuel handling components shall not be located within circulating air channels.

41 Flue Collars

41.1 A flue collar shall be made of material not lighter than that designated for heating surfaces. Such collars shall extend through the casing externally a sufficient distance to permit secure attachment of the vent connector.

42 Air Filters

42.1 An air filter, if supplied as part of the device, shall be accessible for inspection or replacement without the use of special tools and without dismantling the device.

PERFORMANCE

43 General

43.1 The performance of the gas-burning equipment shall meet the applicable requirements when tested as described herein. A device of a type not described specifically herein shall be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed that a device will not continue to meet the requirements in normal usage so as to provide continued safe performance, such supplementary tests shall be conducted as deemed necessary to provide safe service.

43.2 Devices are tested normally to determine suitability for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than indicated in Table 43.1. Devices may be recommended for installation on combustible floors if tests in accordance with these requirements demonstrate that, when so installed, temperatures will not exceed designated limits. At the option of the manufacturer, a device may be tested with clearances less than those indicated in Table 43.1.

Table 43.1
Standard clearances

Type of appliance	Minimum clearances, inches				
	Above	Front	Vent connector	Sides and rear	Below
Form XI	2	18	6	6	–
Form XII	6	18	6	6	–
Form XIIb	6	18	6	6	6
Form XV	6	–	6	6	12
Form I	2	24	18	6	–
Form II	6	24	18	6	–
Form IIb	6	24	18	6	6
Form III	18	48	18	18	–
Form IIIb	18	48	18	18	18
Form IV	48	96	36	36	–
Form XI –	Warm Air Furnace, downflow and upflow types, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner – equipped with a draft hood.				
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 XIIb –	Warm Air Furnace, horizontal forced, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner and installed with 6 inch (15.2 cm) below clearance – equipped with draft hood.				
Form XV –	Unit heater, suspended type not larger than 100 cubic feet (2.8 m^3) in size excluding fan compartment and burner equipment, equipped with integral blowers and fans, and equipped with a draft hood.				
Form I –	Warm Air Furnace, downflow and upflow types, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner - not equipped with a 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 IIb –	Warm Air Furnace, horizontal forced, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner and installed with 6 inch (15.2 cm) below clearance – not equipped with draft hood.				
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 IIIb –	Low Heat Industrial Device, suspended types, horizontal and duct furnaces and unit heaters, not classified under Forms IIb, XIIb, or XV.				
Form IV –	Form IV – Medium Heat Industrial Devices, steam boilers operating in excess of 1000°F (537°C) flue gas temperature.				

43.3 For a device tested in a partial enclosure at clearances less than those designated as standard in Table 43.1, a ceiling of equivalent construction is to be placed above the partial enclosure. Clearances from chimney and vent connectors are to be not less than 6 inches (152 mm). When the chimney or vent connector clearances are less than those designated as standard in Table 43.1, the connector arrangement is to be as specified in 44.2.4 and Figure 44.2.

43.4 An evaluation of any condensation that may collect in the flue gas ductwork or components shall be undertaken to determine the pH content. The pH content is to be measured as undiluted condensate. An initial condensate sample is to be taken upon a cold start and additional samples are to be taken to be representative of all firing conditions that produce condensate. The pH measurement is to be performed in accordance with the Standard Test Method for pH of Aqueous Solutions With the Glass Electrode, ASTM E70. If the pH is greater than or equal to 3.0, no further evaluation of the effects of the condensate is required. If the pH concentration is less than 3.0, the venting system of the appliance shall be evaluated in accordance with the Standard for Venting Systems for Gas Burning Appliances, Categories II, III, and IV, UL 1738.

44 Test Installations

44.1 Floor-mounted devices

44.1.1 The devices in the as received condition are to be placed in a partial enclosure formed by two walls of 1 inch nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. All joints are to be sealed or tight. The walls of the partial enclosure are to extend 3 feet (0.9 m) beyond the end and side of the device and at least 1 foot (0.3 m) above the top of the device. Except as permitted in 43.2, the wall is to be the minimum distance specified in Table 43.1 from the side and back of the device; except where the flue gases are vented horizontally from the back of the device, in which case the wall of the enclosure is to be the specified distance from the nearest point of any draft hood. Medium heat devices need not be placed in the partial enclosure unless they are to be tested at clearances less than those designated as standard in Table 43.1.

44.1.2 As an alternative to the above, when tested at clearances designated as Standard in Table 50.1, the partial test enclosure may be eliminated and thermocouples attached to the outer casing panels as specified by 45.2.4 – 45.2.6. The temperature at points on external surfaces of the device, except within 9 inches (229 mm) of the flue collar or any inspection or relief opening, shall not exceed the values specified in Table 48.1.

44.1.3 If the flue gases are vented horizontally, a length of single wall vent pipe is to be run horizontally through the wall of the test structure. An elbow and vertical vent pipe is to be attached on the far side of the wall to provide a vent arrangement similar to Style III, Figure 44.2. If the flue gases are vented vertically, a vertical vent pipe is to be attached to the outlet of the draft hood or, if no draft hood is provided to a vent collar of the device.

44.1.4 If the device is designed for direct installation on combustible flooring, the floor beneath the device is to be 1 inch (25.4 mm) white-pine flooring superimposed by one layer of building paper; and then by 3/4 inch (19.1 mm) plywood, unpainted or finished with clear sealer.

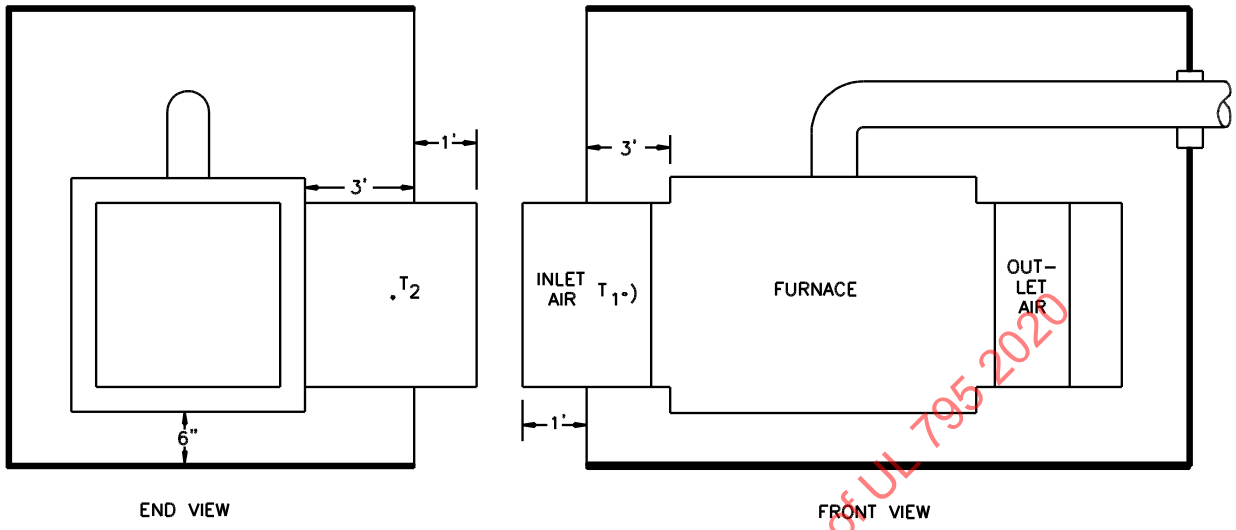
44.1.5 If a boiler is normally insulated in service, it may be tested with the covering furnished by the manufacturer as standard equipment.

44.2 Suspended furnaces

44.2.1 Except as permitted in 43.2, the furnace in the as received condition is to be installed in a partial enclosure (see Figure 44.1) with clearances as specified by Table 43.1 between the surfaces of the test enclosure and the closest portions of the furnace, any draft hood excepted. A draft hood is to be located within the enclosure. The walls and ceiling of the enclosure are to be at least 6 inches (152 mm) from a draft hood relief opening and the nearest point of a draft hood exterior to the furnace.

Figure 44.1

Test enclosure for suspended furnace

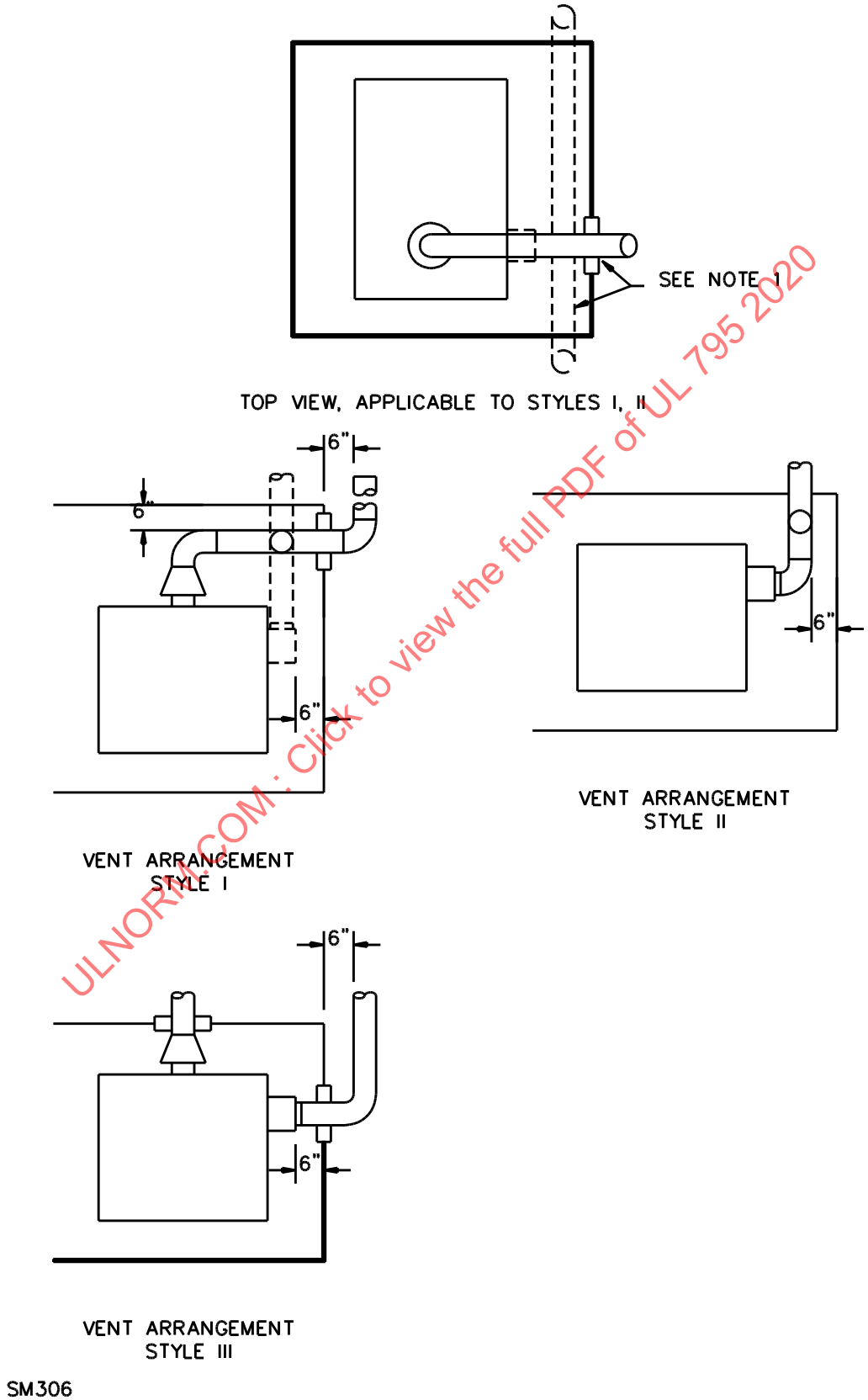


44.2.2 The enclosure is to be constructed of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick finished in flat black with all joints sealed.

44.2.3 Furnaces with vertical flue outlets are to be tested with two vent arrangements, Styles I and III, as shown in Figure 44.2. Furnaces having horizontal flue outlets are to be tested with two vent arrangements, Styles II and III, as shown in Figure 44.2. A closed insulating thimble, 4 inches (102 mm) larger in diameter than the vent pipe, is to be used where the vent pipe may pierce the enclosure. For test purpose, a single-wall vent pipe is to be used with the specified clearance to test wall and ceiling surfaces.

Figure 44.2

Vent arrangement



44.2.4 The cold air inlet and warm air outlet openings are to be extended beyond the test enclosure by appropriate duct work. A metal plenum chamber having the same dimensions as the discharge opening of the furnace is to be provided by the manufacturer for test purpose. The length of the plenum and the size of the warm air duct are to be as indicated in Figure 44.4. The inlet air duct is to have the same dimensions as the inlet opening of the furnaces. The ducts are to extend at least 1 foot (0.3 m) beyond the walls of the enclosure.

Figure 44.3

Test ducts for furnaces

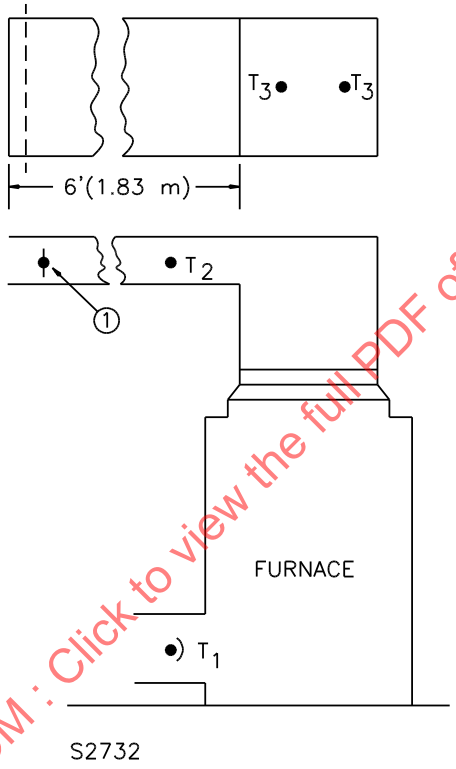
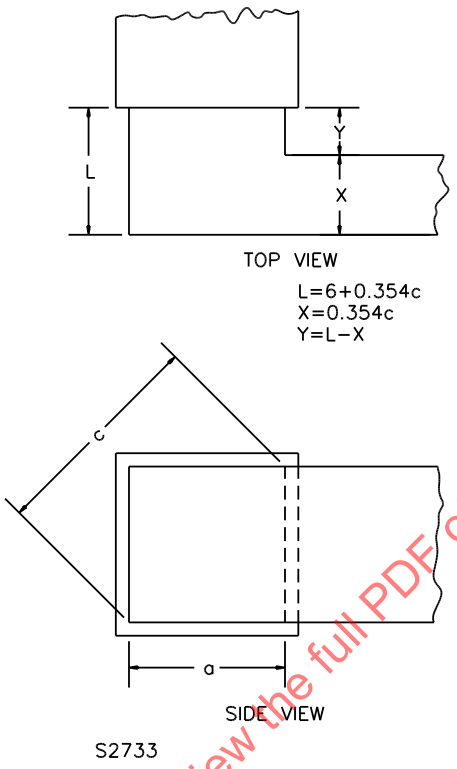


Figure 44.4

Plenum and duct size for suspended furnaces



44.3 Unit heaters

44.3.1 Except as permitted in 43.2, unit heaters are to be suspended in a tunnel-type enclosure so that the clearance between the major top portion of the heater and between the vertical side walls and the vertical sides of the heater are to be as specified by Table 43.1. For heaters having an external vertical-type draft hood the clearances between the top of the sloping side of the external vertical draft hood and the ceiling are to be not less than 1 inch (25.4 mm). The enclosure is to extend 18 inches (45.7 cm) beyond the front and back and 12 inches (30.5 cm) below the heater. The vertical walls and ceiling of the enclosure are to be at right angles and are to be constructed of 1 inch (25.4 mm) nominal thickness wood boards, or plywood 3/4 inch (19.1 mm) thick, finished a flat black. All joints are to be sealed tight.

44.3.2 Air distribution devices or louvers integrally attached to propeller fan type unit heaters are to be set at any allowable position that may produce maximum temperature conditions.

44.3.3 Each air discharge opening of a unit heater for use with ducts is to be fitted with a straight duct extending 36 inches (91.4 cm) from the normal air discharge opening and of the same cross-sectional area and shape as the air discharge opening. This duct, for testing purposes only, is to be furnished by the manufacturer. To provide a means to symmetrically restrict the outlet end of the duct, an adjustable restrictor is to be furnished which forms a diamond shaped opening at the outlet end of the duct.

44.3.4 If the flue gases are vented horizontally, a length of horizontal single-wall vent pipe sufficient to extend to the edge of the enclosure and permit attachment of an elbow and a vertical vent is to be attached to the outlet collar of the heater or draft hood, if one is provided. In no case is the clearance between the horizontal run of vent pipe and combustible construction to be less than 6 inches (152 mm).

44.3.5 If the flue gases are vented vertically, a vertical vent is to be attached and extended directly through the ceiling of the enclosure, at which point a closed insulated thimble having a diameter 4 inches (102 mm) larger than the vent pipe is to be used.

44.3.6 For the purpose of test, a single-wall vent pipe is to be used.

44.4 Test ducts for furnaces

44.4.1 The cold air inlet and warm air outlet openings are to be connected to appropriate duct work. The cross-sectional area of the air inlet duct is to be equivalent to the area of the cold air inlet opening of the furnace

44.4.2 Air outlet ducts, 6 feet (1.83 m) long, are to be connected to the plenum as illustrated. The size of the ducts is to be commensurate to the size of the warm air outlet and be furnished by the manufacturer for this test. The size of the ducts for forced-air furnaces is to be such that they will not impose a static pressure in the plenum in excess of that recommended by the manufacturer.

44.4.3 Temperatures are to be measured at points subjected to the maximum heat. For determining the temperature of the inlet and outlet air, thermocouples are to be located with the tip on the longitudinal axis of each duct as indicated. One or more thermocouples are to be attached to the top surface of the plenum in a central location.

45 Test Methods

45.1 Firing conditions

45.1.1 The conditions for firing burners during tests outlined in these requirements are to be as described below unless otherwise directed by an individual test requirement.

45.1.2 The draft is to be as recommended by the manufacturer.

45.1.3 The firing rate at high fire is to be equivalent to the rated input of the equipment being fired.

45.1.4 The firing rate at intermediate fires is to be as recommended by the manufacturer.

45.2 Temperature measurements

45.2.1 Unless otherwise indicated, surface temperatures are to be determined by a potentiometer and bead type thermocouples not larger than 24 AWG.

45.2.2 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 vent connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches away from the vent connector. Thermocouples are to be attached to other pertinent materials and parts, such as those mentioned in Table 64.1.

45.2.3 If electrical conductors are involved, temperatures are to be measured on surfaces of the conductor insulation, which conductors are to be placed against enclosure surfaces they are likely to touch. The junction of the thermocouple should be held in good thermal contact with the surface of electrical conductors, preferably with an adhesive or cement. Pressure sensitive tape may be used, provided good thermal contact is achieved, and provided the application of the tape does not create air spaces adjacent to the conductor or between layers of tape and provided that the tape has an emissivity comparable to that of the conductor.

45.2.4 Thermocouples are to be secured to wood surfaces by staples over 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 device at points of zero clearance.

45.2.5 Thermocouples are to be attached to metal surfaces at high temperature by welding, soldering or brazing. The attachment should be made with a minimum projection of the thermocouple lead and the brazing metal outward from the metal surface. Thermocouples may be attached to metal surfaces at lower temperature with cement or pressure sensitive tape, provided good thermal contact is achieved and provided that the tape does not create an air space adjacent to the metal surfaces.

45.2.6 Thermocouples are to be attached to surfaces other than as described above by being cemented or taped to the surface in a manner to assure good thermal contact with the surface. The temperature on the surface of the casing of portable and mobile heaters is to be determined by a thermocouple attached to the surface under a flexible, oven dry, felted asbestos pad, 6 square inches (38.7 square mm), 0.4 inch (10.2 mm) thick, and weighing not less than 1.0 nor more than 1.5 pounds per square foot (4.9 nor more than 7.3 kgs per square meter).

45.2.7 The outlet air temperature in rectangular ducts connected to forced-air furnaces is to be measured by nine thermocouples of identical length wired in parallel. The test duct cross-section is to be divided into three equal horizontal and three equal vertical areas with a thermocouple located centrally in each of the nine areas thus obtained. The thermocouple grid is to be located in a plane perpendicular to the axis of air flow and within 6 inches (152 mm) downstream of the location closest to the plenum where any couple will see any surface of the heat exchanger. The duct is to extend at least 6 inches beyond the thermocouple grid.

45.2.8 Unless otherwise indicated, the limits are based upon the rise in temperature above the ambient measured during the test as described below.

45.2.9 If the results of a furnace test involving the operation of a limit control are likely to be affected by the temperature of the inlet air, the test is to be conducted under conditions which maintain the inlet air temperature between 60°F (15.5°C) and 80°F (26.7°C).

45.2.10 For furnaces for installation with ducts, the ambient temperature is to be measured by a thermocouple located in the air inlet as shown by Figure 44.3.

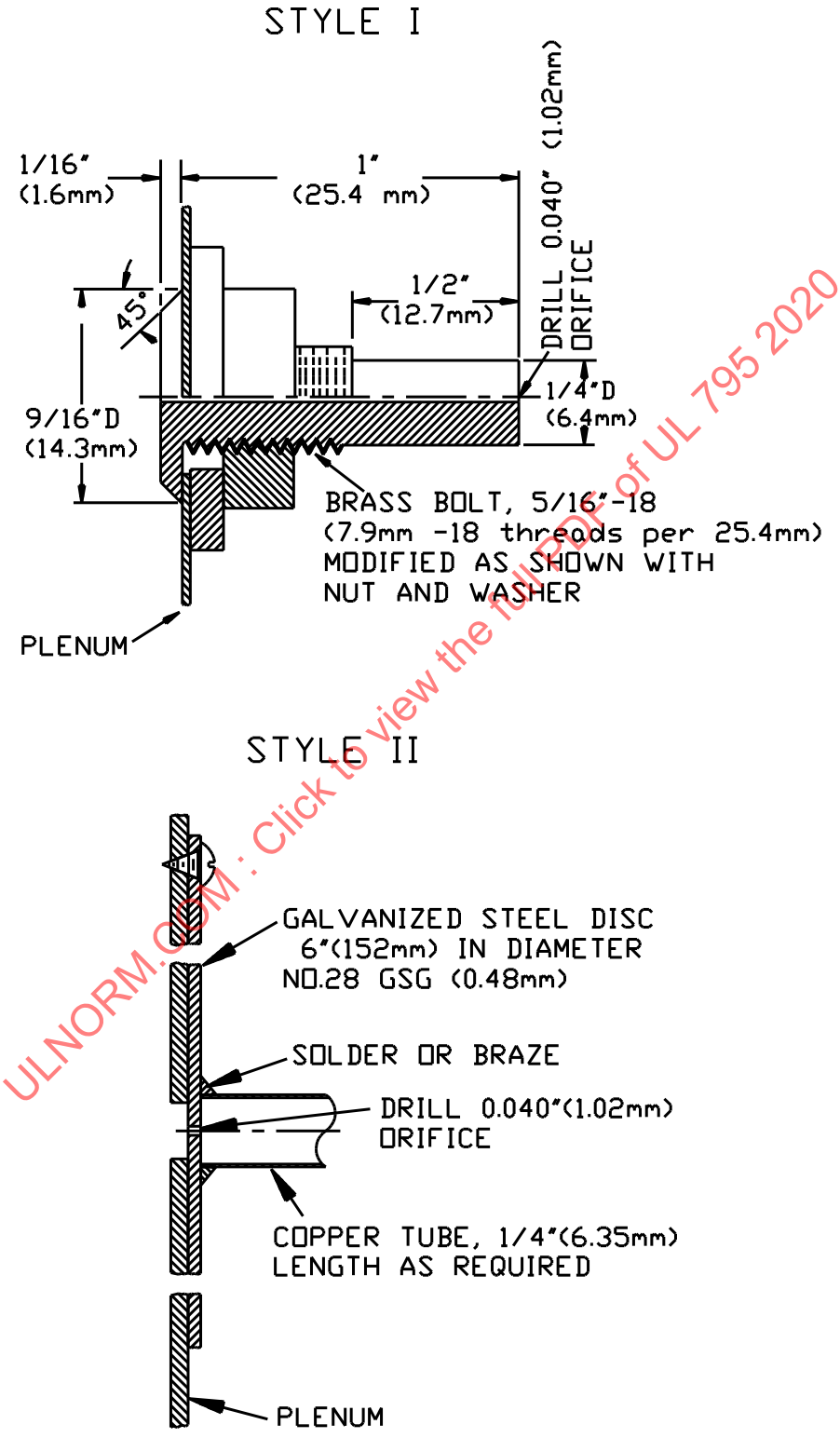
45.2.11 For furnaces without ducts and boilers, the ambient temperature is to be measured by a thermometer or thermocouple shielded from direct radiation and suspended not less than 4 feet (1.22 m) from the outside of the test enclosure with the bulb at a point opposite the midpoint of one side of the device.

45.2.12 An inclined draft gauge with a pressure tap located as shown by Figure 44.4 is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of ±0.0025 inch (±0.0635 mm) and is to be capable of being read directly to 0.005 inch (0.127 mm).

45.2.13 The static pressure connection is to consist of one of the arrangements shown in Figure 45.1.

Figure 45.1

Static pressure pickup arrangements



45.2.14 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.

45.2.15 Devices 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 (1.52 m) nor more than 5 feet 6 inches (1.68 m) above the highest point of the draft hood relief opening.

45.2.16 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.

45.2.17 Devices not equipped with draft hoods are to have attached a 3 foot (.91 m) 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.

45.2.18 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 (.3 m) 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.

45.2.19 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 paragraphs 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. See 46.1.20.

45.2.20 The water temperature is to be measured by a thermocouple located in the boiler so that the water temperature 1 inch (25.4 mm) below the outlet connection of a hot-water boiler and 1 inch (25.4 mm) below the surface of the water in a steam boiler may be determined.

45.2.21 Steam pressure is to be measured by a commercial steam gauge of appropriate range.

46 Burner Assembly Tests

46.1 Combustion test

46.1.1 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.

46.1.2 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.

46.1.3 A boiler, furnace, or heater shall be capable of functioning uniformly and reliably at the maximum input recommended by the manufacturer without a loss of heat to the chimney or vent in excess of 25 percent of the heat input to the device.

46.1.4 The maximum temperature of flue gases during any of the tests in Section 48, Temperature Tests, at the maximum input recommended by the manufacturer shall not be in excess of the temperatures listed in Table 46.1. The maximum temperatures specified in Table 46.1 are for the purpose of obtaining appropriate temperatures on combustible construction in proximity of the chimney or vent connector when the indicated clearances are maintained. Only appliances equipped with draft hoods or appliances without draft hoods that exhibit a negative pressure of the flue gases (see 46.1.5) are suitable for connection to a Type B gas vent. All other appliances are suitable only for connection to a chimney.

Table 46.1
Maximum flue gas temperatures

Type of device	Maximum temperature rise above ambient	
	°F	(°C)
Appliances equipped with draft hoods and appliances intended for connection to a Type B gas vent	400	(204.4)
Other appliances	850	(454.4)

46.1.5 With respect to 46.1.4, 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) down-stream from the connection of the vent pipe to the flue gas outlet of the appliance. The vent pipe are to be connected in accordance with 45.2.17. The pressure of the flue gases shall be negative at all permitted inputs of the appliance.

46.1.6 The performance of a burner assembly or device during the Combustion test, 46.1, 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) The concentration of carbon monoxide in the flue gases is not in excess of 4/100 of 1 percent in an air free sample taken at all firing rates.

e) No soot has been deposited on surfaces of the heat exchanger, flue passages, or vent connector of the heating device fired for the test.

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

g) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions.

46.1.7 A burner assembly is to be installed for test in a boiler of a size commensurate with the firing rate of the burner assembly to be tested. A burner assembly intended for application to a specific device may be tested as applied to that device or a representative of the device for which the burner assembly is designed.

46.1.8 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.

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

46.1.10 Tests are to be conducted at normal gas pressures. The manifold pressure is to be as recommended by the manufacturer.

46.1.11 The burner assembly or device is to be fired with the test gases for which the equipment is rated. The input, air-fuel ratio, and other operating conditions are to be in accordance with the manufacturer's instructions.

46.1.12 A boiler is to be fired at rated input and 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 in a low pressure steam boiler.

c) 95 percent of maximum rated temperature in a high pressure water boiler.

d) 95 percent of rated working pressure in a high pressure steam boiler.

46.1.13 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.

46.1.14 A furnace or heater is to be fired at rated input and the limit control is to be bypassed to permit continued operation when required by a test. The circulating air flow is to be adjusted by restricting the outlet to maintain its design outlet air temperature ±5°F (3°C). The unit is to be fired for the temperature test until equilibrium temperatures are attained. During this test the static pressure in the supply plenum shall be maintained at not more than the value specified by the manufacturer in the installation instructions.

46.1.15 A burner assembly of the ON and OFF type is to be fired 10 minutes ON and 10 minutes OFF for intermittent firing tests.

46.1.16 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.

46.1.17 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.

46.1.18 The fuel burning rate, draft over fire CO_2 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, tests are to be conducted with different combinations of burner sections or groups operating at a time.

46.1.19 The duration of these tests is to be that required to obtain conclusive performance data.

46.1.20 Measurements of flue-gas temperature and CO_2 are to be made. The hourly flue or stack loss is to be computed as the summation of heat above room temperature carried by CO_2, N_2, free air, and water vapor. For the purpose of this computation, water vapor is assumed to exist as a vapor above room temperature; condensation occurring at room temperature. The stack loss is not to exceed 25 percent of the gross heating value of the gas being fired. The maximum flue-gas temperature is not to exceed the limits specified in 46.1.4.

46.2 Combustion air failure test

46.2.1 A mechanical-draft burner assembly or device shall not operate improperly during interruption and upon restoration of the combustion air supply, as determined by test in accordance with 46.2.2 and 46.2.3.

46.2.2 The initial conditions for the test to determine conformance to the preceding paragraph are to be as specified for Combustion test, 46.1. 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 fan supplying air for combustion is to be stopped, i. e., 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 46.2.3.

46.2.3 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 46.2.4 and 46.2.5. 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.

46.2.4 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 gas to the main burner for direct ignition by an electric igniter, whichever is applicable. Purging shall continue for a sufficient time to provide 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 2,500,000 Btu per hour (732 kW), 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.

46.2.5 Purge periods at air flow rates not less than those indicated in (a) and (b) may be considered as providing purging in accordance with 46.2.4:

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.

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.

46.3 Undervoltage test

46.3.1 A burner assembly or device shall operate in accordance with these requirements when tested at a voltage of 85 percent of rated voltage for alternating current or 80 percent of rated voltage for direct current equipment.

46.3.2 The initial conditions for test are to be as specified for Combustion test, 46.1. The test may be conducted during the course of the combustion test. The voltage of the power supply to the burner assembly or device is to be regulated to maintain the minimum voltage specified and the burner assembly ignited and fired at high fire in the intended manner until steady-state conditions are attained.

46.3.3 The performance of the burner or device shall be such that:

a) Ignition of the main burner flame is effected as intended 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.

e) The burner assembly is capable of operation without interruption.

46.4 Power interruption test

46.4.1 A power operated burner assembly or device shall not operate improperly 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.

46.4.2 The initial conditions for test to determine conformance to the preceding paragraph are to be as specified for Combustion test, 46.1. 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 Table 46.2.

Table 46.2
Required programming and timings based on maximum fuel input rating

Operation	Maximum firing rate per combustion chamber		
	Above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732, 678 W)[d]	**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

Table 46.2 Continued on Next Page

Table 46.2 Continued

Operation	Maximum firing rate per combustion chamber		
	Above 400,000 Btuh (117,228 W) to 2,500,000 Btuh (732, 678 W)[d]	**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)**
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.	Safety shutdown except may recycle once.	Safety shutdown
Gas pressure supervision	Low and high gas pressure switches required for direct ignition, not required for piloted ignition systems.[e]	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 (732,678 W). See 31.3 in the Standard for Commercial-Industrial Gas Burners, UL 295.

[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).

[d] These requirements also apply to gas-fired high pressure steam and high temperature water boiler assemblies up to 400,000 Btuh (117,228 W).

[e] See 37.1 in the Standard for Commercial-Industrial Gas Burners, UL 295.

46.4.3 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.

46.4.4 A burner assembly or device equipped with multiple igniters, each of which is capable of functioning independently of the others, shall be so designed that when the equipment is tested in accordance with the following requirements, any one igniter will effect ignition while the others are inactive. See Pilot supervision test, 46.5, Ignition, gas-electric high tension test, 46.6, and Ignition, gas-electric hot-wire – Undervoltage test, 46.7.

46.5 Pilot supervision test

46.5.1 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.

46.5.2 Test to determine conformance with the preceding paragraph is to be made in conjunction with Combustion test, 46.1. 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.

46.5.3 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.

46.5.4 The test to determine conformance with the preceding paragraph is to be made in conjunction with Combustion test, 46.1. 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 at least 5 minutes.

46.6 Ignition, gas-electric high tension test

46.6.1 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 46.6.3 – 46.6.5. The pilot, in turn, shall effect ignition of the main burner fuel as introduced into the ignition zone.

46.6.2 An electric high tension ignition system arranged for ignition of main burner gas directly shall effect the ignition when tested in accordance with 46.6.3 – 46.6.5. See also 46.11.1 – 46.11.3.

46.6.3 The burner assembly or device, arranged and installed as specified for Combustion test, 46.1 is to be tested for conformance to the preceding paragraph 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 (1.6 mm).

46.6.4 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.

46.6.5 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.

46.7 Ignition, gas-electric hot-wire – Undervoltage test

46.7.1 When a gas-electric hot-wire ignition system is energized at a reduced voltage not less than specified herein and with the combustion air supplied at room temperature, no improper performance shall be obtained. The voltage shall be not less than 70 percent of the rated voltage or not less than the minimum voltage below which the burner or device is restrained positively from attempting ignition, whichever is higher. See 46.7.2. This requirement does not apply to a burner or device equipped with a positive means to reduce the risk of the equipment attempting ignition at voltages less than 85 percent of rated voltage for alternating current equipment or 80 percent of rated voltage for direct current equipment. See also 46.7.4.

46.7.2 A positive means for reducing the risk of a burner assembly attempting ignition below a given voltage is one that will always reduce the risk of an attempt to start when the voltage is below a specific value and will disconnect the burner assembly from the power source if the voltage drops below a specific value after an attempt to start has begun.

46.7.3 The burner assembly or device, arranged and installed as specified for Combustion test, 46.1, is to be tested for conformance to 46.7.1 after it has been subjected to the combustion test.

46.7.4 The voltage of the power supply to the burner assembly or device is to be regulated to a value not less than specified in 46.7.1. The equipment is to be energized. Five trials are to be made at each test voltage. If ignition is effected, such ignition is to be effected safely and no flame is to flash outside the device being fired.

46.8 Ignition, gas-electric hot-wire – Igniter endurance test

46.8.1 The igniter of a gas-electric hot-wire ignition system shall be capable of functioning as intended for at least 6000 ignition cycles when tested in accordance with 46.8.2.

46.8.2 Three samples of the igniter are to be tested. The ignition system is to be connected to a power source having a voltage equivalent to 110 percent of the rated primary voltage of the ignition system. The ignition system is to be energized and then de-energized successively as repeating cycles. The duration of the ON period is to be the pilot flame-establishing period for equipment. The duration of the OFF period is to be twice the ON period. The duration of the OFF period is to be twice the ON period unless the ignition system requires a longer time to complete a cycle of operation, in which case the OFF period is to be twice the on period unless the ignition system requires a longer time to complete a cycle of operation, in which case the OFF period is to be the minimum allowed by the system. There is to be no electrical or mechanical failure of the igniters during the test.

46.9 Ignition, gas-electric hot-wire – Temperature test

46.9.1 Parts of a gas-electric hot-wire ignition system shall not attain temperature rises in excess of those indicated for such parts in Column 1, Table 48.1 when the system is energized as described below:

a) A system designed to automatically recycle on ignition or flame failure shall be allowed to cycle until equilibrium temperatures are attained by the parts.

b) A system designed to require manual reset upon ignition for flame failure shall be energized and then reset as quickly as the system will allow after lockout until five attempts for ignition have been made.

c) A system which remains energized upon ignition failure shall be energized continuously until equilibrium temperatures are attained by the parts.

d) A system manually energized by means of a momentary contact switch which cannot be left in the ON position shall be energized for 5 minutes.

e) A system manually energized by means of a switch which can be left in the ON position shall be energized continuously until equilibrium temperatures are attained by the parts.

46.9.2 Test to determine conformance with 46.9.1 is to be made with the burner installed as specified for Combustion test, 46.1, but with the fuel supply to the burner shut off during attempted trials for ignition.

46.10 Ignition, multiple burner test

46.10.1 An assembly employing multiple burners which are automatically lighted shall be designed so that, when tested in accordance with 46.10.2 and 46.10.3, the fuel delivered for combustion by each will be ignited by the flame at each other. Furthermore, no improper ignition or combustion shall be obtained when the fuel delivered by any one or more burners is interrupted during an ignition or firing cycle.

46.10.2 The initial conditions for test to determine conformance to 46.10.1 are to be as specified for Combustion test, 46.1. 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.

46.10.3 The initial conditions for this test are to be as specified for Combustion test, 46.1. 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 ignited as intended, no flame is to flash outside the device being fired, and stable combustion is to be obtained.

46.10.4 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. Intended ignition of all gases from the other burner ports shall occur.

46.11 Delayed ignition test

46.11.1 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, 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 46.11.2 and 46.11.3.

46.11.2 The appliance shall be arranged as specified for Combustion test, 46.1 – 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.

46.11.3 Ignition of the main burner or the 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 the pilot shall be in accordance with 46.11.1 for each of the trials.

47 Operation Tests

47.1 Device limit control cutout test

47.1.1 A limit control shall function to reduce the risk of a device, when tested as described herein, delivering water, steam or air at a temperature or pressure in excess of that specified by these requirements.

47.1.2 The limit control is to be adjusted in accordance with 31.3.2, 31.3.3, and 31.5.1. The device is to be placed in operation. An auxiliary limit control, if adjustable, is to be set to the minimum allowable setting. A modulating type operating control provided to regulate the fuel input between high and low fire values shall be bypassed to permit the device 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, shall also be bypassed during this test.

47.1.3 The boiler is to be filled to a normal level with water. A steam or a hot water boiler is to be provided with a pressure relief valve.

47.1.4 A slow closing valve is to be placed in the steam outlet line of a steam boiler.

47.1.5 For a hot water boiler, the water temperature is to be measured by a thermocouple placed as described in 45.2.20. The inlet and outlet water valves are to be adjusted in such a manner that some hot water is passing the thermocouple bead during the test. The boiler is to be fired at rated input and the water control valves adjusted or the steam outlet closed until the limit control functions. Neither the maximum water temperature in the boiler nor the pressure is to exceed the values indicated in Section 31, Limit Controls.

47.1.6 A furnace designed for distributing air through a special duct system is to be tested while maintaining a static pressure not more than the designed value.

47.1.7 The furnace or heater is to be placed in operation. Each warm air duct outlet is to be restricted symmetrically until the limit control functions. The restriction is to be removed to permit return of the furnace or heater to normal operation. Again symmetrically restrict each warm air duct outlet to either raise the outlet air temperature to a value not more than 10 degrees below the temperature that will cause the limit control to function, but maintaining a static pressure in the supply plenum not more than the value specified by the manufacturer in the installation instructions.

47.1.8 The cold air inlet is to be gradually restricted, symmetrically, to cause the limit control to function. The restriction is then to be removed and the unit operated until approximately equilibrium outlet air temperatures are obtained. Again the cold air inlet is to be restricted over a period of 10 minutes until any automatic reset type limit control acts to shut off the main burner flame. During the test an auxiliary limit control is not to function. The outlet air temperature (T_L) at the instant any automatic reset type limit control functions is to be measured. The temperature thus obtained is not to exceed the appropriate value specified in 31.5.1.

47.1.9 Without changing the inlet or outlet duct restriction, the furnace or heater is to be operated until it recycles on the limit control. An auxiliary limit control is not to function. The temperature obtained is not to exceed the appropriate value specified in 31.5.1 at the time the limit control functions.

47.2 Continuity of operation for furnaces and heaters test

47.2.1 A furnace or heater fired at rated input shall be capable of continuous operation without the limit control functioning to cause reduction in the input when the device is tested as described herein.

47.2.2 The limit control is to be bypassed to permit continued operation during this test. The device is to be placed in operation.

47.2.3 Each warm air duct outlet of a forced air device is to be restricted symmetrically to maintain an external static pressure in the supply plenum of the value specified by the manufacturer in the device installation instructions.

47.2.4 Operation of the device is to be continued until equilibrium outlet air temperature is obtained. The inlet air temperature (T_1) and the outlet air temperature (T_2) are to be measured. For this test, the inlet air temperature (T_1) is to be measured by a thermocouple located in the center of the inlet air duct.

47.2.5 During this test, the firing of the device is not to be interrupted by the functioning of any automatic control. To be in conformance with 47.2.1.

T_2 minus T_1 is to be not more than T_L minus 70

Where:

T_1 is the inlet air temperature in this test, °F;

T_2 is the outlet air temperature in this test, °F;

T_L is the outlet air temperature at which limit control functioned in Device limit control cut out test, 47.1, °F.

47.3 Air flow of horizontal furnaces test

47.3.1 During normal operation of a horizontal furnace from a cold start, a limit control shall operate to reduce the risk of abnormal air temperature under conditions of reversed air flow through the furnace.

47.3.2 A rectangular duct the same size as the inlet air opening of the furnace is to be attached to the return air inlet of the furnace and extended vertically to a distance of 4 feet (1.2 m) above the top of the return air opening of the furnace. A rectangular duct the same size as the outlet air opening of the furnace is to be attached to the outlet air opening of the furnace and extended vertically downward to a distance of 2 feet (0.6 m) below the lower edge of the outlet air opening. The furnace is to be operated against an external static pressure as specified by 47.1.7. Under conditions of this test, the normal temperature rise can vary. A limit control, if adjustable, is to be adjusted to the maximum temperature setting and minimum differential.

47.3.3 Air temperature is to be measured by three individual bead type 24 AWG thermocouples located in the plane of the return air (inlet air) connection of the furnace on a horizontal line one-third of the distance below the top of the return air opening of the furnace. One thermocouple is to be located 1 inch (25.4 mm) from one side of the opening, one at the center, and the other 1 inch (25.4 mm) from the opposite side of the opening.

47.3.4 The circulating fan motor is to be disconnected from the electrical circuit. A continuous pilot is to be lighted and allowed to burn for 15 minutes. Gas to the main burner(s) is then to be turned on and the furnace operated until a limit control functions to shut off the main burner gas.

47.3.5 The maximum temperature indicated by any one of the three thermocouples at the return air opening of the furnace is not to exceed 175°F (79.4°C) above room temperature prior to or during the first cycle of the limit control, and is not to exceed 90°F (32.2°C) above room temperature on the sixth and subsequent cycles of a limit control.

48 Temperature Tests

48.1 General

48.1.1 When a burner assembly, boiler, furnace, or heater is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to adversely affect operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage when such damage to the material or part may cause the equipment to become unsafe for use. The temperature rises at specific points shall be not greater than those specified in Table 48.1 unless otherwise indicated. See Continuous operation test, 48.2, Blocked inlet of furnaces and heaters test, 48.3, and Fan failure of furnaces and heaters test, 48.4.

Table 48.1
Maximum temperature rises

Item	Maximum rise above inlet-air temperature[a]			
	Column 1		Column 2	
	°F	(°C)	°F	(°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,	1230	(683)	1230	(683)
0.2 – 0.5 percent nickel or copper				
Ductile, nodular, cast iron	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)
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)

Table 48.1 Continued on Next Page

Table 48.1 Continued

Item	Maximum rise above inlet-air temperature[a]			
	Column 1		Column 2	
	°F	(°C)	°F	(°C)
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 67.1(k)	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)
250°C rating	405	(225)	450	(250)
Flexible cord –				
Types SO, ST, SJO, SJT[i]	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.[g,j] 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)[g,j] In open motors -				

Table 48.1 Continued on Next Page

Table 48.1 Continued

Item	Maximum rise above inlet-air temperature[a]			
	Column 1		Column 2	
	°F	(°C)	°F	(°C)
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.[g,j] 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.[g,j] 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.[g]				
Thermocouple method	117	(65)	208	(115)
Class 130 insulation on coils other than motor coils.[g]	153	(85)	252	(140)
Class 155 insulation	Not specified As determined by test			
Class 180 insulation				
Fuses[k]	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)
Class 2 transformer enclosure	108	(60)	153	(85)
Power and ignition transformer enclosure	117	(65)	162	(90)
Capacitors – Electrolytic type[h]	72	(40)	Not specified	
Other types[i]	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 48.1. Thermoplastics shall in no case attain temperature at which the material begins to flow. Rubber-insulated conductors within a Class A insulated motor,

Table 48.1 Continued on Next Page

Table 48.1 Continued

Item	Maximum rise above inlet-air temperature[a]			
	Column 1		Column 2	
	°F	(°C)	°F	(°C)
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 g.				
[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 be not 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.				

48.2 Continuous operation test

48.2.1 The burner assembly or device is to be operated under the conditions as specified for Combustion test, 46.1. During this test, the temperature rise above ambient or inlet air, as the case may be, for any item is not to exceed the value indicated for such item in Column 1, Table 48.1.

48.3 Blocked inlet of furnaces and heaters test

48.3.1 The bypass is to be removed from the limit control, and it and the fan control are to be adjusted to the maximum temperature setting and minimum differential.

48.3.2 The furnace or heater is to be fired and the flow of circulating air regulated to maintain an outlet air temperature enough below that required to operate the limit control, which will allow continuous operation of the device, maintaining a static pressure in the supply plenum not more than the value recommended by the manufacturer in the device installation instructions. After steady state-air temperature conditions are attained, the following test is to be conducted.

48.3.3 The inlet air opening or filter of the device is to be gradually restricted until the limit control functions. Then the device is to be allowed to cycle on the limit control, if of the automatic reset type, until equilibrium temperatures have been attained. If the device is equipped with manual reset limit control, the test is to be continued until maximum temperatures are attained.

48.3.4 During this test, the temperature rises above inlet air temperature are not to exceed the values specified in Column 2 of Table 48.1 during the period terminating 1 hour after the first shut off effected by automatic reset limit control. Thereafter, the temperature rises are not to exceed the values specified in

Column 1, Table 48.1, except that a motor may attain a temperature not in excess 208°F (115°C) above inlet air temperature during any part of this test. See 48.1.1.

48.3.5 If the device is equipped with manual reset limit control and the control functions during this test, the temperature rises above inlet air temperature during the test are not to exceed the values specified in Column 2, Table 48.1. See 48.1.1.

48.4 Fan failure of furnaces and heaters test

48.4.1 The device is to be operated under the conditions described in 48.3.2 and 48.3.3.

48.4.2 The circulating air fan drive is to be disengaged unless the fan is directly attached to the driving motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The device is then allowed to be cycled by the limit control if of the automatic reset type. If the device is equipped with auxiliary manual reset limit control, the test is to be continued until maximum temperatures are attained.

48.4.3 If the device is equipped with automatic reset limit control only, the temperature rises above inlet air temperature are not to exceed the values specified in Column 2, Table 48.1 during the period terminating 1 hour after the first shut off effected by the limit control. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 48.1, except that a motor may attain a temperature not in excess of 208°F (115°C) above inlet air temperature during any part of this test. See 48.1.1.

48.4.4 If the device is equipped with manual reset control and the control functions during this test, the temperature rises above inlet air temperature during the test are not to exceed the values specified in Column 2, Table 48.1. See 48.1.1.

48.5 Blocked outlet of furnaces and duct-connected heaters test

48.5.1 The furnace or heater is to be operated under the conditions described in 48.3.1 and 48.3.2 to begin this test.

48.5.2 The warm air outlets are to be closed and the device allowed to be cycled by the limit control if of the automatic reset type or otherwise to function as it will. If the device is equipped with manual reset limit control, the test is to be continued until maximum temperatures are attained.

48.5.3 If the device is equipped with automatic reset limit control only, the temperature rises above inlet air temperature are not to exceed the values specified in Column 2, Table 48.1 during the period terminating 1 hour after the first shut off effected by the limit control. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 48.1, except that a motor may attain a temperature not in excess of 208°F (115°C) above inlet air temperature during any part of this test. See 48.1.1.

48.5.4 If the device is equipped with manual reset limit control and the control functions during this test, the temperature rises above inlet air temperature during the test are not to exceed the values specified in Column 2, Table 48.1. See 48.1.1.

49 Low Water Cutoff of Boilers Test

49.1 A boiler equipped with a low water cutoff control or controls for compliance with 31.2.1 – 31.2.2 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 49.2 – 49.5.

49.2 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 49.4 and 49.5). 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 49.3.

49.3 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 49.4 and 49.5.

49.4 With respect to 49.2 and 49.3, 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.

49.5 If any of the controls whose operation is being tested in accordance with 49.2 – 49.4 includes a time delay feature, it shall be determined that the time delay from burner shutdown to safety shutdown shall be in compliance with 31.2.3. The burner shutdown by the control that causes safety shutdown has to occur before the water level falls below the lowest level permitted by 31.2.2.

50 Short-Circuit Test

50.1 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 has been investigated and found to be acceptable 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.

50.2 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.

50.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the device. See Table 50.1. The full-load current is determined by adding the motor full-load current of each other motor, as determined in accordance with the National Electrical Code, ANSI/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 employed as the basis of 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 50.1
Short circuit test currents

Full-load current rating of device, amperes				
Single phase				Circuit capacity, amperes
115 Volts	208 Volts	230 – 240 Volts	277 Volts	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	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				Circuit capacity, amperes
208 Volts	220 – 240 Volts	440 – 480 Volts	550 – 600 Volts	
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.6	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.7 – 9.6	–	–	2000
9.6 – 23.3	9.7 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

50.4 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.

50.5 Except as indicated in 50.7 and 50.8, an overcurrent protective or a thermal protective device on a furnace 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. There shall be no ignition of cheesecloth surrounding the enclosure of the protective device when samples are subjected to the Short-Circuit Test.

50.6 The nearest standard size fuse, rated not higher than the current indicated in 50.5 but not less than 15 amperes, is to be employed for the test. The maximum fuse size marked on the furnace, see 67.7, shall not exceed this value.

50.7 With reference to 50.5, the protective device may be tested with a fuse having a lower rating than indicated; provided the furnace will start and operate without blowing the fuse and is marked to indicate such a maximum limit of fuse protection.

50.8 The test specified in 50.1 may be waived if:

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

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 product and is acceptable for branch-circuit protection;

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

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified 12.18(e).

However, if short-circuiting between live parts of different circuits may result, the test shall be waived.

50.9 For the test specified in Exception No. 2 to 17.2.3, 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 50.1 and is to be measured without the lead to be tested in the circuit. The voltage source for the test circuit is to be rated voltage and the power factor is to be 0.9 – 1.0 unless a lower power factor is agreeable to those concerned. None of the conductors or lead terminations shall be damaged as a result of this test.

51 Overload Test, High-Voltage Transformers

51.1 A high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type (see 18.2.1) shall be subjected to the test described in 51.4 and 51.5.

51.2 Temperatures of a thermally protected high-voltage transformer, measured on the surface of the windings, shall not exceed the insulation-temperature rating. Insulation-temperature rating is defined as the rating for the class of insulation; such as 105° C for Class 105 insulation, 130° C for Class 130 insulation, and the like.

51.3 The transformer shall comply with the Dielectric Voltage-Withstand Test, Section 53, immediately following the test specified in 51.4 and 51.5.

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

51.5 A variable-resistance load is to be connected to the output terminals and the transformer is to be operated continuously at rated voltage. 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 25° C (77° F). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 10°C (18° F) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

52 Burnout Test, High-Voltage Transformers

52.1 A high-voltage transformer shall be subjected to the test described in 52.2 and 52.3. 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 (see 18.2.1) or that is protected by an overcurrent device, or devices, in accordance with the requirements in 18.2.4 need not be tested.

52.2 Three samples of the transformer are to be operated continuously at rated voltage, and at rated frequency, with the enclosure grounded. The test is to be conducted at ambient (room) temperature of approximately 25°C (77°F) 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 not less than required for the product.

52.3 Except as indicated in 52.4, 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; or

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.

52.4 A transformer that cannot provide the output current required by 52.3 is to be tested with its output terminals short-circuited.

53 Dielectric Voltage-Withstand Test

53.1 A burner or device shall withstand, without breakdown for 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 shall be:

a) 1000 volts plus twice rated voltage, except as noted in (b).

b) 900 volts for motors rated at not more than 1/2 horsepower (373 W output) and not more than 250 volts.

53.2 If higher than rated voltage is developed in a motor circuit through the use of capacitors, the rated voltage of the device is to be employed in determining the Dielectric Voltage-Withstand Test potential; unless the developed steady-state capacitor voltage exceeds 500 volts, in which case the test potential for the parts affected is to be 1000 volts plus twice the developed capacitor voltage.

53.3 Meters provided in an assembly are to be disconnected from the circuit and tested separately.

53.4 A low-voltage circuit shall be capable of withstanding, for 1 minute without breakdown, a 60 Hz potential of 500 volts applied between low-voltage live parts of opposite polarity and between low-voltage live parts and dead metal parts.

53.5 The Dielectric Withstand Test between low-voltage parts of opposite polarity may be waived on the complete assembly provided the components have been separately subjected to this test condition and the wiring is with material as tabulated in Table 13.1.

53.6 A 500 VA or larger transformer, the output voltage of which is essentially sinusodial and can be varied, is to be used to determine compliance with the foregoing. 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 of 1 minute. The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment during the duration of the test.

53.7 A spark ignition system shall be capable of withstanding for 1 minute, without breakdown, the application of a 60 Hz potential of:

a) 150 percent of the maximum voltage to ground between bare current carrying parts and noncurrent carrying parts; and

b) 150 percent of the maximum voltage to each other between bare current carrying parts of opposite polarity.

53.8 The tests to determine conformance to the preceding paragraph is to be made with the ignition transformer disconnected. An arc occurring during the test at a location adjacent to the electrode tips that will result in safe ignition is not to be considered a failure.

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

53.10 The test to determine conformance with the preceding paragraph is to 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).

54 Draft Hood Equipped Devices

54.1 Blocked outlet test

54.1.1 Devices for outdoor installation with the venting system provided as a part of the unit are exempt from the following requirements. See 33.6.

54.1.2 With the outlet of the draft hood blocked, the concentration of carbon monoxide in an air free sample of the flue gases shall not exceed 4/100 of 1 percent when the device is tested in an atmosphere having a normal oxygen supply.

54.1.3 The device is to be operated for at least 15 minutes with gas at normal test pressure. The outlet of the draft hood is then to be blocked and a sample of the flue gases is to be secured and analyzed.

54.1.4 If applicable, flue gases shall not issue from the condensate drain line (s) when tested in accordance with the test method specified above.

54.1.5 For the purposes of this test, the condensate trap, if provided with the appliance, shall be installed according to the manufacturers instructions and initially filled with water.

54.2 Downdrafts and updrafts test

54.2.1 Total downdraft pressures ranging from zero to 0.05 inch water column imposed at the outlet of the draft hood shall not extinguish the main burner flames nor cause them to flash back, lift, float, burn outside the device, nor produce a concentration of carbon monoxide in an air free sample of the flue gases in excess of 4/100 of 1 percent when the device is tested in an atmosphere having a normal oxygen supply.

54.2.2 The device is to be operated for at least 15 minutes with gas at normal test pressure. A straight section of vent pipe of suitable diameter and of a length at least equal to ten pipe diameters is to be attached directly to the outlet of the draft hood and connected to the outlet of a blower. The total draft pressure is to be measured with a Pitot tube and a differential gauge which may be read directly to 0.005 inch water column. The Pitot tube is to be inserted in the straight section of vent pipe at a point midway between its ends, so that:

a) The head of the tube is coincident with the axis of the vent pipe; and

b) The impact opening of the Pitot tube faces the flow stream.

54.2.3 The draft in the vent pipe is to be varied from the minimum total pressure to the maximum value specified above, and the effect noted. A sample of the flue gases is to be taken ahead of the draft hood and analyzed.

54.2.4 Downdrafts imposed as stated in 54.2.1 shall not extinguish the pilot burner flames nor cause them to flash back when they are operated separately from the main burner(s).

54.2.5 A chimney action, consisting of a static updraft and velocity updraft numerically totaling between 0.06 and 0.07 inch water column, applied to the outlet of the draft hood, shall not cause a fractional increase in the volume of flue gases greater than twice the numerical sum of the pressure head and five times the velocity head expressed as inches of water column.

54.2.6 The device is to be operated for at least 15 minutes with gas at normal test pressure.

54.2.7 A straight length of vent pipe of suitable diameter and of a length at least equal to ten pipe diameters is to be attached directly to the outlet of the draft hood and connected to the inlet of a blower. The pressure and velocity heads are to be measured with a Pitot tube and a differential gauge which may be read directly to 0.005 inch water column. The Pitot tube is to be inserted in the straight section of vent pipe at a point midway between its ends, so that:

a) The head of the tube is coincident with the axis of the vent pipe; and

b) The impact opening of the Pitot tube faces the flow stream.

54.2.8 An updraft is to be imposed at the outlet of the draft hood so that the numerical sum of the pressure head and velocity head will be between 0.06 and 0.07 inch water column. Under this condition, a sample of the flue gases is to be taken ahead of the draft hood. The ratio of carbon dioxide concentration for normal operation, as in the combustion test, to that under updraft, as above, is not to be more than 1 ±2 (h_p ±5h_v), where "h_p" is the pressure head and "h_v" is the velocity head.

54.3 Spillage test

54.3.1 Flue gases shall not issue from the relief opening(s) of a draft hood or a draft diverting device when tested in accordance with the test method specified below.

54.3.2 For the purpose of this test, uninsulated sheet metal vent pipe the same size as the draft hood outlet is to be used. Elbows are to be 90 degree, four-piece, sheet metal elbows. The vent pipe is to have a reasonably smooth inner contour.

54.3.3 If the flue gases are vented horizontally, a section of vent pipe extending horizontally, an elbow, and vertical vent pipe are to be attached to the draft hood as shown in Figure 54.1. The length of the horizontal and the height of the vertical pipe are to be as specified in Figure 54.1.