ANSI/CAN/UL 795:2024

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

STANDARD FOR SAFETY

Commercial-Industrial Gas-Fired Package Boilers

ANSI/UL 795-2024

SCC FOREWORD

National Standard of Canada

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UL Standard for Safety for Commercial-Industrial Gas-Fired Package Boilers, ANSI/CAN/UL 795

Ninth Edition, Dated February 29, 2024

Summary of Topics

This new Ninth Edition of ANSI/CAN/UL 795 dated February 29, 2024 merge requirements from ULC/ORD-C795, Commercial-Industrial Gas-Fired Package Boilers, with UL 795, Standard for Commercial-Industrial Gas-Fired Heating Equipment, as a Joint Canada-US Standard.

The requirements are substantially in accordance with Proposal(s) on this subject dated December 16, 2022, May 26, 2023 and October 13, 2023.

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FEBRUARY 29, 2024

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Standard for Commercial-Industrial Gas-Fired Package Boilers

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, 2016

Ninth Edition

February 29, 2024

This ANSI/CAN/UL Safety Standard consists of the Ninth Edition.

The most recent designation of ANSI/UL 795 as an American National Standard (ANSI) occurred on February 29, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

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.

This standard has been designated as a National Standard of Canada (NSC) on date February 29, 2024.

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Preface

This is the Ninth Edition of ANSI/CAN/UL 795, Standard for Commercial-Industrial Gas-Fired Package Boilers.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 795 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

Annex A is identified as Normative, as such, form mandatory parts of this Standard.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This joint American National Standard and National Standard of Canada is based on, and now supersedes, the Eighth Edition of UL 795 and the First Edition of ULC/ORD-C795-2021.

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

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This Edition of the Standard has been formally approved by the Technical Committee (TC) on Combustion Appliances, TC 795.

This list represents the TC 795 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

TC 795 Membership

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International Classification for Standards (ICS): 27.060.20; 97.100.20

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This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

INTRODUCTION

1 Scope

1.1 These requirements apply to factory-built gas-fired package boilers having input ratings of more than 400,000 Btu/h (117,228 W), per individual combustion chamber, having the following:

a) For the United States: Inlet/supply pressures up to 15 psi (103 kPa), and intended primarily for commercial and industrial installation;

b) For Canada: Inlet/supply gas pressures >0.5 psi (3.4 kPa) up to 15 psi (103 kPa) and intended primarily for commercial and industrial installation.

1.2 These requirements also apply to all high pressure steam and high temperature water gas-fired boiler assemblies regardless of Btu/h (kW) input or inlet/supply pressure.

1.3 Package boilers covered by these requirements are designed to be automatically operated without a competent attendant being constantly on duty at the burners while the appliances are in operation.

1.4 Package boilers covered by these requirements are intended for connection to electrical supply circuits limited to 600 V ac or less.

1.5 Boiler assemblies covered by the requirements of this standard are intended for the following fuel gases, as applicable to the manufacturer's rating:

a) Natural gas;

b) Hydrogen-natural gas blends[a];

c) LP-gas;

d) LP-Gas/Air blends; and

e) Manufactured gas.

[a] Up to 25 % H_2 and 75 % natural gas blend shall be the limit for the purposes of this standard.

1.6 Additional installation and operation requirements are available for commercial-industrial gas-fired package boilers as defined by:

a) In the United States:

1) The National Fuel Gas Code, NFPA 54; and

2) The Liquefied Petroleum Gas Code, NFPA 58, as applicable.

b) In Canada: The Natural gas and propane installation code, CSA B149.1.

1.7 These requirements also apply to furnaces and air heaters (United States only) having input ratings of more than 400,000 Btu/h (117,228 W), per individual combustion chamber, having inlet/supply gas pressures up to 15 psi, and intended primarily for commercial and industrial installation. Annex A shall be used to evaluate furnaces and air heaters (United States only). All requirements of this standard apply unless modified by this Annex.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See the individual sections of this Standard for component requirements.

2.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard; or

b) Is superseded by a requirement in this standard.

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

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3 Units of Measurement

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

4 Referenced Publications

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.

4.2 The following publications are referenced in this Standard:

ASME Boiler and Pressure Vessel Code

ASTM A29/A29M, *Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought*

ASTM A90/A90M, *Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A653, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM B487, *Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section*

ASTM B499, *Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals*

ASTM B504, *Standard Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM E70, *Standard Test Method for pH of Aqueous Solutions With the Glass Electrode*

CSA B51, *Boiler, Pressure Vessel, and Pressure Piping Code*

CSA B149.1, *Natural gas and propane Installation Code*

CSA B140.1 Series, *Atomizing- and Vapourizing-type Oil Burners*

CSA C22.1, *Canadian Electrical Code, Part I, Safety Standard for Electrical Installations*

CSA C22.2 No. 0.8, *Safety Functions Incorporating Electronic Technology*

CSA C22.2 No. 0.15, *Adhesive Labels*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 4, *Enclosed and Dead Front Switches*

CSA C22.2 No. 5, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

CSA C22.2 No. 13, *Transformers for oil-or gas-burner ignition equipment*

CSA C22.2 No. 14, *Industrial Control Equipment*

CSA C22.2 No. 18.1, *Metallic Outlet Boxes*

CSA C22.2 No. 18.3, *Conduit, Tubing, Cable Fittings*

CSA C22.2 No. 24, *Temperature-indicating and -regulating equipment*

CSA C22.2 No. 41, *Grounding and Bonding Equipment*

CSA C22.2 No. 42, *General Use Receptacles, Attachment Plugs, and Similar Wiring Devices*

CSA C22.2 No. 45.1, *Electrical Rigid Metal Conduit – Steel*

CSA C22.2 No. 49, *Flexible Cords and Cables*

CSA C22.2 No. 51, *Armoured Cables*

CSA C22.2 No. 56, *Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit*

CSA C22.2 No. 65, *Wire Connectors*

CSA C22.2 No. 66.1, *Low Voltage Transformers – Part 1: General Requirements*

CSA C22.2 No. 66.3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

CSA C22.2 No. 75, *Thermoplastic-Insulated Wires and Cables*

CSA C22.2 No. 77, *Motors with inherent overheating protection*

CSA C22.2 No. 83.1, *Electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel*

CSA C22.2 No. 85, *Rigid PVC Boxes and Fittings*

CSA C22.2 No. 111, *General-Use Snap Switches*

CSA C22.2 No. 153, *Electrical quick-connect terminals*

CSA C22.2 No. 158, *Terminal Blocks*

CSA C22.2 No. 190, *Capacitors for Power Factor Correction*

CSA C22.2 No. 198.1, *Extruded Insulating Tubing*

CSA C22.2 No. 209, *Thermal Cut-Offs*

CSA C22.2 No. 239, *Control and Instrumentation Cables*

CSA C22.2 No. 248, *Low-Voltage Fuses Series*

CSA C22.2 No. 286, *Industrial control panels and assemblies*

CSA C22.2 No. 4248, *Fuseholders Series*

CSA C22.2 No. 60947-1, *Low-Voltage Switchgear and Controlgear – Part 1: General Rules*

CSA C22.2 No. 60947-5-2, *Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches*

CSA C22.2 No. 61058-1, *Switches for Appliances – Part 1: General Requirements*

CSA E60730-1, *Automatic Electrical Controls – Part 1: General Requirements*

CSA E60730-2-6, *Automatic Electrical Controls, Part 2, Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements*

CSA E60730-2-9, *Automatic Electrical Controls; Part 2: Particular Requirements for Temperature Sensing Controls*

CSA E60730-2-15, *Automatic electrical controls – Part 2-15: Particular requirements for automatic electrical air flow, water flow and water level sensing controls*

CSA CGA 3.4, *Industrial and Commercial Gas-Fired Conversion Burners*

CSA/AM ANSI Z21.12, *Draft Hoods*

CAN1-6.2, *Draft Hoods*

NFPA 54, *National Fuel Gas Code*

NFPA 58, *Liquefied Petroleum Gas Code*

NFPA 70, *National Electrical Code*

NMX-J-005, *General-Use Snap Switches*

NMX-J-009/248, *Low-Voltage Fuses Series*

NMX-J-009/4248, *Fuseholders Series*

NMX-J-010, *Thermoplastic-Insulated Wires and Cables*

NMX-J-017, *Conduit, Tubing, Cable Fittings*

NMX-J-023/1, *Metallic Outlet Boxes*

NMX-J-162, *Enclosed and Dead Front Switches*

NMX-J-266, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

NMX-J-436, *Flexible Cords and Cables*

NMX-J-515, *Low-Voltage Switchgear and Controlgear – Part 1: General Rules*

NMX-J-534, *Electrical Rigid Metal Conduit – Steel*

NMX-J-536, Electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel

NMX-J-543, *Wire Connectors*

NMX-J-590, *Grounding and Bonding Equipment*

NMX-J-726, *Metal Clad Cable*

UL 1, *Flexible Metal Conduit*

UL 6, *Electrical Rigid Metal Conduit – Steel*

UL 20, *General-Use Snap Switches*

UL 62, *Flexible Cords and Cables*

UL 83, *Thermoplastic-Insulated Wires and Cables*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 98, *Enclosed and Dead Front Switches*

UL 224, *Extruded Insulating Tubing*

UL 248-1, *Low-Voltage Fuses – Part 1: General Requirements*

UL 295, *Commercial-Industrial Gas Burners*

UL 296, *Oil Burners*

UL 353, *Limit Controls*

UL 360, *Liquid-Tight Flexible Metal Conduit*

UL 467, *Grounding and Bonding Equipment*

UL 486A-486B, *Wire Connectors*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

UL 498, *Attachment Plugs and Receptacles*

UL 506, *Specialty Transformers*

UL 508, *Industrial Control Equipment*

UL 508A, *Industrial Control Panels*

UL 514A, *Metallic Outlet Boxes*

UL 514B, *Conduit, Tubing, Cable Fittings*

UL 514C, *Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers*

UL 726, *Oil-fired Boiler Assemblies*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 797, *Electrical Metallic Tubing – Steel*

UL 810, *Capacitors*

UL 873, *Temperature-Indicating and -Regulating Equipment*

UL 969, *Marking and Labeling Systems*

UL 1004-3, *Thermally Protected Motors*

UL 1059, *Terminal Blocks*

UL 1277, *Power and Control Tray Cable*

UL 1569, *Metal Clad Cable*

UL 1738, *Venting Systems for Gas Burning Appliances*

UL 1998, *Software in Programmable Components*

UL 2250, *Instrumentation Tray Cable*

UL 4248-1, *Fuseholders – Part 1: General Requirements*

UL 5085-1, *Low Voltage Transformers – Part 1: General Requirements*

UL 5085-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

UL 60691, *Thermal-Links – Requirements and Application Guide*

UL 60730-1, *Automatic Electrical Controls – Part 1: General Requirements*

UL 60730-2-6, *Automatic Electrical Controls, Part 2, Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements*

UL 60730-2-9, *Automatic Electrical Controls; Part 2: Particular Requirements for Temperature Sensing Controls*

UL 60730-2-15, *Automatic electrical controls - Part 2-15: Particular requirements for automatic electrical air flow, water flow and water level sensing controls*

UL 60947-1, *Low-Voltage Switchgear and Controlgear – Part 1: General Rules*

UL 60947-5-2, *Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches*

UL 61058-1, *Switches for Appliances – Part 1: General Requirements*

ULC-S636, *Type BH Gas Venting Systems*

5 Glossary

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

5.2 APPLIANCE FLUE – The flue passages within an appliance.

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

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

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

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

5.7 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.

5.8 BURNER –

a) AUTOMATICALLY LIGHTED BURNER – One where fuel to the main burner is normally turned on and ignited automatically;

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

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

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

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

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

5.11 COMBUSTIBLE MATERIAL, NONCOMBUSTIBLE MATERIAL – As used in this standard, these terms are defined in the Standard Glossary of Terms Relating to Chimneys, Vents, and Heat-Producing Appliances, NFPA 97M and/or National Building Code of Canada.

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

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

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

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

5.16 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.

5.17 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.

5.18 ELECTRICAL CIRCUITS –

a) HAZARDOUS-VOLTAGE CIRCUIT – A circuit of any voltage exceeding those of an extra-low-voltage circuit;

b) EXTRA-LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 Vac (42.4 V 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 circuit of voltage above Extra-Low-Voltage, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be an Extra-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 VA and open-circuit secondary voltage rating not exceeding 1000 V.

d) SAFETY CONTROL CIRCUIT – A circuit involving one or more safety controls.

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

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

5.21 FLAME SAFEGUARD – See Primary Safety Control, 5.33.

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

5.23 FLUE GASES – Combustion products and excess air.

5.24 GAS-ELECTRIC HIGH TENSION IGNITION SYSTEM – A system incorporating an electric arc to initiate ignition of a burner.

5.25 GAS-ELECTRIC HOT-WIRE IGNITION SYSTEM – A system incorporating an electric hot surface to initiate ignition of a burner.

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

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

5.28 HIGH LIMIT CONTROL – 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.

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

5.30 HIGH TEMPERATURE WATER BOILER – 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);

5.31 HOT WATER BOILER – 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);

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

5.33 PRIMARY SAFETY CONTROL – An automatic control that monitors the operation of a gas-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.

5.34 PROTECTIVE (SAFETY) CONTROL – 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 5.60).

5.35 OPERATING LIMIT CONTROL – A protective (safety) 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.

5.36 HEAT EXCHANGER – An assembly designed to transfer heat between different elements of the boiler assembly, typically the combustion chamber and the heating medium. In a direct heat exchanger, heat generated in the combustion chamber is transferred directly through walls of the heat exchanger to the heating medium, such as steam or water, held in close contact with the combustion-chamber walls. In an indirect heat exchanger an intermediate medium transfers heat from the combustion chamber to the heating medium.

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

5.38 HYDROGEN-NATURAL GAS BLEND – A fuel compromised of H_2 and natural gas in a mixture no greater than twenty-five percent H_2 and no less than seventy-five percent natural gas.

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

5.40 LINER – See Radiation Shield, 5.56.

5.41 LINING – Those interior surfaces of a combustion chamber which are exposed to combustion during use of the boiler assembly.

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

5.43 LP-GAS/AIR BLENDS – 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.

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

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

5.46 MANUFACTURED GAS – A gas obtained by destructive distillation of coal, or by the thermal decomposition of oil, or by the reaction of steam passing through a bed of heated coal or coke. Examples are coal gases, coke oven gases, producer gas, blast furnace gas, blue (water) gas, carbureted water gas.

5.47 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.

5.48 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.

5.49 PLENUM – Refer to Annex A, Furnaces and Air Heaters (United States only).

5.50 PILOT –

a) CONTINUOUS PILOT – A pilot that burns throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

b) INTERMITTENT PILOT – 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.

c) INTERRUPTED PILOT – 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.

d) PROVED PILOT – A pilot flame supervised by a primary safety control.

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

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

5.53 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.

5.54 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.

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

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

5.57 SAFETY CONTROL – See Protective (Safety) Control, 5.34.

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

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

5.60 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:

a) In the United States, the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

b) In Canada, the Standard for Automatic Electrical Controls – Part 1: General Requirements, CSA E60730-1.

5.61 VALVE –

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

SAFETY SHUTOFF VALVE – 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.

5.62 VENT CONNECTOR – The pipe which connects a gas-fired boiler assembly to a gas vent or chimney.

CONSTRUCTION – MECHANICAL

6 General

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

6.2 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;

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)”.

and

« DANGER – Pour éviter les blessures causées par des pièces mobiles, éteignez (l'équipement) avant de (retirer-ouvrir) ce (capot-porte) »

6.3 The distance from an opening in a required guard or enclosure to the moving part mentioned in 6.2 shall be in accordance with Table 6.1, but the minor dimension of the opening shall not in any case exceed 3 in (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 lbf (22.2 N).

Table 6.1
Maximum Distances Between Moving Parts and Openings in Enclosures

Minor dimensions of opening in (mm)[a]	Minimum distance from opening to moving part in (mm)
1/4 (6.4)	1/2 (12.7)
3/8 (9.6)	1-1/2 (38.1)
1/2 (12.7)	2-1/2 (63.5)
3/4 (19)	4-1/2 (114.3)
1 (25.4)	6-1/2 (165.1)
1-1/2 (38.1)	10-1/2 (266.7)

Table 6.1 Continued on Next Page

Table 6.1 Continued

Minor dimensions of opening in (mm)[a]	Minimum distance from opening to moving part in (mm)
2 (50.8)	14-1/2 (368.3)
Over 2 (Over 50.8)	30 (762)
[a] Openings less than 1/4 in (6.4 mm) are not to be considered for clearances to moving parts.	

6.4 A moving part is not to be considered when judging compliance with 6.2 and 6.3 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

6.5 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, ASME Boiler and Pressure Vessel Code and/or CSA B51, Boiler, pressure vessel, and pressure piping code, -stamped 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 43.3.

8 General Components and Devices

8.1 Wire connectors shall comply with UL 486A-486B/CSA C22.2 No. 65/NMX-J-543.

8.2 Thermoplastic wiring material shall comply with UL 83/CSA C22.2 No. 75/NMX-J-010.

8.3 Flexible cords and cables shall comply with UL 62/CSA C22.2 No. 49/NMX-J-436.

8.4 Fittings for conduit and/or metal clad cable shall comply with UL 514B/CSA C22.2 No. 18.3/NMX-J-017.

8.5 Fuseholders shall comply with UL 4248-1/CSA C22.2 No. 4248.1/NMX-J-009/4248/1, and the applicable Part 2 through 17 (e.g. UL 4248-9/CSA C22.2 No. 4248.9/NMX-J-009/4248/9 for Class K).

8.6 Fuses shall comply with UL 248-1/CSA C22.2 No. 248.1/NMX-J-009/248/1; and the applicable Part 2 through 10 (e.g. UL 248-5/CSA C22.2 No. 248.5/NMX-J-009/248/5 for Class G).

8.7 Circuit breakers shall comply with UL 489/CSA C22.2 No. 5/NMX-J-266.

8.8 Terminal blocks shall comply with:

a) In the United States, UL 1059; or

b) In Canada, CSA C22.2 No. 158, or CSA C22.2 No. 153.

8.9 Electrical (junction) boxes shall comply with UL 514A/CSA C22.2 No. 18.1/NMX-J-023/1 or CSA C22.2 No. 85, 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:

a) In the United States, UL 498; or

b) In Canada, CSA C22.2 No. 42.

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 (69 MPa) 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 boiler assembly, and so as 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 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.

NOTE: 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 in (152 mm) 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 an Extra-Low-Voltage circuit are to comply with the requirements of 10.3 in their relation to uninsulated live parts in a Hazardous-Voltage circuit and to moving parts.

11 Electrical Enclosures

11.1 Uninsulated Hazardous-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 Carbon Steel or Stainless Steel Sheet Metal for Enclosures

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[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
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:

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]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated	Metal coated
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(MSG)	(GSG)
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	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		inches	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(AWG)	
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 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),

Table 11.2 Continued on Next Page

Table 11.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches (AWG)	(mm)
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) Flammability;

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.

11.4 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:

a) In the United States, UL 746C; or

b) In Canada, CSA C22.2 No. 0.17.

11.5 An enclosure complying with the requirements of the following is considered to comply with the requirements of 11.3 (a) – (f):

a) In the United States, UL 508A; or

b) In Canada, CSA C22.2 No. 286.

11.6 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.

11.7 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 in (127 mm) to the outer cabinet unless the thickness of sheet metal is in compliance with Table 11.1.

e) 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.

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

11.8 The requirements of 11.7 apply only to parts of Hazardous-Voltage circuits as defined by 5.18(a).

11.9 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:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1.

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

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

11.12 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.

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

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

11.15 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.

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

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

11.17 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.

11.18 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.

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

11.20 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 in (12.7 mm) does not permit a flat feeler gauge, 5/64 by 1/2 in (2.0 by 12.7 mm) to enter.

b) An opening between the box and motor frame having no dimension exceeding 1/2 in (12.7 mm) does not permit the entrance of a 13/64 in (5.16 mm) diameter rod.

11.21 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 in (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 film- coated-wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4 in (19.1 mm) diameter rod is acceptable under the conditions described in Figure 11.3.

Figure 11.1

Probe for Uninsulated Live Metal Parts

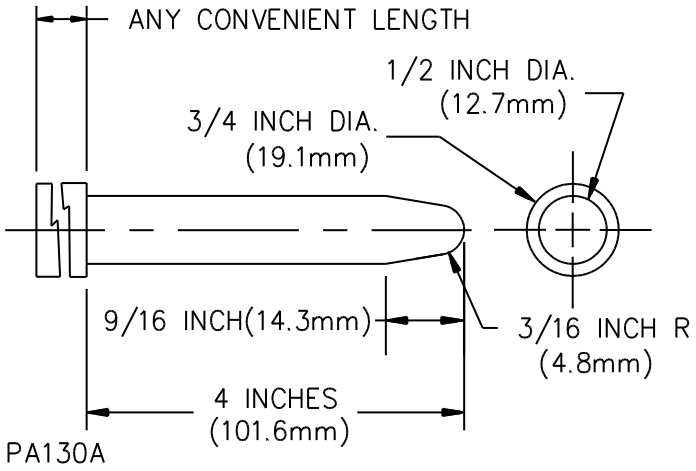


Figure 11.2

Probe for Film-Coated Wire

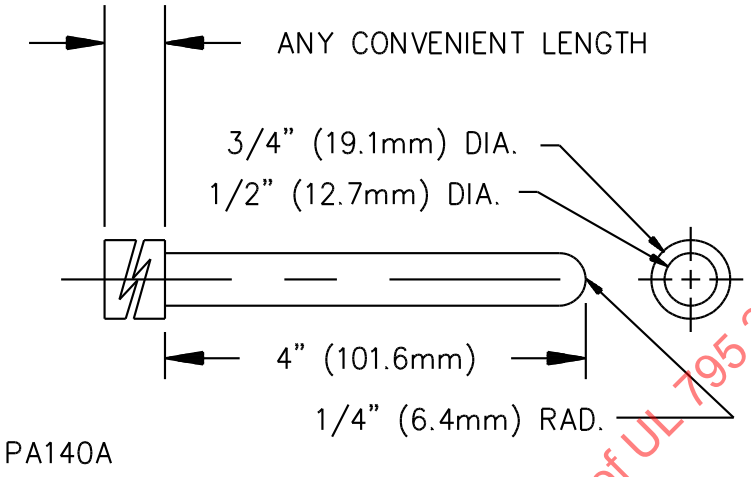
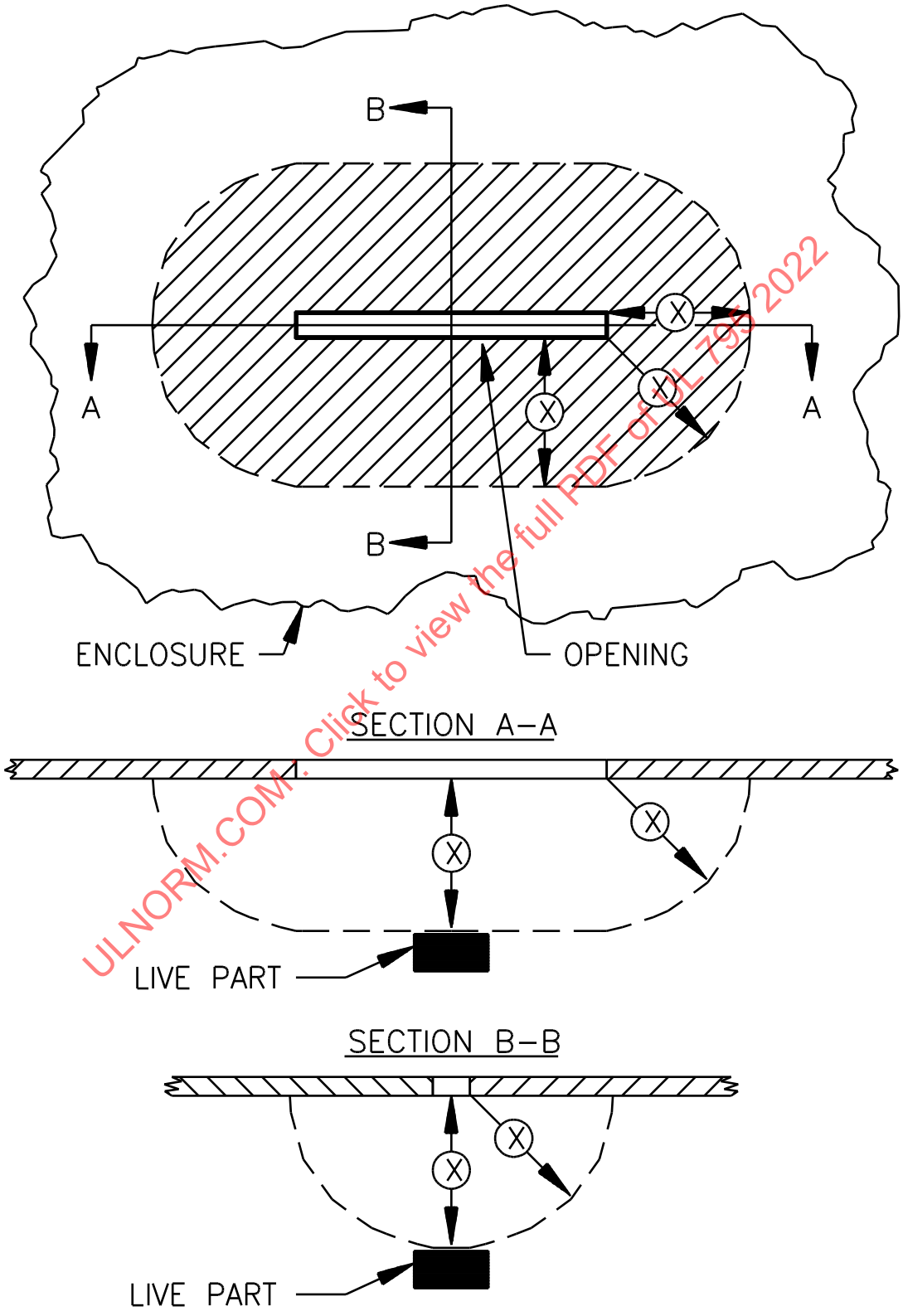


Figure 11.3

Opening in Enclosure



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11.22 The opening is acceptable if, within the enclosure, there is no uninsulated live metal part or film-coated wire:

a) Less than X in (mm) from the perimeter of the opening, as well as

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

11.23 During the examination for conformance with the requirements in 11.21, parts of the enclosure, including air filters, which may be removed without the use of tools are to be removed.

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

11.25 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.

11.26 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.

11.27 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.

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

11.29 A fuseholder shall be so designed, installed, or protected that adjacent uninsulated Hazardous-Voltage live parts within 4 in (1016 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 in (0.711 mm) in thickness.

11.30 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 11.31.

11.31 A hinged cover is not required for an enclosure in which the only fuses enclosed are:

a) Control circuit fuses of 2 A 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 Extra-Low-Voltage circuits.

11.32 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.

11.33 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 11.32.

11.34 A door or cover giving direct access to fuses in other than Extra-Low-Voltage circuits shall shut closely against a 1/4 in (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 in (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.

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

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

11.37 As an alternative to compliance with 11.2 to 11.36, enclosures shall comply with the requirements of UL 50/CSA C22.2 No. 94.1/NMX-J-235.

12 Field Wiring Connections

12.1 As applied in this section a wiring terminal is a terminal to which power supply or control circuit connections will be made in the field when the boiler assembly 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:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1.

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 (mm)

Wire size		Number of wires				
		2	3	4	5	6
AWG	(mm^2)					
14	(2.1)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)
12	(3.3)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	3/4	3/4
10	(5.3)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	3/4	3/4
8	(8.4)	3/4 (19)	3/4	1 (25.4)	1 (25.4)	1-1/4 (31.8)

Table 12.1 Continued on Next Page

Table 12.1 Continued

Wire size		Number of wires				
		2	3	4	5	6
6	(13.3)	3/4	1 (25.4)	1 (25.4)	1-1/4 (31.8)	1-1/4 (31.8)
4	(21.2)	1 (25.4)	1 (25.4)	1-1/4 (31.8)	1-1/4 (31.8)	1-1/2 (38.1)
3	(26.7)	1 (25.4)	1-1/4 (31.8)	1-1/4 (31.8)	1-1/2 (38.1)	1-1/2 (38.1)
2	(33.6)	1 (25.4)	1-1/4 (31.8)	1-1/4 (31.8)	1-1/2 (38.1)	2 (50.8)
1	(42.4)	1-1/4 (31.8)	1-1/4 (31.8)	1-1/2 (38.1)	2 (50.8)	2 (50.8)
0	(53.5)	1-1/4 (31.8)	1-1/2 (38.1)	2 (50.8)	2 (50.8)	2-1/2 (63.5)
2/0	(67.4)	1-1/2 (38.1)	1-1/2 (38.1)	2 (50.8)	2 (50.8)	2-1/2 (63.5)
3/0	(85.0)	1-1/2 (38.1)	2 (50.8)	2 (50.8)	2-1/2	2-1/2 (63.5)
4/0	(107.2)	2 (50.8)	2 (50.8)	2-1/2 (63.5)	2-1/2 (63.5)	3 (76.2)
MCM						
250	(127)	2 (50.8)	2-1/2 (63.5)	2-1/2 (63.5)	3 (76.2)	3 (76.2)
300	(152)	2 (50.8)	2-1/2 (63.5)	3 (76.2)	3 (76.2)	3-1/2 (88.9)
350	(177)	2-1/2 (63.5)	2-1/2 (63.5)	3 (76.2)	3-1/2 (88.9)	3-1/2 (88.9)
400	(203)	2-1/2 (63.5)	3 (76.2)	3 (76.2)	3-1/2 (88.9)	4 (101.6)
500	(253)	3 (76.2)	3 (76.2)	3-1/2 (88.9)	4 (101.6)	4 (101.6)

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 in (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 following shall be included:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1,

Exception No. 1: The total length of flexible metal conduit of any ground return path in the equipment is not more than 6 ft (1.83 m).

Exception No. 2: No circuit conductor protected by an overcurrent-protective device rated at more than 20 A is included.

Exception No. 3: The conduit is no larger than 3/4-in (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 12.2. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor.

Table 12.2
Size of Junction Boxes

Size of conductor AWG	Free space within box for each conductor in^3 (cm^3)
14 or smaller	1.5 (24.6)
12	1.75 (28.7)
10	2.25 (36.9)
8	2.75 (45.1)
6	4.5 (73.7)

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 in (152 mm) long for connection of field wiring conductors corresponding to the marked rating of the assembly shall be provided and be of at least the size required by:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1,

12.9 Leads may be less than 6 in (152 mm) in length if the use of a longer lead may 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:

a) Be transmitted to terminals, splices, or internal wiring;

b) Cause the lead to separate from its terminal; or

c) Result in damage to the lead from sharp edges.

12.11 Leads shall be tested in accordance with the Strain Relief Test in Section 58.

12.12 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.

12.13 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts, which may not always be of the same polarity, 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 in (0.711 mm).

12.14 Leads provided for spliced connections to an external Hazardous-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.

12.15 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 12.20, 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.

12.16 A wire binding screw at a Hazardous-Voltage wiring terminal for field connection shall be not smaller than No. 10 (4.8 mmmajor 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.

12.17 A terminal plate for a wire binding screw shall be of metal not less than 0.030 in (0.762 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 in (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm^2); and in either case there shall be not less than two full threads in the metal.

12.18 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.

12.19 A wire binding screw shall thread only into metal.

12.20 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.

12.21 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.

12.22 A box or enclosure included as part of the assembly and in which a branch circuit supplying power to the boiler assembly is to be connected, shall not require that it be moved for normal care of the boiler assembly 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 Hazardous-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:

1) In the United States, UL 1 or UL 360; or

2) In Canada, CSA C22.2 No. 56; or

3) UL 6/CSA C22.2 No. 45.1/NMX-J-534, as applicable;

b) Enclosed within Electrical metallic tubing that complies with:

1) UL 797/CSA C22.2 No. 83.1/NMX-J-536; or

2) UL 224/CSA C22.2 No. 198.1; or

3) enclosed within a metal raceway electrical enclosure;

c) Within a metal-clad cable that complies with:

1) In the United States, UL 1569/NMX-J-726; or

2) In Canada, CSA C22.2 No. 51; or

d) Exposed Run Tray Cable, Type TC-ER, that complies with:

1) In the United States, UL 1277; or

2) In Canada, CSA C22.2 No. 239, or

3) For applications not exceeding 150 V and/or 5 A, Exposed Run Instrumentation Tray Cable, Type ITC-ER, that complies with the requirements of:

i) In the United States, UL 2250; or

ii) In Canada, CSA C22.2 No. 239.

e) The cable utilized shall:

1) Comply with the crush and impact requirements of:

i) In the United States, UL 1569/NMX-J-726; or

ii) In Canada, CSA C22.2 No. 51;

2) Be secured and supported at intervals not exceeding 6 ft (1.8 m); and

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

13.6 Table 13.1 includes some wiring materials conforming to the requirements for enclosed conductors:

a) In the United States, Groups A and B; or

b) In Canada, Group B only.

Table 13.1
Typical Wiring Materials

Group	Type of wire, cord, or cable[a,b]	Wire size		Insulation thickness	
		AWG	(mm^2)	in	(mm)
A	Thermoplastic or thermoset appliance wiring material, with insulation thicknesses shown at the right corresponding to wire sizes indicated; or Type TW; or Type[d] AC, ACT, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, THW, XHH, XHHW, MTW, THHN, THW-MTW, THWN, PF, PGF, PFF, PGFF; or Type[c] GTF, TW75, TEW, TR-32, R90, RW90, T90, SEW-1, SEW-2	10 to 22	(5.3 to 0.41)	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	(54.0)	5/64	(2.0)
		2/0	(67.0)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.2)	5/64	(2.0)
B	Appliance wiring material having thermoplastic or thermoset insulation, with insulation thicknesses shown at right corresponding to the wire sizes indicated; or Type S, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, SPT-3, ST, STO, STOO; or Type[d] SE, SJE, or Type[c] NMD90, NMWU	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)
		4	(21.2)	9/64	(3.6)
		2	(33.6)	10/64	(4.0)
C	Appliance wiring material with cross-linked synthetic polymer insulation; or Type S, SJ; or Type[d] SP-3	Same as for Group B			

[a] The designated cord or cable, or types of wire other than appliance wiring material, may be used without regard to the values specified in the Table.

[b] Type CL wire may be used within a separate metal enclosure as leads of components

[c] Wire types included only in CSA C22.1.

[d] Wire types included only in NFPA 70.

13.7 Flexible metal conduit, if used, shall be not smaller than 3/8 in (9.6 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads, within the Scopes of other Standards.

13.8 Flexible metal conduit, if used, shall be mechanically secured at intervals not exceeding 4-1/2 ft (1.37 m) and within 12 in (30.5 cm) on each side of every junction box except for lengths not over 36 in (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 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 Hazardous-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 V between parts attached to the same assembly with a predetermined fixed relationship one to the other may be done with Type SO, ST or STO cord, or equivalent, 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 permit normal maintenance and service.

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

13.18 Cords or wiring material as referenced in 13.6 may be employed if the wiring is enclosed by a 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 boiler assembly 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 in (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 in (12.7 mm) in diameter larger than the object that will be installed through the opening.

d) Openings are not closer than 6 in (152 mm) 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), polymeric materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements in:

a) In the United States, UL 94; or

b) In Canada, CSA C22.2 No. 0.17.

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 in (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 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.

13.24 Conductors that conform to the following are considered to meet the intent of the requirements for short-circuit performance in motor circuits having two or more motors, 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 ft (1.2 m) in length provided that the circuit will be protected by a fuse or HACR Type circuit breaker rated 60 A 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 in (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 connected to any other circuit, other than wiring terminals; and

c) Any uninsulated live parts of electrical components whose short-circuiting may result in operation of the boiler assembly in a manner that involves a risk of fire, electric shock, or injury to persons, except at wiring terminals.

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 circuits.

14.5 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 requirements for segregation by barriers, that the conductors entering each opening will be connected to the terminals opposite the opening.

14.6 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.

14.7 To determine if a device complies with the requirements for segregation by barriers, 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.

14.8 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.

14.9 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 in (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 in (1.6 mm) wide.

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

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; and

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.

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 of these as follows:

a) A separate device responsive to motor current and rated to set to trip at not more than the percentage of the motor nameplate full-load current rating specified in Table 16.1. If the percentage protection specified in Column A of Table 16.1 does not correspond to the percentage value of an overload relay of a standard size, the device of the next higher size may be used. However, the overload device of the next higher size shall protect against currents exceeding the percentage values specified in Column B of Table 16.1.

b) A separate overload device which combines the functions of overload and overcurrent protection and is responsive to motor current rated or set at values not greater than the percentages of the motor nameplate full-load current rating as specified Table 16.1. Such a device shall be capable of fully protecting the circuit and motor both under overload and short circuit conditions. If the marked service factor of a motor is less than 1.15, or if the service factor or service factor current is not marked on the motor, the rating or setting of separate overload devices, if used, shall not exceed 115 % of the full load current of the motor.

c) A protective device integral with the motor that complies with UL 2111, or UL 1004-1 (and CSA C22.2 No. 77) and UL 1004-3 (and CSA C22.2 No. 77). An impedance-protected motor shall comply with UL 1004-1 and UL 1004-2. An electronically protected motor shall comply with UL 1004-1 and UL 1004-7 (and CSA C22.2 No. 77).

Table 16.1
Protective Device Activation Level

	Maximum percent of full-load current rating protection	
	A	B
Motor with marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 72 °F (40 °C)	125	140
Any other motor	115	130

16.2 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.

16.3 A three-phase motor shall be provided with overload protection as specified in 16.1. The protection shall consist of three overcurrent units or the devices as specified in 16.1. If current responsive devices provide the only protection, then such devices shall consist of three current responsive elements that are either connected directly in the motor circuit conductor; or fed by two or three current transformers, and so connected that all three phases will be protected.

16.4 With reference to 16.3, acceptable three-phase protective devices include thermal protectors, a combination of thermal protectors and overcurrent units, or another method of protection, where the specific protective arrangement has been investigated and found to provide protection under primary, single-phase fault conditions when power is supplied from transformers connected wye-delta or delta-wye.

16.5 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.

16.6 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.

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

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

16.9 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.

16.10 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.

16.11 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.

16.12 Conformance to the requirements to prevent entry of a falling drop of liquid, or a particle, 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.

16.13 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 motor.

16.14 The requirement in 16.13 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-circuited main winding;

2) Open-circuited starting winding;

3) Starting switch short-circuited; and

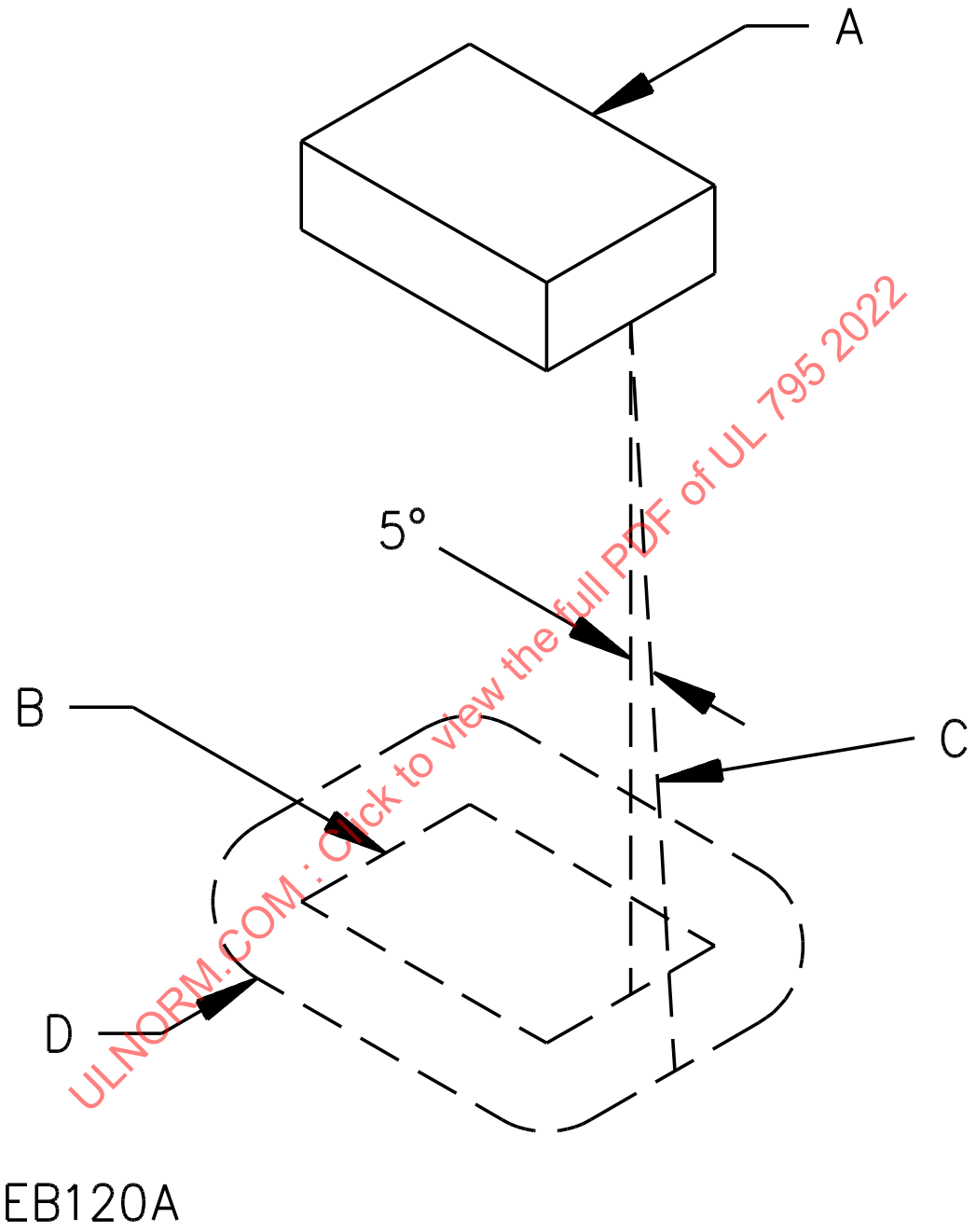
4) Capacitor short-circuited, permanent split capacitor type; or

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.

16.15 The barrier mentioned in 16.14 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 – Regions to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. This line is always (1) tangent to the component, (2) 5° from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

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

17 Overcurrent Protection of Hazardous-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 Hazardous-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 66.10.

17.2 Tapped hazardous-voltage control circuits

17.2.1 For the purpose of these requirements, a tapped Hazardous-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 control circuit that is tapped from the main power circuit at a point outside of the control equipment enclosure that is rated Hazardous-Voltage:

a) In the United States, shall be protected as specified Column A of Table 430-72(b) of NFPA 70; or

b) In Canada, shall be protected as specified in Tables 1 through 4 of CSA C22.1.

17.2.3 Conductors of Hazardous-Voltage control circuits shall be provided with overcurrent protection. The rating of the overcurrent-protective device or devices shall not exceed the applicable values 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 ft (1.2 m) long between points of opposite polarity may be protected by a fuse or an HACR Type circuit breaker rated 60 A 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 in (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 % of value specified for 140 °F (60 °C) conductors in:

a) In the United States, Table 310-17 of NFPA 70; or

b) In Canada, CSA C22.1.

[c] 300 % of value specified for 140 °F (60 °C) conductors in:

a) In the United States, Table 310-16 of NFPA 70; or

b) In Canada, CSA C22.1.

17.3 Overcurrent-protective devices

17.3.1 Overcurrent protection for a conductor of a Hazardous-Voltage control-circuit, 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 66.8.

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.

17.3.3 The devices shall be either a circuit breaker, or a fuse suitable for branch-circuit protection such as HRCI-J, -R, -T, -L or HRCII-C, or Class CC, G, H, J, K, L, R, or T cartridge fuses or 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 66.9.

18 Overcurrent Protection of Transformers

18.1 Hazardous-voltage transformers

18.1.1 A transformer, other than as described in 18.3.1 and 18.3.2, is considered to be a Hazardous-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, Hazardous-Voltage Transformers, Section 52.

Exception: This requirement is not applicable to an interchangeable ignition transformer that conforms to the requirements for ignition transformers in:

a) In the United States, UL 506; or

b) In Canada, CSA C22.2 No. 13.

18.2 Thermal protection

18.2.1 If a Hazardous-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, Hazardous-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, Hazardous-Voltage Transformers, Section 52.

18.2.2 A thermal cutoff shall comply with the requirements in:

a) In the United States, UL 60691; or

b) In Canada, CSA C22.2 No. 209.

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:

c) In the United States,

1) UL 873; or

2) UL 60730-1, and UL 60730-2-9; or

b) In Canada,

1) CSA C22.2 No. 24, or

2) CSA E60730-1, and CSA E60730-2-9.

18.2.3 If a Hazardous-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 Hazardous-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 % if transformer supplies a motor control circuit.

[b] If 125 % 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 A.

18.2.5 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 % 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 Extra-low-voltage transformers

18.3.1 Except as specified in 18.3.2, a transformer having a rated output of not more than 30 V and 1000 VA (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 % 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 5.18(b)] shall, in accordance with the requirements in UL 5085-1/CSA C22.2 No. 66.1 and UL 5085-3/CSA C22.2 No. 66.3, 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 66.8.

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 devices shall be either a circuit breaker, or a fuse suitable for branch-circuit protection such as HRCI-J, -R, -T, -L or HRCII-C, or Class CC, G, H, J, K, L, R, or T cartridge fuses or a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the boiler assembly, 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 66.9.

19 Switches and Controllers

19.1 Except as indicated in 19.2, all boiler assemblies incorporating more than one motor intended for connection to the same power supply shall be equipped with a controller for controlling the loads involved.

19.2 A controller is not required for a boiler assembly having more than one motor intended for connection to a single supply line if the marked maximum overcurrent protective device does not exceed 20 A at 125 V or less; or 15 A at a voltage greater than 125 V but not greater than 600 V, and with not more than 6 A 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 66.11 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the boiler assembly 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 UL 98/CSA C22.2 No. 4/NMX-J-162, UL 20/CSA C22.2 No. 111/NMX-J-005 or UL 61058-1/CSA C22.2 No. 61058-1.

19.12 Controllers shall comply with the following, as applicable:

a) In the United States:

1) UL 508;

2) UL 60947-1/CSA C22.2 No. 60947-1/NMX-J-515; or

3) UL 60947-5-2/CSA C22.2 No. 60947-5-2.

b) In Canada:

1) CSA C22.2 No. 14;

2) CSA C22.2 No. 60947-1; or

3) CSA C22.2 No. 60947-5-2.

20 Capacitors

20.1 Capacitors 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 in (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 in (0.711 mm) thick. 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 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:

a) In the United States, UL 810; or

b) In Canada, CSA C22.2 No. 190.

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 providing equivalent performance.

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 voltage-withstand, and other properties needed for the application.

22 Spacings – Hazardous-Voltage Circuits

22.1 The spacings between uninsulated live parts of opposite polarity and between uninsulated live parts and dead (grounded non-current-carrying) metal parts shall be not less than the values specified in Table 22.1.

Table 22.1
Spacings

Ratings		Minimum spacing in inches (mm)		
Volt-amperes	Volts	Through air	Over surface	To enclosure[c]
0 – 2000	0 – 300[a]	1/8 (3.2)[b]	1/4 (6.4)	1/4 (6.4)
More than 2000	0 – 150	1/8 (3.2)[b]	1/4 (6.4)	1/2 (12.7)
	151 – 300	1/4 (6.4)	3/8 (9.6)	1/2 (12.7)
	301 – 600	3/8 (9.6)	1/2 (12.7)	1/2 (12.7)

[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 (6.4 mm).

[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 V, the over-surface spacings for glass-insulated terminals of motors may be 1/8 in (3.2 mm) where 1/4 in (6.4 mm) is specified in the table and may be 1/4 in (6.4 mm) where 3/8 in (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 in (0.711 mm) thick; however, a liner or barrier not less than 0.013 in (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 – Extra-Low-Voltage Circuits

23.1 The spacings for Extra-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 3.2 mm (1/8 in). See 22.4.

23.3 Spacing shall be not less than 1/4 in (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 in (0.8 mm), provided that the construction of the parts is such that spacings will be definitely maintained.

23.5 The spacings in Extra-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, Extra-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 V or less.

23.7 Two or more transformer devices supplying circuits classified as Class 2, Extra-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 Hazardous-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.

Exception: These requirements are not applicable to mechanical service functions which are not normally performed with the equipment energized.

24.2 Accessibility and the reduction of risk of electric shock and injury to persons 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 in (35.6 mm) from the plane of the access opening.

b) Uninsulated live parts outside the control assembly projected clear space, except for live parts within a control panel or unguarded moving parts are located not closer than 6 in (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

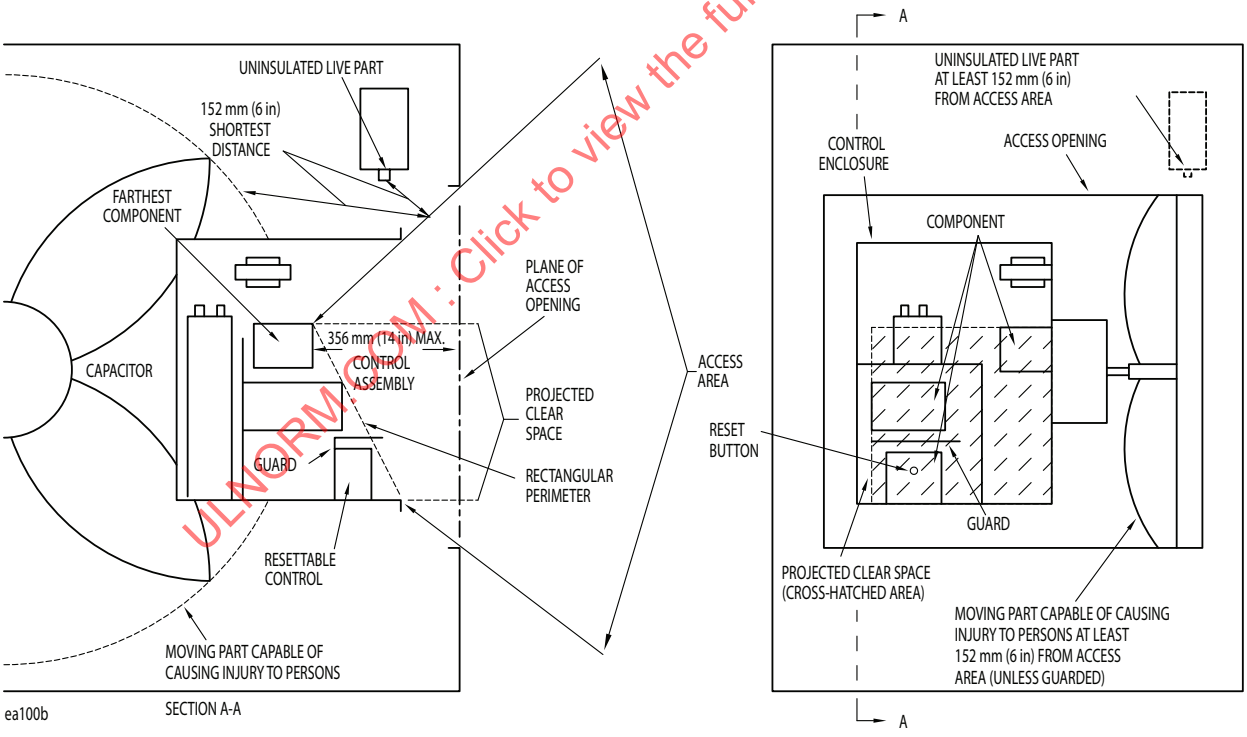
c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet, within the access area, is completely free of obstructions, including wiring.

d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

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

25.1 Exposed or accessible dead (non-current-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 grounding terminal or lead.

25.2 Except as indicated in 25.3, uninsulated dead metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping, valves, and the like, are to be bonded for grounding if they may be contacted by the user or service personnel during servicing of the boiler assembly.

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 by grounded metal parts from electrical components or wiring so that it cannot become energized;

b) Isolated metal parts, such as a motor controller magnet frame or armature, or 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; and

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 in (0.8 mm) thick and that is secured in place.

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, it 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, brazing, welding, or making a bolted or screwed connection. The bonding connection shall penetrate nonconductive coatings, such as paint.

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, min
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)

Table 25.2 Continued on Next Page

Table 25.2 Continued

Rating of overcurrent device amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
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 shall 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 6 AWG (13.3 mm^2) for copper, or 4 AWG (21.1 mm^2) for aluminum, as required:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1,

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) A green, not readily removable, terminal screw with a hexagonal head;

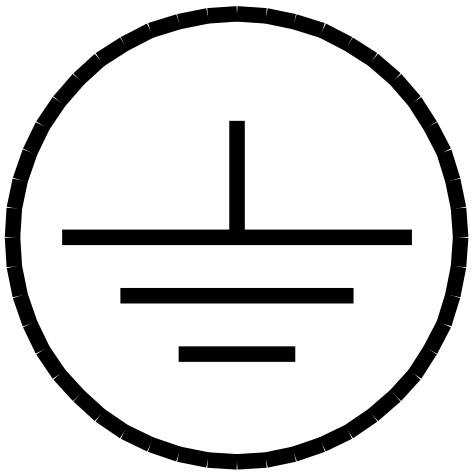
b) A green, hexagonal, not readily removable terminal nut; or

c) 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 UL 467/CSA C22.2 No. 41/NMX-J-590.

CONSTRUCTION – BURNER ASSEMBLIES

26 General

26.1 Each gas burner assembly employed in a gas-fired boiler assembly covered by these requirements shall be constructed and tested in accordance with:

a) In the United States, UL 295; or

b) In Canada, CSA CGA 3.4.

Exception: A natural-draft burner may be evaluated to the requirements of this standard.

26.2 With respect to 26.1, a burner assembly equal to or less than 400,000 Btu/h (117,228 W), used on a gas-fired high pressure steam or high temperature water boiler assembly, shall comply with:

a) In the United States, the requirements specified for burner assemblies rated above 400,000 Btu/h (117,228 W) to 2,500,000 Btu/h (732,678 W) in UL 295; or

b) In Canada, the requirements of conversion burners with inputs in excess of 117,228 W (400,000 Btu/h) to 2,930,710 W (10,000,000 Btu/h) in accordance with CSA CGA 3.4.

26.3 When the gas burner is installed on the boiler assembly, 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/h (3,663,388 W) and equipped to fire fuel gas having a specific gravity less than one shall also include a normally open 3/4 in (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 shall be designed to burn only one fuel at a time. It 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 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 The gas burner portion of the gas-oil burner assembly shall be constructed and tested in accordance with:

a) In the United States, UL 295; or

b) In Canada, CSA CGA 3.4.

27.4 The oil burner portion of the gas-oil burner assembly shall be constructed and tested in accordance with:

a) In the United States, UL 296, or

b) In Canada, CSA B140.1 Series, as applicable.

27.5 In addition to the requirements of 27.4 for oil burners, a combination Gas-Oil Boiler Assembly shall be evaluated to the applicable requirements of:

a) In the United States, UL 726, or

b) In Canada, CSA B140.7.

CONSTRUCTION – BOILER ASSEMBLIES

28 General

28.1 Except as permitted by 28.2, each boiler assembly 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 rest of the boiler assembly. The burner assembly shall include the primary safety control. The rest of the boiler assembly shall include all the other parts constituting the complete gas-fired boiler assembly.

28.2 A boiler assembly, if not manufactured as a single 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. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe operation of the boiler assembly, 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, gas-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 Refer to Annex A, Furnaces and Air Heaters (United States only)

28.4 A radiation shield or baffle employed to reduce the risk of unintended temperatures shall be assembled as part of the boiler assembly; or be part of a subassembly that must be attached to the boiler assembly for its normal operation; or be designed so that the boiler assembly cannot be assembled for operation without first attaching the required shield or baffle in its proper position.

28.5 Each boiler assembly shall afford convenient operation by the user of those parts requiring attention or manipulation 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, or vent-relief openings shall not be less than 1.8 in (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:

a) In the United States, the applicable section of the ASME Boiler and Pressure Vessel Code;

1) “S” – Designates a high pressure steam or high-temperature water boiler constructed in accordance with Section I, Rules for Construction of Power Boilers; or

2) “H” – Designates a low pressure steam or hot water boiler constructed in accordance with Section IV, Rules for Construction of Heating Boilers; or

3) “M” – Designates a miniature boiler constructed in accordance with Section I, Part PMB, Rules for Construction of Power Boilers; or

b) In Canada, the applicable section of CSA B51.

29 Accessibility

29.1 All flue gas passageways or heating surfaces of gas-fired boiler assemblies 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 boiler assembly 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 boiler assembly.

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 burner controls and the requirements for combustion-air and primary safety controls shall be in accordance with Sections 26 – 27 of these requirements, as applicable.

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 relevant control standards specified in 31.2.6, 31.3.5 – 31.3.7, 31.4.3 – 31.4.5, as applicable.

31.1.3 The purpose of the requirement in 31.1.2 is to reduce the risk of interposing other controls and devices in the limit-control circuit, 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.

31.1.4 A boiler equipped with an operating or modulating 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 per 31.3.1(a) or 31.4.1(a), as applicable, that is set to shut off the fuel at a pressure or temperature value below the set point of the high limit control.

31.1.5 A limit control that operates to shut off fuel in case of abnormal low water condition, abnormal/unintended (high) temperature or abnormal/unintended (high) pressure shall cause safety shutdown (see 5.58) so that a manual reset is required to restore the burner operation. As applicable, see 31.3.1(b) and 31.4.1(b).

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.

31.2 Liquid level limit (protective) controls

31.2.1 Fixed-setting hot-water temperature limit controls shall be marked with the operating temperature, and steam-pressure controls shall be marked with the operating pressure of their fixed points. Adjustable setting hot-water temperature limit controls shall have their temperature range marked, and steam-pressure controls shall have their pressure range marked.

31.2.2 A hot water 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 in (406 mm).

c) Maximum heating surface – 20 ft^2 (1.86 m^2)

d) Gross volume, exclusive of casing and insulation – 5 ft^3 (0.142 m^3).

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, per the manufacturer's recommendation. The time delay for safety shutdown shall not exceed the boiler manufacturer's recommended time or 90 s, whichever is less.

31.2.6 A liquid level limit control shall comply with:

a) In the United States:

1) UL 353; or

2) UL 60730-2-15; or

b) In Canada:

1) CSA E60730-2-15;

2) The requirements for protective controls in CSA E60730-1; or

3) The limit control requirements of CSA C22.2 No. 24.

31.3 Pressure limit (protective) controls

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 (high) 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. In the United States only, 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. In the United States only, 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:

a) In the United States:

1) UL 353; or

2) The requirements for pressure cut-outs in UL 60730-2-6; or

b) In Canada:

1) The requirements for pressure cut-outs in CSA E60730-2-6, or

2) The limit control requirements of CSA C22.2 No. 24, and a maximum drift of 5 % and an initial deviation value not exceeding 5 %.

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 comply with the requirements of:

a) In the United States: Type 2 Protective Control requirements per UL 60730-2-6; or

b) In Canada:

1) Type 2 Protective Control requirements per CSA E60730-2-6; or

2) The limit control requirements of CSA C22.2 No. 24.

The pressure limit control shall have a maximum drift of 5 % and an initial deviation

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 conform to the requirements for:

a) In the United States:

1) Software Class 2 in accordance with UL 1998 and UL 353; or

2) Software Class C in UL 60730-1; or

b) In Canada:

1) Software Class C in accordance with CSA C22.2 No. 0.8 and CSA C22.2 No. 24; or

2) Software Class C in accordance with CSA E60730-1 and CSA E60730-2-6.

The pressure limit control shall have a maximum drift of 5 % and an initial deviation value not exceeding 5 %.

31.4 Temperature limit (protective) controls

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 (high) 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:

a) In the United States:

1) UL 353; or

2) The requirements for protective electrical controls in UL 60730-2-9; or

b) In Canada:

1) CSA E60730-2-9; or

2) CSA C22.2 No. 24.

The limit control shall have a maximum drift of 5 % 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 shall conform to the requirements of:

a) In the United States,

1) UL 353; or

2) Type 2 Protective Control requirements per UL 60730-2-9; or

b) In Canada,

1) The limit control requirements of CSA C22.2 No. 24; or

2) Type 2 Protective Control requirements per CSA E60730-2-9.

An electronic limit control shall have a maximum drift of 5 % 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 31.4 shall conform to the requirements for:

a) In the United States,

1) Software Class 2 in accordance with UL 1998, and UL 353; or

2) Software Class C in accordance with UL 60730-1 and UL 60730-2-9; or

b) In Canada,

1) Software Class C in accordance with CSA C22.2 No. 0.8 and CSA C22.2 No. 24; or

2) CSA E60730-1, and CSA E60730-2-9.

32 Installation of External Controls and Fittings

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 (25 mm) 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 (19 mm) 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 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 (6.4 mm) 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 The steam pressure connections to the steam pressure limit control shall be not smaller than:

a) 1/4-inch (6.4 mm) NPS, when the pipe is of nonferrous material;

b) 1/2-inch (12.7 mm) NPS for ferrous materials up to 5 ft (1.5 m) in length; or

c) 1-inch (25 mm) NPS for ferrous materials over 5 ft (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 boiler assembly 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 boiler assembly equipped with an atmospheric or natural-draft burner, except a boiler assembly 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:

a) In the United States, CSA/AM ANSI Z21.12; or

b) In Canada, CAN1-6.2.

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 s.

33.8 An adjustable flue damper shall not be used in connection with a boiler assembly 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 manufacturer's 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 in (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 intended to be piped/vented collectively, 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 % of the areas of all the additional vent lines.

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

Table 34.1
Vent Line Sizing

Fuel line size, nominal pipe size in (mm)	Vent line size, nominal pipe size in (mm)
Up to 1-1/2 (38.1)	3/4 (19)
2 (50.8)	1 (25.4)
2-1/2 (63.5)	1-1/4 (31.8)
3 (76.2)	1-1/4 (31.8)
4 (101.6)	2 (50.8)
5 (127)	2 (50.8)
6 (152.4)	2-1/2 (63.5)
8 (203.2)	3 (76.2)

35 Bases

35.1 Refer to Annex A, Furnaces and Air Heaters (United States only).

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 boiler assembly 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, as defined in ASTM A29/A29M, having a minimum thickness of 0.053 in (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 (firebox) 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 boiler assembly is tested as specified in the Temperature Tests, Section 48.

38 Materials in Air Handling Compartments

38.1 Refer to Annex A, Furnaces and Air Heaters (United States only)

39 Casings

39.1 Refer to Annex A, Furnaces and Air Heaters (United States only)

40 Fuel Lines and Components

40.1 Refer to Annex A, Furnaces and Air Heaters (United States only)

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 boiler assembly, shall be accessible for inspection or replacement without the use of special tools and without dismantling the boiler assembly.

PERFORMANCE

43 General

43.1 The performance of the boiler assembly shall meet the applicable requirements when tested as described herein when evaluated with each fuel (see 1.4) that the boiler assembly is rated for. A boiler assembly 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 boiler assembly 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.

Exception: When a boiler assembly is rated for hydrogen-natural gas blends, it shall be initially test fired with natural gas in accordance with this standard. Subsequently, the boiler assembly shall be test fired with the intended hydrogen-natural gas blend to the Burner Assembly Tests, as applicable to the boiler assembly design, without any modifications to the burner. See Section 46.

43.2 Boiler assemblies 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 for the applicable boiler assemblies, unless the manufacturer requests testing at reduced clearances. At the option of the manufacturer, a boiler assembly operating at not more than 1000 °F (537 °C) flue gas temperature may be evaluated and tested as suitable for installation on combustible floors and when so tested at clearances not less than indicated for Form II and Form III in Table 43.1 for the applicable boiler assemblies.

Table 43.1
Standard Clearances

Type of appliance	Minimum clearances, in (cm)				
	Above	Front	Vent connector	Sides and rear	Below
Form XII[1]	6 (15)	18 (46)	6 (15)	6 (15)	–
Form II[2]	6 (15)	24 (61)	18 (46)	6 (15)	–
Form III[3]	18 (46)	48 (122)	18 (46)	18 (46)	–
Form IV[4]	48 (122)	96 (244)	36 (91)	36 (91)	–

NOTES

1 – Hot water boilers and low pressure steam boilers, larger than 100 ft^3 (2.8 m^3) in size excluding burner – equipped with draft hood.

2 – Hot water boilers and low pressure steam boilers, not larger than 100 ft^3 (2.8 m^3 in size excluding burner – not equipped with draft hood.

3 – Low Heat Industrial Device, for the purposes of this standard, 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.

4 – Steam boilers, operating in excess of 1000 °F (537 °C) flue gas temperature.

43.3 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 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:

a) In the United States, UL 1738; or

b) In Canada, ULC-S636.

44 Test Installations

44.1 Floor-mounted boiler assemblies

44.1.1 Boiler assemblies in the as received condition are to be placed in a partial enclosure formed by two walls of 1 in (25.4 mm) nominal thickness wood boards or plywood 3/4 in (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 ft (0.9 m) beyond the end and side of the boiler assembly and at least 1 ft (0.3 m) above the top of the boiler assembly. 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 boiler assembly; except where the flue gases are vented horizontally from the back of the boiler assembly, in which case the wall of the enclosure is to be the specified distance from the nearest point of any draft hood. Power (Steam) boilers need not be placed in the partial enclosure unless they are to be tested at clearances less than those designated as Form IV in Table 43.1.

44.1.2 As an alternative to the above, when tested at clearances designated as Standard in Table 43.1, 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 boiler assembly, except within 229 mm (9 in) 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 boiler assembly is designed for direct installation on combustible flooring, the floor beneath the boiler assembly is to be 1 in (25.4 mm) white-pine flooring superimposed by one layer of building paper; and then by 3/4 in (19.1 mm) plywood, unpainted or finished with clear sealer.

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

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 of the boiler assembly at high fire is to be equivalent, ±2 % to the rated input of the equipment being fired.

45.1.4 The firing rate of the boiler assembly at intermediate and minimum fires is to be equivalent, ±2 %, to the manufacturer's recommendation.

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 (0.20 mm^2).

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 in (152 mm) 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 boiler assembly 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.

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

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

45.2.9 Boiler assemblies 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 ft (1.52 m) nor more than 5 ft 6 in (1.68 m) above the highest point of the draft hood relief opening. Boiler assemblies having a horizontally discharging draft hood outlet are to have attached an uninsulated black-iron 1.57 rad (90°) 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 ft (1.52 m) nor more than 5 ft 6 in (1.68 m) above the highest point of the draft hood relief opening.

45.2.10 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 ft 6 in (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 (0.20 mm^2) placed successively at the specified locations. The flue-gas temperature is to be the arithmetic average of these nine individual readings.

45.2.11 Boiler assemblies not equipped with draft hoods are to have attached a 3 ft (0.91 m) length of uninsulated black-iron pipe, the same size as the vent collar or induced-draft fan outlet of the boiler assembly. The pipe may be attached directly to a vertical or horizontal flue-gas outlet.

45.2.12 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 ft (0.3 m) of the normal flue-gas outlet of the boiler assembly. 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 (0.20 mm^2) successively placed at the specific positions. The flue-gas temperature is to be the average of these nine individual readings.

45.2.13 Any flue-gas sample is to be taken in a plane in the vent pipe not more than 3 in (76.2 mm) from the plane of temperature measurement specified above unless the boiler assembly 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 46.2.19.

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

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

46 Burner Assembly Tests

46.1 Burner fuel train leak test

46.1.1 When a boiler assembly is rated for hydrogen-natural gas blends and prior to conducting the burner assembly tests within this section, a leak test shall be performed on the manufactured supplied piping and the burner fuel train per 46.1.2 and 46.1.3.

46.1.2 The test pressure shall be 1.5 times the maximum rated inlet/supply pressure to the boiler assembly or 5 psi, whichever value is greater.

46.1.3 The test gas shall be representative of the highest volume fraction of hydrogen in the natural gas blend as specified by the boiler assembly manufacturer. The remaining composition of test gas may be an inert gas such as nitrogen. For the purpose of this test, an equivalent volume fraction of helium may be substituted for the volume fraction of hydrogen.

46.1.4 The fuel train shall be disconnected from the burner and outlet piping shall be capped. The complete supply piping and fuel train shall be pressurized to the applicable test pressure and there shall be no leakage or visible permanent distortion for the specified duration of the test.

46.1.5 In accordance with 46.1.4, the use of gas detection equipment having an accuracy of 2000 ppm (0.2 %) hydrogen or helium, as applicable, shall reveal no leaks at joints and seams once the supply piping and burner fuel train have been pressurized to the applicable test pressure.

Exception: The use of pressure gauges, having a minimum accuracy of 5 % of measured value, with a resolution of no greater than 0.1 psi can be utilized. The pressure gauges must maintain the applicable test pressure for a minimum duration of 30 minutes.

46.1.6 At the conclusion of the leak test, the fuel train shall be reconnected to the burner and compliance with 45.1 shall be verified.

46.2 Combustion test

46.2.1 Combustion shall be complete in the space provided by the boiler assembly or, if a burner assembly in the space recommended by the manufacturer, and no carbon monoxide in concentration in excess of 0.04 % (400 ppm) shall be present in air free samples of the flue gases taken over the full operating range of the burner assembly.

46.2.2 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.

46.2.3 A boiler assembly 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 % of the heat input to the boiler assembly.

46.2.4 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 46.2.5) 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 boiler assembly	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)

46.2.5 With respect to 46.2.4, 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 in (152 mm) down-stream from the connection of the vent pipe to the flue gas outlet of the appliance. The vent pipe is to be connected in accordance with 45.2.11. The pressure of the flue gases shall be negative at all permitted inputs of the appliance.

46.2.6 The performance of a burner assembly or boiler assembly during the Combustion test, 46.2, 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 boiler assembly being fired and without damage to parts of the boiler assembly.

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 0.04 % (400 ppm) 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 boiler assembly 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.

46.2.7 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 boiler assembly may be tested as applied to that boiler assembly or a representative of the boiler assembly for which the burner assembly is designed.

46.2.8 All heating surfaces in contact with combustion products and the vent pipe of the boiler assembly to be fired for the test are to be thoroughly cleaned before the combustion test is begun.

46.2.9 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.

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

46.2.11 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.

46.2.12 A boiler assembly 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 (83 kPa) in a low pressure steam boiler.

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

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

46.2.13 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.

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

46.2.15 A modulating burner assembly is to be fired in successive cycles, each cycle consisting of 10 min on high fire, 10 min on intermediate fire, 10 min on minimum fire, and 10 min off for intermittent firing tests.

46.2.16 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.

46.2.17 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.

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

46.2.19 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 % of the gross heating value of the gas being fired. The maximum flue-gas temperature is not to exceed the limits specified in 46.2.4.

46.3 Combustion air failure test

46.3.1 A boiler assembly equipped with a mechanical-draft burner assembly shall not operate improperly during interruption and upon restoration of the combustion air supply, as determined by test in accordance with 46.3.2 and 46.3.3.

46.3.2 The initial conditions for the test to determine conformance to the requirement are to be as specified for Combustion test, 46.2. 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 46.3.3.

46.3.3 The fuel shall be shut off due to the inherent design of the burner assembly or by action of a control before any conditions develop that may cause a risk of fire or explosion. For an automatically lighted burner assembly whose maximum rated input does not exceed 2,500,000 Btu/h (732 kW) the light off may be accomplished automatically upon restoration of the air supply after completion of the purge in accordance with 46.3.4 and 46.3.5. For a manually lighted burner and for an automatically lighted burner whose maximum rated input is in excess of 2,500,000 Btu/h (732 kW) a manual reset shall be necessary to restart the burner after restoration of the air supply.

46.3.4 A forced or induced draft burner assembly shall provide preignition purging for the combustion chamber, heat exchanger, and flue passages of the boiler assembly to which the burner assembly is to be applied, immediately before ignition of an interrupted pilot 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 combustion air proven to be at a level equivalent for combustion at 60 % of the rated high fire of the boiler assembly. See Table 46.2.

Exception: For a burner assembly having an input not exceeding 2,500,000 Btu/h (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 s.

46.3.5 Purge periods at air flow rates not less than those indicated in (a) and (b) may be considered as providing purging in accordance with 46.3.4:

a) A purge period of 30 s, 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; or

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

Table 46.2
Required Programming and Timings Based on Maximum Fuel Input Rating

Operation	Maximum firing rate per combustion chamber		
	Above 400,000 Btu/h (117,228 W) to 2,500,000 Btu/h (732,678 W)[d]	Above 2,500,000 Btu/h (732,678 W) to 5,000,000 Btu/h (1,465,356 W)	Above 5,000,000 Btu/h (1,465,358 W) to 12,500,000 Btu/h (3,663,389 W)[f]
Prepurge period	Required, see 46.3.4.	Required, see 46.3.4.	Required, see 46.3.4.
Pilot ignition type and flame establishing period	Intermittent or interrupted, 15 s maximum[c]	Interrupted, 10 s maximum	Interrupted, 10 s maximum
Main burner flame establishing period			
Ignited by pilot	15 s maximum	10 s maximum	10 s maximum
Direct ignition	4 s maximum	4 s maximum[a]	4 s maximum[a]
Flame failure reaction time[b]	4 s maximum	4 s maximum	4 s maximum
Safety shutoff valve closing time after de-energization	5 s maximum	1 s maximum	1 s 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/h (732,678 W). See Ignition Systems – General section in UL 295, or CSA CGA 3.4.

[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 s if the pilot input exceeds 400,000 117 Kw (Btu/h).

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

[e] See Gas Pressure Controls section in UL 295, or CSA CGA 3.4.

[f] For packaged boilers having a maximum firing rate per combustion chamber in excess of 12,500,000 Btu/h (3,663,388 W), the requirements for operation indicated are applicable.

46.4 Undervoltage test

46.4.1 A boiler assembly shall operate in accordance with these requirements when tested at a voltage of 85 % of rated voltage for alternating current or 80 % of rated voltage for direct current equipment.

46.4.2 The initial conditions for test are to be as specified for Combustion test, 46.2. 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.

46.4.3 The performance of the burner assembly or boiler assembly 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 boiler assembly 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 0.04 % (400 ppm); and

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

46.5 Power interruption test

46.5.1 A boiler assembly equipped with 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.

46.5.2 The initial conditions for test to determine conformance to the requirement are to be as specified for Combustion test, 46.2. 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.

46.5.3 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.

46.5.4 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, 46.6, Ignition, gas-electric high tension test, 46.7, and Ignition, gas-electric hot-wire – Undervoltage test, 46.8.

46.6 Pilot supervision test

46.6.1 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.

46.6.2 The test to determine conformance is to be made in conjunction with Combustion test, 46.2. 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.

46.6.3 The combustion detector of a primary safety control which is capable of detecting the presence of an 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 % of the signal strength required to hold in the flame relay at 110 % of rated voltage.

46.6.4 The test to determine conformance is to be made in conjunction with Combustion test, 46.2. 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 assembly or device capable of reflecting the spark, will not result in a signal strength in excess of that specified. Each trial shall extend for the designed pilot flame establishing period.

46.7 Ignition, gas-electric high tension test

46.7.1 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 46.7.3 – 46.7.5. The pilot, in turn, shall effect ignition of the main burner fuel as introduced into the ignition zone.

46.7.2 An electric high tension ignition system arranged for ignition of main burner gas directly shall effect the ignition when tested in accordance with 46.7.3 – 46.7.5. See also 46.12.1 – 46.12.3.

46.7.3 The burner assembly or device, arranged and installed as specified for Combustion test, 46.2 is to be tested for conformance 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 in (1.6 mm).

46.7.4 The voltage of the power supply to the ignition system is to be regulated to 70 % of rated voltage, and the voltage of the power supply to the safety control circuit is to be regulated to 85 % of rated voltage for alternating current equipment and 80 % of rated voltage for direct current equipment.

46.7.5 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 boiler assembly being fired.

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

46.8.1 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 % 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 46.8.2. This requirement does not apply to a burner assembly or device equipped with a positive means to reduce the risk of the equipment attempting ignition at voltages less than 85 % of rated voltage for alternating current equipment or 80 % of rated voltage for direct current equipment. See also 46.8.4.

46.8.2 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.

46.8.3 The burner assembly or device, arranged and installed as specified for Combustion test, 46.2, is to be tested for conformance to 46.8.1 after it has been subjected to the combustion test.

46.8.4 The voltage of the power supply to the burner assembly or device is to be regulated to a value not less than specified in 46.8.1. 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 boiler assembly being fired.

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

46.9.1 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 46.9.2.

46.9.2 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 % 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 the boiler assembly. 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 the minimum allowed by the system. There is to be no electrical or mechanical failure of the igniters during the test.

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

46.10.1 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 min; or

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.

46.10.2 Test to determine conformance with 46.10.1 is to be made with the burner installed as specified for Combustion test, 46.2, but with the fuel supply to the burner shut off during attempted trials for ignition.

46.11 Ignition, multiple burner test

46.11.1 A boiler assembly employing multiple burners which are automatically lighted shall be designed so that, when tested in accordance with 46.11.2 and 46.11.3, 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.

46.11.2 The initial conditions for test to determine conformance to 46.11.1 are to be as specified for Combustion test, 46.2. 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 boiler assembly being fired, and stable combustion is to be maintained.

46.11.3 The initial conditions for this test are to be as specified for Combustion test, 46.2. 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 boiler assembly being fired, and stable combustion is to be obtained.

46.11.4 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.

46.12 Delayed ignition test

46.12.1 For a boiler assembly 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/h (117 kW), 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 46.12.2 and 46.12.3.

46.12.2 The boiler assembly shall be arranged as specified for Combustion test, 46.2, 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.

46.12.3 Ignition of the main burner or the pilot, whichever is applicable, is to be delayed initially for 1 s from the time the gas valve is energized. The test is then to be repeated with the delay period successively increased by 1 s, 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 46.12.1 for each of the trials.

47 Operation Tests

47.1 Boiler assembly limit control cutout test

47.1.1 When tested as described below, a limit control shall function to reduce the risk of a boiler assembly delivering water or steam at a temperature or pressure in excess of that specified by these requirements.

47.1.2 The limit control is to be adjusted, as applicable, per the setting requirements of 31.3.2, 31.3.3, or 31.4.1. The boiler assembly is to be placed in operation. An auxiliary limit control, if adjustable, is to be set to the minimum allowable setting. A modulating type control provided to regulate the fuel input between high and low fire values shall be bypassed to permit the boiler assembly to operate on high fire. The ON-OFF type operating control, set to shut off the burner at a setting below the set point of the limit control(s), 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 45.2.14. 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.

48 Temperature Tests

48.1 General

48.1.1 When a boiler assembly is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to 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.

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, 0.2 – 0.5 percent nickel or copper	1230	(683)	1230	(683)
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)

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)
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1230	(683)	1230	(683)
Types 501, 502 iron-chromium steels	1230	(683)	1230	(683)
Type 430 iron-chromium steel	1430	(794)	1430	(794)
Type 442 iron-chromium steel	1560	(867)	1560	(867)
Type 446 iron-chromium steel	1560	(867)	1560	(867)
Type 309 iron-chromium-nickel steel	1730	(961)	1730	(961)
Heating surfaces:				
Aluminum coated steel	1030	(572)	1130	(648)
Ceramic coated steel (A19 or equivalent)	1030	(572)	1130	(648)
Low carbon steel	830	(461)	930	(517)
Gray cast iron	830	(461)	930	(517)
Chrome alloy cast iron, 0.5 – 1.0 percent chrome, 0.2 – 0.5 percent nickel or copper	1010	(561)	1110	(617)
Type 410 iron-chromium steel	1080	(600)	1180	(656)
Type 430 iron-chromium steel	1130	(648)	1330	(738)
Type 442 iron-chromium steel	1560	(867)	1660	(922)
Type 446 iron-chromium steel	1560	(867)	1660	(922)
Type 321 iron-chromium-nickel steel	1340	(744)	1530	(850)
Type 347 iron-chromium-nickel steel	1375	(764)	1530	(850)
Type 316 iron-chromium-nickel steel	1440	(800)	1580	(878)
Type 309 iron-chromium-nickel steel	1345	(747)	1545	(858)
Aluminum coated steel liners and radiation shields[b]	830	(461)	830	(461)
Galvanized steel[c]	480	(267)	630	(350)
Points on or within a terminal box or compartment, unless marked in accordance with 66.1(h)	63	(35)	108	(60)
Wire, coded	25 °C (45 °F) less than temperature rating in NFPA 70		Temperature rating in 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				

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)
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 –				
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)

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)
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, 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 boiler assembly is to be operated under the conditions as specified for Combustion test, 46.2. 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 of Table 48.1.

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 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 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 31.2.5. The burner shutdown by the control that causes safety shutdown shall occur before the water level falls below the lowest level permitted by 31.2.2 – 31.2.3.

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 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 Extra-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:

a) In the United States, NFPA 70; or

b) In Canada, CSA C22.1,

for the marked horsepower (W) 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 V	208 V	230 – 240 V	277 V	
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 V	220 – 240 V	440 – 480 V	550 – 600 V	
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 boiler assembly 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 % 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 A, is to be employed for the test. The maximum fuse size marked on the boiler assembly, see 66.6, 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 boiler assembly 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 boiler assembly 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 13.18(e) and 13.19.

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

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 boiler assembly 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 determined to meet the performance requirements of this standard. None of the conductors or lead terminations shall be damaged as a result of this test.

51 Overload Test, Hazardous-Voltage Transformers

51.1 A Hazardous-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 Hazardous-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 221 °F (105 °C) for Class 105 insulation, 266 °F (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 9 °F (5 °C).

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 77 °F (25 °C). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 18 °F (10 °C) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

52 Burnout Test, Hazardous-Voltage Transformers

52.1 A Hazardous-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 Hazardous-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 77 °F (25 °C) and operation is to be continued until:

a) Burnout occurs; or

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

The test circuit is to be protected by fuses rated 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 min of operation, with no further readjustment during the remainder of the test:

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

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

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

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 boiler assembly shall withstand, without breakdown for 1 min, the application of a 60 Hz potential between Hazardous-Voltage live parts and dead metal parts, and between live parts of Hazardous-Voltage and Extra-Low-Voltage circuits. The test potential shall be:

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

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

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 V, in which case the test potential for the parts affected is to be 1000 V 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 An Extra-Low-Voltage circuit shall be capable of withstanding, for 1 min without breakdown, a 60 Hz potential of 500 V applied between Extra-Low-Voltage live parts of opposite polarity and between Extra-Low-Voltage live parts and dead metal parts.

53.5 The Dielectric Voltage-Withstand Test between Extra-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 described in 13.6.

53.6 A 500 VA or larger transformer, the output voltage of which is essentially sinusoidal 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 min. 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 min, without breakdown, the application of a 60 Hz potential of:

a) 150 % of the maximum voltage to ground between bare current-carrying parts and non-current-carrying parts; and

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

53.8 The tests to determine conformance are 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 min, 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 is to be conducted immediately after the insulator has been conditioned for 24 h in air having a relative humidity of 85 ±5 % at a temperature of 90 ±3 °F (32 ±2 °C).

54 Draft Hood Equipped Boiler Assemblies

54.1 Blocked outlet test

54.1.1 Boiler assemblies for outdoor installation with the venting system provided as a part of the boiler assembly are exempt from the following requirements. See 33.5.

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 0.04 % (400 ppm) when the boiler assembly is tested in an atmosphere having a normal oxygen supply.

54.1.3 The boiler assembly is to be operated for at least 15 min 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 manufacturer's 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 (1.3 mm [0 to 12 Pa]) 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 boiler assembly, nor produce a concentration of carbon monoxide in an air free sample of the flue gases in excess of 0.04 % (400 ppm) when the boiler assembly is tested in an atmosphere having a normal oxygen supply.

54.2.2 The boiler assembly is to be operated for at least 15 min 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 (0.13 mm [1.24 Pa]) 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 (1.52 and 1.78 mm [15 and 17 Pa]) 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 (mm) of water column.

54.2.6 The boiler assembly is to be operated for at least 15 min 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 (0.13 mm [1.24 Pa]) 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 (1.52 and 1.79 mm [15 and 17 Pa]) 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:

a) 1 + 2·(hp + 5·hv), where "hp" is the pressure head and "hv" is the velocity head, as water column in; or

b) 1 + 0.008·(hp + 5·hv), where "hp" is the pressure head and "hv" is the velocity head, as Pascals.

54.3 Spillage test

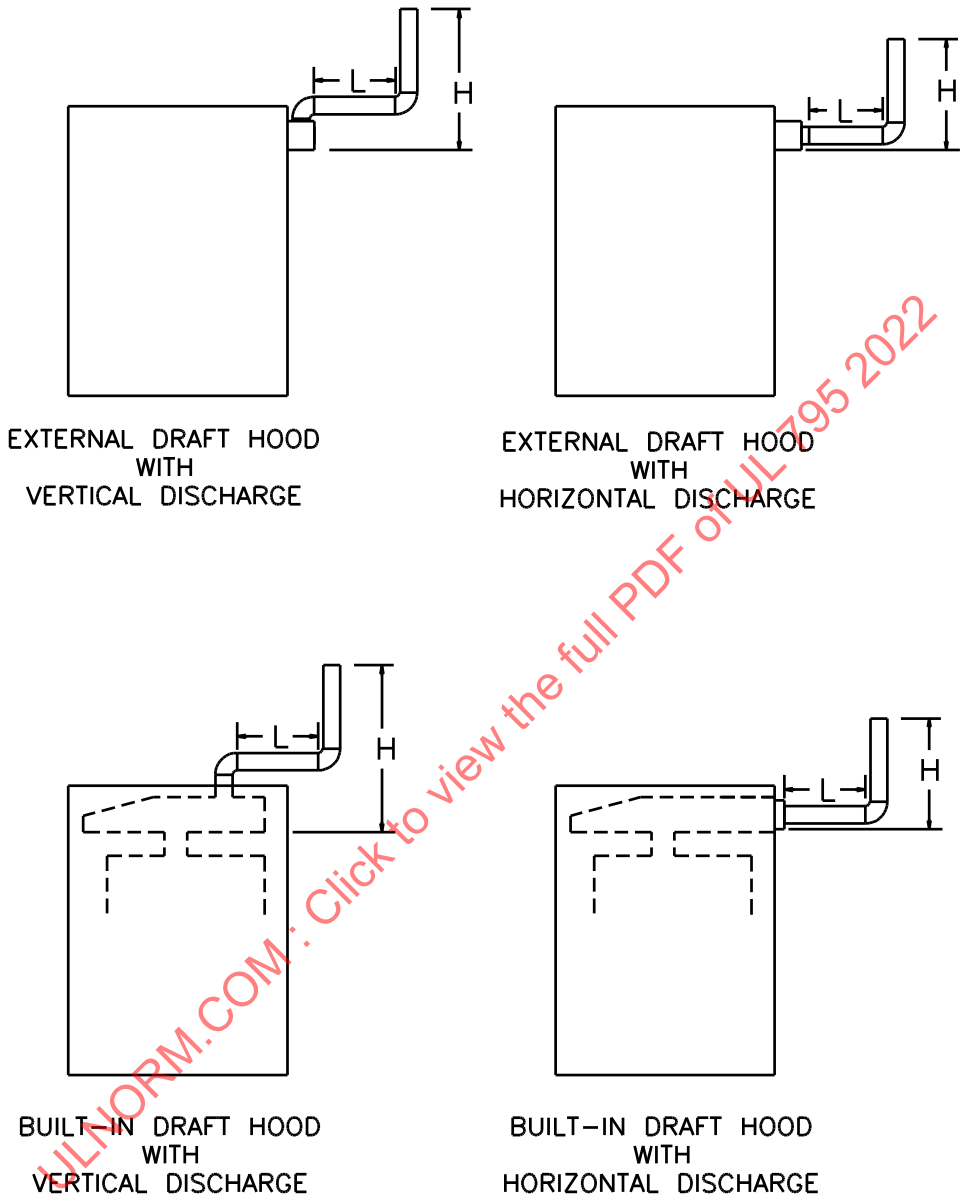
54.3.1 Flue gases shall not issue from the relief opening(s) of a draft hood or a draft diverting device when tested in accordance with the test method specified below.

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 1.57 rad (90°), 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.

Figure 54.1

Arrangement of Vent Pipe for Draft Hood Pillage Test



Notes:

L – 2 ft (0.6 m) for vent pipe sizes not exceeding 12 in (305 mm) and equivalent to 2 vent pipe diameters for vent pipe sizes larger than 12 in (305 mm).

H – 1.5 m (5 ft) for vent pipe sizes not exceeding 12 in (305 mm) equivalent to not less than 5 and not more than 5-1/2 vent pipe diameters for vent pipe sizes larger than 12 in (305 mm). It is to be measured from the highest point of the draft hood relief opening or openings to the top of the vertical vent pipe.

For other details see 54.3.1 – 54.3.5.

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

54.3.5 The horizontal run of vent pipe is to be pitched upward 1/4 in/ft (21 mm/m).

54.3.6 The boiler assembly is to be operated for at least 15 min with gas at normal test pressure. A fuming or smoking material, such as titanium tetrachloride, is to be introduced ahead of the draft hood so as to form a dense smoke. A beam of light is to be directed across the relief opening(s). This requirement is to be deemed met when no smoke can be observed escaping from the relief opening(s).

54.4 Condensing-type boiler assemblies

54.4.1 A boiler assembly equipped with a condensate disposal system(s) shall be subjected to tests to determine a blocked condensate drain line(s) condition results in satisfactory operation or burner shutdown and safety shutdown in accordance with 54.4.2 – 54.4.4.

54.4.2 The condensate disposal system(s) is to be blocked at the narrowest dimension of the system. The test is to be started with the boiler assembly at any convenient input and the condensate disposal system(s) filled with the maximum level of water permissible to continue operation of the boiler assembly. The burner shall ignite in a normal manner.

54.4.3 From the start of the boiler assembly and throughout the duration of the test, the concentration of carbon monoxide in an air free sample of the flue gases shall not exceed 0.04 % (400 ppm) when the boiler assembly is tested in an atmosphere having a normal oxygen supply.

54.4.4 The boiler assembly shall be operated for sufficient duration to determine compliance with 54.4.1.

55 Blocked Outlet of Forced or Induced Draft Equipped Condensing Appliances Test

55.1 Boiler assemblies for outdoor installation, with the venting system provided as a part of the boiler assembly are exempt from the following requirements. See 33.5.

55.2 With the outlet of the boiler assembly with a forced or induced draft system blocked, the concentration of carbon monoxide in an air free sample of the flue gases shall not exceed 0.04 % (400 ppm) when the boiler assembly is tested in an atmosphere having a normal oxygen supply.

55.3 The boiler assembly is to be operated for at least 15 min with gas at normal test pressure. The outlet of the boiler assembly with a forced or induced draft system is then to be blocked and a sample of the flue gases is to be secured and analyzed.

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

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

56 Direct Vent Tests

56.1 Direct vent system leakage test

56.1.1 In direct vent systems of appliances having a separate air intake section and a separate combustion chamber-vent section:

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4 % of the products of combustion; and

b) The leakage from the air intake section of the system shall not exceed 8 % of the products of combustion. See 56.1.2 – 56.1.5.

56.1.2 The vent and air intake terminations are to be removed, and the entrance of the air intake section sealed at the point it enters the combustion air intake housing integral to the appliance. The entire system, including the combustion air and flue gas connections between the appliance and the vent and air intake terminations, is to be installed and sealed in accordance with the manufacturer's instructions. Both the flue outlet and the air inlet is to then be sealed at the point of connection to the vent and air intake terminations. The sealing means is to include fittings for supplying air to both the air intake and combustion chamber-vent sections of the system and provisions for measuring the internal pressure in each section of the system.

56.1.3 The internal pressure in the system is to be measured by a water-filled manometer which may be read directly to 0.01 inch (0.25 mm [25 Pa]) water column or equivalent means.

56.1.4 Clean air is to be permitted to flow through a metering device and into the section of the direct vent system being pressurized through the air supply fitting. The air supply fitting to the section of the system not being pressurized is to be open. The internal air pressure in the section of the system being pressurized is to be adjusted to 0.01 inch (0.25 mm [25 Pa]) water column above the normal operating system pressure for forced draft systems operating at positive combustion chamber pressure. The leakage rate is to be noted in ft^3/h (m^3/h) for both the air intake and combustion chamber-vent sections of the direct vent system.

56.1.5 The leakage rate is to be determined by the following equations:

$$L_c = 0.04 \times V \times I$$

$$L_a = 0.08 \times V \times I$$

where:

L_c = Allowable leakage rate from combustion chamber-vent section of direct vent system, ft^3/h (m^3/h).

L_a = Allowable leakage rate from air intake section of direct vent system, ft^3/h (m^3/h).

V = 15 ft^3 (1.45 m^3) of flue products based on the formation of approximately 10 ft^3 (0.967 m^3) of flue products plus 5 ft^3 (0.483 m^3) of excess air, when approximately 1,000 Btu (3.6 MJ) of gaseous fuel is burned.

I = Gas input rating, in thousands of Btu/h (kW).

56.1.6 In a direct vent system of an appliance having all or part of the vent portion of the combustion chamber-vent section enclosed within the air intake section:

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4 % of the products of combustion, as calculated in 56.1.5; and

b) The leakage from the total system shall not exceed 8 % of the products of combustion plus the leakage, in percent, determined for the combustion chamber-vent section. See 56.1.7 – 56.1.10.

56.1.7 In a direct vent system in an appliance having all or part of the vent portion of the combustion chamber-vent section enclosed within the air intake section, the combustion chamber-vent section of the system shall be considered that portion of the combustion chamber-vent section not contained within the air intake section.

56.1.8 The vent-air intake termination is to be removed, and the entrance of the air intake section sealed at the point it enters the combustion air intake housing integral to the appliance. The entire system, including the combustion air and flue gas connections between the appliance and the vent/air intake termination, is to be installed and sealed in accordance with the manufacturer's instructions. Any vent extension located within the air intake section need not be installed. The direct vent system is then to be sealed at the point of connection to the vent/air intake termination. The sealing means is to include fittings for supplying air simultaneously to the air intake and combustion chamber-vent sections of the system and provisions for measuring the internal pressure.

56.1.9 Using the test apparatus and method of test specified in 56.1.3 and 56.1.4, the total system is to be pressurized and the leakage rate noted in ft^3/h (m^3/h).

56.1.10 The combustion chamber-vent section of the system is then to be sealed, with the appropriate fittings noted above, at the first joint of the vent portion of the combustion chamber-vent section contained within the air intake section downstream of the combustion chamber. Using the test apparatus and method of test specified in 56.1.3 and 56.1.4, the combustion chamber-vent section is to be pressurized and the leakage rate noted in ft^3/h (m^3/h).

56.2 Direct vent wind tests

56.2.1 An appliance designed to vent the flue gases horizontally through an outside wall, or an appliance intended for installation with an air intake termination, shall comply with 56.2.3 – 56.2.11 when the vent (or air) termination is subjected to the effects of specified wind velocities at various angles.

56.2.2 Unless otherwise specified, testing shall be conducted at both the minimum and maximum vent lengths specified by the manufacturer.

56.2.3 A pilot shall be capable of being ignited when the vent (or air) termination is exposed to the effect of a wind having a nominal velocity of 10 mph (4.47 m/s).

56.2.4 The appliance is to be fired at rated input while installed as indicated in Section 44. Deflector walls are to be positioned to prevent the wind from the wind source from affecting that section of the appliance normally located indoors.

56.2.5 A wind produced by a blower having sufficient capacity to develop a 0.04 inch (1.0 mm [10 Pa]) water column static pressure [nominal 10 mph (4.47 m/s) wind velocity] shall be directed against the outside surface of the test structure on which the vent (air) termination is attached. Static pressure shall be measured by means of static pressure taps encompassing the area of the vent (or air) termination. The wind source shall be located so the wind is directed perpendicular to the surface of the wall structure to which the termination is attached.

56.2.6 Additional tests may be conducted with a wind of the same velocity emanating from other directions.

56.2.7 The main burner shall not become extinguished and shall ignite without excessive delay, and the ignition system shall ignite when the vent (or air intake) system is exposed to a wind having a velocity of 40 mph (17.88 m/s).

56.2.8 The test method specified in 56.2.4 shall be applied except the blower shall be capable of producing a static pressure on the surface of the test wall of 0.66 inch water column (164 Pa) [nominal 40 miles per hour (17.88 m/s) wind velocity].

56.2.9 While operating under the above wind conditions, the pilot and main burner shall ignite without excessive delay and shall not become extinguished, and the carbon monoxide in the flue gases shall not exceed the limit specified in 46.2.

56.2.10 The conditions specified in 56.2.7 are to be imposed on the vent termination and sufficient flue gas samples secured and analyzed under the various conditions to determine the carbon dioxide concentration.

56.2.11 The carbon dioxide concentration with the appliance subjected to any of the conditions specified in 56.2.7 shall not be less than 50 % of the carbon dioxide concentration produced by the appliance when operated at normal rated input under a still air condition.

56.3 Direct vent rain test

56.3.1 Water shall not enter the vent (or air intake) system in a quantity sufficient to interfere with normal operation of the appliance and shall not accumulate within the appliance when subjected to the test in this section.

56.3.2 The test shall be conducted at rated input with the minimum vent length specified by the manufacturer. The appliance venting system or air intake shall be installed in accordance with the manufacturer's installation instructions.

56.3.3 The rain test apparatus is to consist of three spray heads mounted as shown in Figure 63.1. Spray heads are to be dimensioned as shown in Figure 63.2. The water pressure is to be maintained at 5 psi (34.5 kPa) at each spray head. The boiler assembly is to be centrally located within the spray pattern under normal conditions most likely to cause entrance of water into the terminal. The distance between the center nozzle and the boiler assembly is to be approximately 3 ft (0.91 m), however, since the overall size of boiler assembly vary, adjustments are to be made in the position of the nozzles to allow the greatest quantity of water to enter the terminal.

56.4 Direct vent load test

56.4.1 The horizontal vent (or air-intake) termination shall be sufficiently rigid in construction and supported so it shall withstand a load of 150 lb (68.0 kg) without extensive damage or alteration of its position with respect to the appliance. Following application of this load, the appliance shall comply with the combustion test specified in 46.2 at rated input.

56.4.2 A vertical suspension load of 150 lb (68.0 kg) shall be evenly distributed without impact over the vent termination. The load shall then be removed and shall not have caused substantial distortion of any part of the vent termination or alteration of its position relative to the appliance so the appliance would not operate satisfactorily.

56.4.3 The appliance shall then be operated at rated input until equilibrium conditions are attained. A sample of the flue gases shall then be secured and analyzed to determine the carbon monoxide in the flue gases does not exceed that indicated in 46.2.

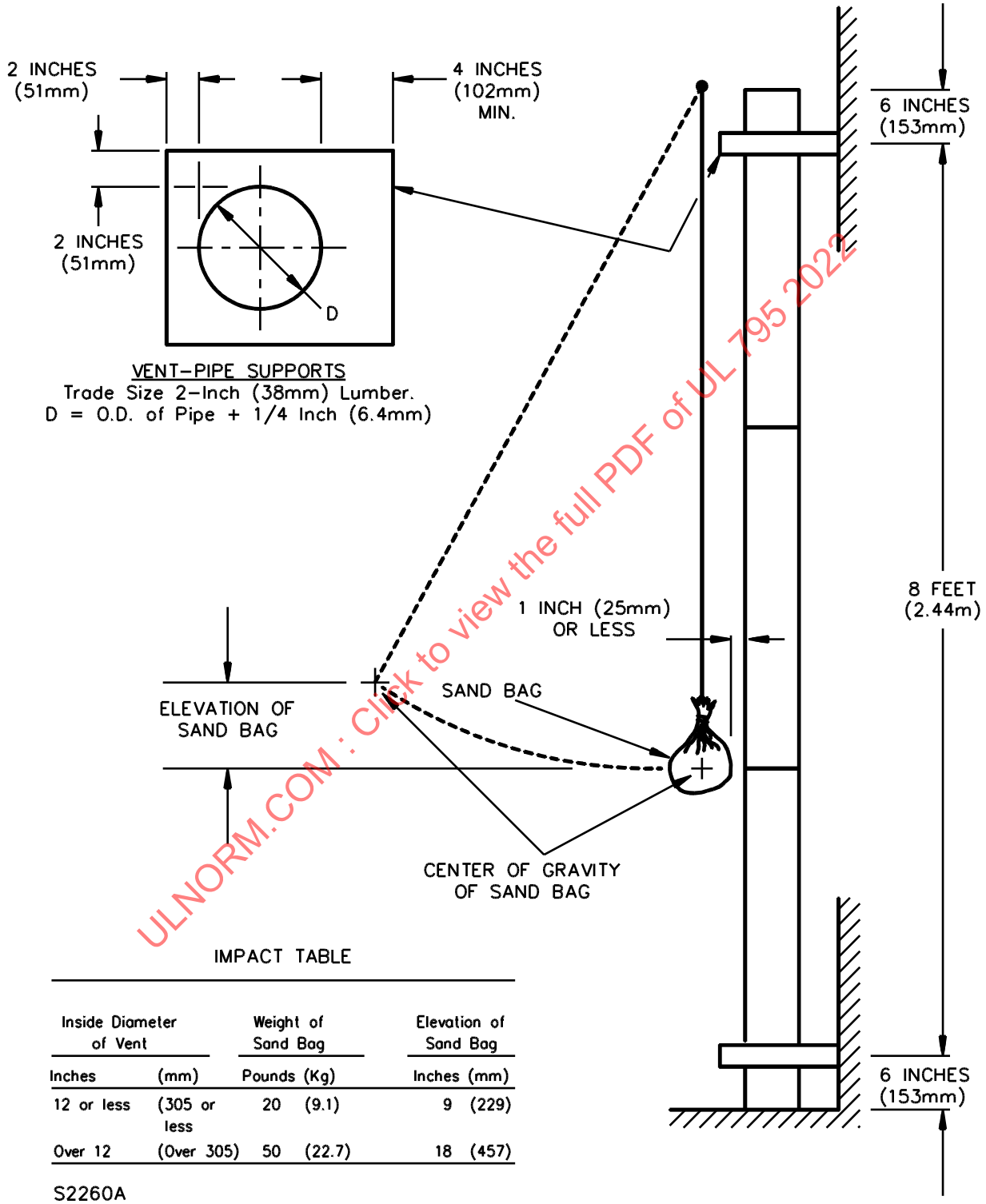
56.5 Direct vent impact test

56.5.1 A vent (or air-intake) termination shall not break, disassemble, or become damaged to the extent that performance would be unacceptable for further use as a result of three impacts of a sand bag as described in 56.5.2 – 56.5.4. Following impact of the vent (or air intake) termination, the appliance shall comply with the combustion test specified in 46.2 at rated input.

56.5.2 The impact shall be produced by a pendulum consisting of a rope suspending a cloth bag filled with sand and having the weight shown in Figure 56.1. The bag is to be formed by tightly drawing up all sides and the corners of a flat section of canvas or other suitable material. A plastic liner may be used to prevent sand loss. The bag is to have an at-rest position with no more than 1 in (25.4 mm) distance between the edge of the bag and the surface of the vent termination. The point of impact is to be on the same horizontal plane as the center of gravity of the bag. The distance of swing is to be that required to raise the center of gravity of the bag to the elevation specified in Figure 56.1 and Figure 56.2 above the center of gravity of the bag at its at-rest position.

Figure 56.1

Vertical Vent Impact Test



IMPACT TABLE

Inside Diameter of Vent		Weight of Sand Bag		Elevation of Sand Bag	
Inches	(mm)	Pounds	(Kg)	Inches	(mm)
12 or less	(305 or less	20	(9.1)	9	(229)
Over 12	(Over 305)	50	(22.7)	18	(457)

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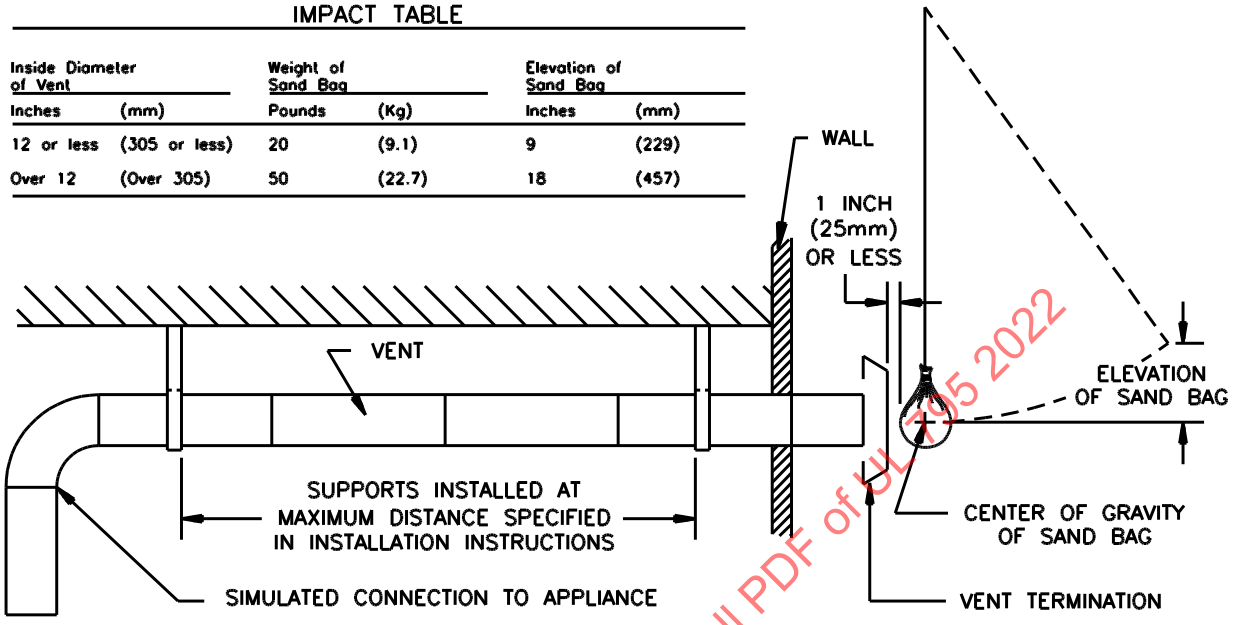
Figure 56.2

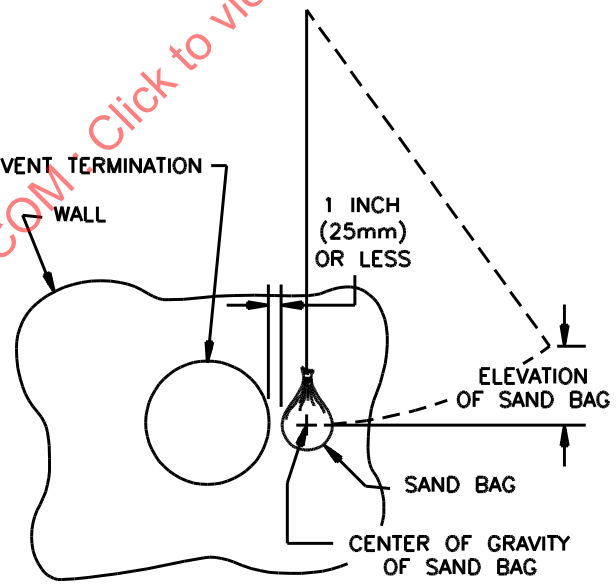
Horizontal Vent Impact Test

IMPACT TABLE

Inside Diameter of Vent		Weight of Sand Bag		Elevation of Sand Bag	
Inches	(mm)	Pounds	(Kg)	Inches	(mm)
12 or less	(305 or less)	20	(9.1)	9	(229)
Over 12	(Over 305)	50	(22.7)	18	(457)



ONE IMPACT PERPENDICULAR TO THE TERMINATION



TWO IMPACTS – EACH PERPENDICULAR TO THE VENT PIPE BUT AT THE VENT TERMINATION & 180° APART FROM EACH OTHER

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56.5.3 The length of the pendulum may vary, depending upon the intended point of impact.

56.5.4 The impacts are to be made successively at the following points:

a) For a horizontal venting system that terminates through a wall:

1) One impact perpendicular to the termination; and

2) Two impacts – each impact perpendicular to the vent pipe but at the vent termination and 3.14 rad (180°) apart from each other.

b) For a vertical venting system:

1) One impact at the level of a joint;

2) One impact at the level halfway above the first joint tested and the next joint; and

3) One impact at the same level as in (1), but rotated around the axis of the venting system by 1.57 rad (90°) from the impact in (1).

56.5.5 Following each impact, the appliance shall be operated at rated input until equilibrium conditions are attained. A sample of the flue gases is to be secured and analyzed as specified in 46.2, and in each case the carbon monoxide in the flue gases shall not exceed that indicated in 46.2.

56.5.6 At the option of the manufacturer, the vent termination may be replaced following each impact and subsequent combustion test.

57 Flame Test

57.1 Refer to Annex A, Furnaces and Air Heaters (United States only)

58 Strain Relief Test

58.1 As specified in 12.10, each lead shall be capable of withstanding a pull of 10 lbf (44.5 N) for 1 min without damage to the assembly.

OUTDOOR-USE EQUIPMENT

59 General

59.1 An outdoor-use boiler assembly shall comply with applicable requirements of the preceding Sections of this Standard and shall, in addition, comply with the following requirements.

59.2 All outside air inlet openings, including draft hood relief openings, on a boiler assembly for outdoor installation shall be such as to restrict the entrance of a 33/64 in (13.1 mm) diameter rod.

59.3 The bottom of a combustion air opening shall be not less than 12 in (30.5 cm) above the bottom of a boiler assembly for outdoor installation.

60 Enclosures

60.1 An enclosure or enclosures shall be so constructed as to reduce the likelihood of the wetting of live parts and shall protect the system against electric shock due to weather exposure.

60.2 To determine compliance with this requirement, a complete assembly, with supply conduit connections and without pipe thread compounds, is to be subjected to the Rain test, 63.2.

60.3 A water absorbing insulating material shall not become wetted by rain when installed as intended, if such wetting will depreciate its durability or insulating value.

60.4 Any panel or cover in the outer enclosure shall require the use of tools to open; unless it can be determined that removal or opening of the panel or cover will not result in a risk of electric shock due to weather exposure or an injury to persons due to moving parts. Hinges and other attachments shall be resistant to corrosion.

60.5 Access doors or panels shall be constructed so that, with the doors or panels in place, no water will accumulate within the enclosure during the conduct of the Rain Test. See 63.2.1.

60.6 Enclosures for electrical components shall have provision for drainage if knockouts or unthreaded openings in the enclosure are employed.

60.7 Cabinets and enclosures shall have a thickness of not less than 0.032 in (0.81 mm) (No. 20 MSG) if uncoated sheet steel, not less than 0.034 in (0.86 mm) (No. 20 GSG) if zinc coated sheet steel and not less than 0.029 in (0.74 mm) (20 AWG) if copper, brass, or aluminum; except as stated in 60.8.

60.8 Enclosures less than No. 20 MSG which correspond with Table 11.1 or Table 11.2 whichever applies, comply with the intent of this requirement if they are protected by an outer cabinet.

60.9 Metal shall not be used in combinations such as to cause galvanic action which will adversely affect cabinets or enclosures.

60.10 Sheet steel cabinets and electrical enclosures exposed to the effects of weathering shall be protected against corrosion by the following means or by other metallic or nonmetallic coatings which have been shown to give equivalent protection.

60.11 If the enclosure is of No. 16 MSG or heavier and it is not the sole enclosure of current-carrying parts, it is to be protected by a coating at least equal to one of the following:

a) Hot dipped mill galvanized sheet steel conforming with the coating designation G60 or A60 in the Weight (Mass) of Coating Requirements table in ASTM A653, with not less than 40 % of the zinc on any side, based on the minimum single spot test requirement in this ASTM Specification. The weight of zinc coating may be determined by any suitable method; however, in case of question the weight of coating shall be established in accordance with ASTM A90/A90M. An A60 (Alloyed) coating shall also comply with 60.14;

b) A zinc coating, other than that provided on hot dipped mill galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.00041 in (0.0104 mm) with a minimum thickness of 0.00034 in (0.0086 mm);

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces. The suitability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.

60.12 If the enclosure is the sole enclosure of current-carrying parts or if it is lighter than No. 16 MSG, it is to be protected by a coating at least equal to one of the following:

a) Hot dipped mill galvanized sheet steel conforming with the coating designation G90 in of the Weight (Mass) of Coating Requirements table in ASTM A653, with not less than 40 % of the zinc on any side, based on the minimum single spot test requirements in this ASTM Specification. The

weight of zinc coating may be determined by any suitable method; however, in case of question the weight of coating shall be established in accordance with ASTM A90/A90M;

b) A zinc coating, other than that provided on hot dipped mill galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.00061 in (0.0155 mm) with a minimum thickness of 0.00054 in (0.0137 mm);

c) A zinc coating conforming with 60.11 (a) or (b) with one coat of outdoor paint on both surfaces as suitable specified in 60.11(c); or

d) A cadmium coating not less than 0.00075 in (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 in (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The paint shall be on both surfaces and as suitable specified in 60.11(c).

60.13 With reference to 60.10, other finishes, including paints, special metallic finishes and combinations of the two comply with this requirement when comparative tests with galvanized sheet steel, without annealing, wiping or other surface treatment, conforming with 60.11(a) or 60.12, as applicable, indicate they provide equivalent protection. Among the factors which are taken into consideration when judging the suitability of such coating systems are exposure to salt spray, moist carbon dioxide-sulphur, dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light and water.

60.14 A hot dipped mill galvanized A60 (alloyed) coating or an annealed zinc coating which is bent or similarly formed after annealing shall be additionally painted in the bent or formed area if the bending or forming process damages the zinc coating, except that such areas on the inside surface of a cabinet or enclosure which water does not enter during the Rain Test need not be painted.

60.15 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall conform with 60.14.

60.16 Nonferrous cabinets and enclosures may be employed without special corrosion protection. The thickness of the material is to be judged on the basis of its strength and rigidity.

60.17 Nonmetallic cabinets and enclosures are judged on the basis of the effect of exposure to ultraviolet light and water.

60.18 Where the thickness of coatings is specified, they shall be established in accordance with ASTM B487, ASTM B499, or ASTM B504, as applicable.

60.19 As an alternative to compliance with 60.2 to 60.18, enclosures shall comply with the requirements of UL 50E/CSA C22.2 No. 94.2/NMX-J-235.

61 Field Wiring Connections

61.1 Openings provided for field wiring connections shall be suitable for connection of conduit. The openings shall be threaded; unless:

a) They are located wholly below the lowest uninsulated live part within the enclosure; or

b) The location prevents drainage into the enclosure.

Threaded holes for conduit shall be reinforced to provide metal at least 1/4 in (6.4 mm) in thickness; and shall be provided with a conduit end stop unless the thread is tapered.

62 Wiring

62.1 The internal wiring shall be so constructed and assembled as to provide protection against a risk of electric shock due to weather exposure.

62.2 The use of moisture resistant wiring material, such as Type RH, RHW, TW, THW, THWN, TFN, or TFFN enclosed in rigid or flexible steel conduit or electrical metallic tubing, or moisture resistant nonmetallic sheathed cable for the wiring between electrical component enclosures complies with the intent of this requirement. Wiring materials of the type indicated in Table 13.1, Group A, installed in either rigid conduit or electrical metallic tubing with raintight fittings or in liquid-tight flexible steel conduit with suitable fittings also comply. The use of cords or wiring material as described in 13.6 is also recognized. Bushings, where used, are to be nonabsorptive.

62.3 The wiring assembly shall be so constructed and located as to exclude water from electrical enclosures.

62.4 All wires and cords shall be routed and supported so that they will not be immersed in water.

63 Outdoor-Use Equipment Tests

63.1 General

63.1.1 Nonabsorptive electrical insulation shall be used in the construction of electrical components. Untreated fiber is an example of a material that should not be used, while vulcanized fiber on electrical components complies with the intent of this requirement if components are not wetted as a result of the Rain Test.

63.2 Rain test

63.2.1 A boiler assembly designed for outdoor installation shall be constructed so that it will function normally with the pilot(s) and main burner(s) in operation when subjected to a rain exposure without creating a risk of electric shock due to the wetting of live parts, current leakage, or insulation breakdown.

63.2.2 The boiler assembly is to be positioned and leveled in accordance with the manufacturer's instructions. The insulation resistance of the boiler assembly is to be measured before the test by a series voltmeter or other suitable method. The insulation resistance is to be not less than 50,000 Ω before the test.

63.2.3 The rain test apparatus is to consist of three spray heads mounted as shown in Figure 63.1. Spray heads are to be dimensioned as shown in Figure 63.2. The water pressure is to be maintained at 5 psi (34.5 kPa) at each spray head. The boiler assembly is to be centrally located within the spray pattern under normal conditions most likely to cause entrance of water into or on the electrical components and vent assembly. The spray is to be directed toward openings in the cabinet, door, and gasketed covers and panels, including the door. The distance between the center nozzle and the boiler assembly is to be approximately 3 ft (0.91 m), however, since the overall size of boiler assemblies vary, it may be necessary to make adjustments in the position of the nozzles to allow the greatest quantity of water to enter openings in the boiler assembly.