UL 726

STANDARD FOR SAFETY

Oil-Fired Boiler Assemblies

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UL Standard for Safety for Oil-Fired Boiler Assemblies, UL 726

Seventh Edition, Dated November 30, 1995

Summary of Topics

This revision to UL 726 dated September 24, 2024 includes the following changes in requirements:

– Safety shut down on pressure limit on low pressure steam boilers: 13.2.2.

– Redundant LWCOs on low pressure steam boilers: 13.4.1, 13.4.2, and 13.4.5.

– Updates to align with ULSE style manual: Section 3A and Section 4.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated June 28, 2024 and August 9, 2024.

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November 30, 1995

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The Department of Defense (DoD) has adopted UL 726 on January 27, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE 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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INTRODUCTION

1 Scope

1.1 These requirements apply to oil-fired boiler assemblies.

1.2 Requirements for the installation and use of oil-burning equipment are included in the Standard of the National Fire Protection Association for the Installation of Oil-Burning Equipment, NFPA 31.

1.3 *Deleted*

2 General

2.1 The term "appliance" refers to any equipment covered by this Standard.

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

3 Glossary

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

3.1.1 AIR-INTAKE TERMINAL – The fitting which is located on the outside of the structure through which the air for combustion is taken from the outside atmosphere. The terminal is intended to be connected to the combustion air intake of the boiler with additional piping.

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

3.3 ANTIFLOODING DEVICE – A primary safety control which causes the fuel flow to be shut off upon a rise in fuel level or upon receiving excess fuel, and which operates before the hazardous discharge of fuel can occur.

3.4 APPLIANCE FLUE – The flue passages within the appliance.

3.5 AUTOMATICALLY LIGHTED APPLIANCE – An appliance in which fuel to the main burner is normally turned on and ignited automatically.

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

3.6A BIODIESEL – Any biodiesel blend stock as defined by Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels ASTM D6751, intended to be utilized as a complete fuel source (B100) or blended with a distillate fuel oil.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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.

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

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

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

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

3.25.1 DIRECT VENT SYSTEM, BOILER – A boiler which is constructed so that all air supplied for combustion, the combustion system of the boiler, and all products of combustion are completely isolated from the atmosphere of the space in which it is installed.

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

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

3.28 ELECTRICAL CIRCUITS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

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

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

2) Is limited to a maximum of 100 volt-amperes.

A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit;

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

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

3.30 FLUE – A general term for the conduit or passageway through which flue gases pass from the combustion chamber to the outside air.

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

3.32 FLUE GASES – Combustion products and excess air.

3.33 FUEL OIL – Any hydrocarbon oil as defined by the Standard Specification for Fuel Oils ASTM D396 any biodiesel as defined by the Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels, ASTM D6751, or any fuel oil/biodiesel blend.

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3.33A FUEL OIL/BIODIESEL BLEND – Blended fuels composed of a No. 2 or lighter fuel oil component and a biodiesel component. The biodiesel component shall meet the Standard Specification for Biodiesel Fuel Blend Stock (B100) for middle Distillate Fuels, ASTM D6751. The numerical value corresponding to the biodiesel component determines the blend rating (such as B20 for 20 % biodiesel, 80 % diesel).

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

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

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

3.37 INDIRECT FIRED APPLIANCE – An appliance designed so that combustion products or flue gases are not mixed in the appliance with the medium to be heated and provided with a flue collar.

3.38 MANUALLY LIGHTED APPLIANCE – An appliance in which fuel to the main burner is turned on only by hand and ignited under supervision.

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

a) Cleaning or replacing nozzles, atomizers, and pilots;

b) Setting ignition electrodes;

c) Cleaning strainers or replacing strainer or filter elements;

d) Resetting safety control; and

e) Replacing igniter cable.

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

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

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

3.43 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.

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

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

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

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

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

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

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

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

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

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

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

3.52.1 VENT-AIR INTAKE TERMINAL – The device used with a direct vent boiler which is located on the outside of the structure through which the air for combustion is taken from the outside atmosphere and from which flue gases are discharged.

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

3.54 VENT TERMINAL – The fitting at the end of the vent pipe that directs the flue gases to the outdoor atmosphere.

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3A Referenced Publications

3A.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.

3A.2 The following publications are referenced in this Standard:

ASME Boiler and Pressure Vessel Code

ASTM A90, *Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A653/A653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM D396, *Standard Specification for Fuel Oils*

ASTM D6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels*

NFPA 31, *Installation of Oil-Burning Equipment*

NFPA 70, *National Electrical Code*

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 248-5, *Low-Voltage Fuses – Part 5: Class G Fuses*

UL 296, *Oil Burners*

UL/ULC 331, *Strainers for Flammable Fluids, Anhydrous Ammonia and Non-potable Water*

UL 343, *Pumps for Oil Burning Appliances*

UL 353, *Limit Controls*

UL 372, *Automatic Electrical Controls for Household and Similar Use – Part 2: Particular Requirements for Burner Ignition Systems and Components*

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 508, *Industrial Control Equipment*

UL 508A, *Industrial Control Panels*

UL 514A, *Metallic Outlet Boxes*

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

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

UL 574, *Electric Oil Heaters*

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

UL 797, *Electrical Metallic Tubing – Steel*

UL 810, *Capacitors*

UL/ULC 842, *Valves for Flammable Fluids*

UL 969, *Marking and Labeling Systems*

UL 1004-1, *Rotating Electrical Machines – General Requirements*

UL 1004-3, *Thermally Protected Motors*

UL 1059, *Terminal Blocks*

UL 1277, *Power and Control Tray Cable*

UL 1569, *Metal Clad Cable*

UL 2111, *Overheating Protection for Motors*

UL 2250, *Instrumentation Tray Cable*

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

UL 4248-9, *Fuseholders – Part 9: Class K*

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 60730-2-15, *Automatic Electrical Controls i– Part i2-15, iParticular 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 60947-4-1, *Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters*

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

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

4 Components

4.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Standard;

b) Be used in accordance with its rating(s) established for the intended conditions of use; and

c) Be used within its established use limitations or conditions of acceptability.

4.2 A component of a product covered by this Standard 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;

b) Is superseded by a requirement in this standard; or

c) Is separately evaluated when forming part of another component, provided the component is used within its established ratings and limitations

4.3 *Deleted*

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

4.5 *Deleted*

4.6 *Deleted*

4.7 *Deleted*

4.8 *Deleted*

CONSTRUCTION

5 Assembly

5.1 A boiler assembly shall be factory-built as a group assembly and shall include all the essential components necessary for its normal function when installed as intended. An oil-fired boiler assembly may be shipped as two or more major subassemblies. The boiler vessel of an oil-fired boiler assembly shall be constructed, equipped, inspected, tested, and marked in accordance with the ASME Boiler and Pressure Vessel Code, Section 1, Power Boilers or Section IV, Heating Boilers, whichever is appropriate. The oil burner of an oil-fired boiler assembly shall comply with the Standard for Oil Burners, UL 296.

5.2 A boiler assembly, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. See 5.3. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the intended installation or operation of the boiler assembly, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other, without need for alteration or

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alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

5.3 To be in accordance with 5.2, major subassemblies of a boiler assembly are deemed to be the burner and the heat exchanger sections of a cast iron sectional boiler including its base, combustion chamber, casing, and safety controls. A wiring harness may be packaged with one of the major subassemblies.

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

5.5 A boiler assembly shall be such that, for any normal installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to prevent unsafe temperatures is not required.

5.6 A boiler assembly shall afford convenient operation by the user of those parts requiring attention or manipulation in normal usage.

5.7 Adjustable or movable parts shall be provided with locking devices to prevent unintentional shifting.

5.8 Screws or bolts used to attach parts which are detached for normal care or servicing of the appliance shall be capable of holding upon the application of the torques indicated in Table 5.1 after removal and replacement.

Table 5.1
Maximum torque requirements for screws

Screw size	(mm)	Torque, pound-inches	(N·m)
No. 8	(4.2)	20	(2.3)
No. 10	(4.8)	25	(2.8)
1/4 inch	(6.4)	100	(11.3)
5/16 inch	(7.9)	200	(22.6)
3/8 inch	(9.5)	350	(44.5)
7/16 inch	(11.1)	550	(62.1)
1/2 inch	(12.7)	800	(90.3)
9/16 inch	(14.3)	1200	(135.5)

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5.9 An external door, providing access into the combustion chamber of a boiler assembly intended for installation with a clearance of less than 24 inches (610 mm) from the face of or 48 inches (1.22 m) above the door, shall be self-closing.

5.10 A burner shall be secured so it will not twist, slide, or drop out of position.

5.11 Fuel oil pumps provided as part of the burner shall comply with the Standard for Pumps for Oil Burning Appliances, UL 343.

5.12 Strainers supplied with the boiler assembly shall comply with the requirements of the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331.

6 Accessibility for Servicing

6.1 A boiler assembly shall be built to allow cleaning of parts such as heating surfaces in contact with combustion products, and oil strainers, without major dismantling of the boiler assembly or removal of parts required by 5.2 to be factory-assembled.

6.2 The removal of access panels, burners, caps, plugs, etc., specifically designed to permit ready removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 6.1.

6.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the boiler assembly is installed as recommended by the manufacturer. The disposition of parts in the assembly removed for normal care shall be such that their restoration, following removal, will not necessitate their realignment to secure their proper relationship with other parts of the assembly. Special facilities required for normal care to be done by the operator shall accompany the boiler assembly to the user.

6A Air-Intake Terminal

6A.1 The requirements in this section are applicable to boilers equipped to provide for separation (isolation) of the combustion air system from the indoor atmosphere by an installation method.

6A.2 A boiler shall be provided with a combustion air-intake assembly. The intake shall be provided with means for secure attachment to the boiler or building structure. An intake shall communicate with the outside atmosphere. The boiler shall be marked in compliance with 47.19.

6A.3 An air-intake assembly through the roof shall be such that, when the assembly is installed as intended, the air entrance will be at least 6 inches (152.4 mm) above the top surface of the roof and the exit will be at least 6 inches below the top surface of the roof.

6A.4 An air-intake assembly for installation through an outside wall shall extend at least 2 inches (50.8 mm) to 4-3/4 inches (121 mm) beyond the inside face of the wall and shall not project beyond the outside wall more than 3 inches (76.2 mm).

6A.5 The air entrance of an air-intake assembly shall be guarded, shielded, or located to exclude rain, snow, debris, and birds. A screen, if used, shall have a mesh of not less than 1/4 inch (6.4 mm).

6A.6 Openings in perforated or expanded metal panels provided over openings for combustion air shall be a minimum 1/4 inch (6.4 mm) diameter. If the openings are other than circular in shape, they shall be of such size that will permit entrance of a No. 3 DMS (5.4102 mm) drill.

6A.7 The design and path of an air-intake shall provide the intended amount of combustion air to the boiler and of dilution air to any draft regulator.

6A.8 An outer casing or other structural part of an air-intake assembly or connector exposed to the weather shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of galvanized steel, 0.018 inch (0.46 mm) thick, and have a coating of zinc conforming with the coating Designation G90 in Table I of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may, in case of question, be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ANSI/ASTM A90. Such parts that are always inside the structure shall comply with 8.1.

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6B Vent-Air Intake Assemblies

6B.1 The requirements in this section are applicable to direct vented boiler systems that provide for separation (isolation) of the combustion system from the indoor atmosphere by an installation method.

6B.2 A boiler shall be provided with a vent-air intake. The intake for a boiler equipped with a draft regulator shall also provide air for draft regulator dilution. The intake shall be provided with means for secure attachment to the boiler or building structure. An intake shall communicate with the outside atmosphere. The boiler shall be marked in compliance with 47.20.

6B.3 Parts of flueways shall be joined in a manner to prevent disengagement and shall be tight when tested in accordance with this standard.

6B.4 The assembly shall be provided with a cap to prevent the entrance of debris or rain into the flue-gas conveying pipe and into any air passages terminating outside the structure.

6B.5 A cap shall be designed so that flue-gas or air passages will not be obstructed by soot accumulation, by leaves or debris falling or blown onto it, or by birds.

6B.6 A vent-air-intake assembly intended for installation through the roof or outside wall shall be designed for varying thicknesses of roof and wall construction in accordance with 6A.3 or 6A.4.

6B.7 An outer casing or other structural part of a vent-air intake assembly or connector exposed to the weather (exclusive of flue-gas conveying conduit) shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of galvanized steel, 0.018 inch (0.46 mm) thick, and have a coating of zinc conforming with the coating Designation G90 in Table I of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may, in case of question, be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ANSI/ASTM A90. Such parts that are always inside the structure shall comply with 8.1.

7 Casing

7.1 The outer casing or jacket shall be made of steel or equivalent material, braced, reinforced or formed so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel at least 0.020 inch (0.51 mm) (No. 24 MSG) thick if uncoated, or 0.023 inch (0.58 mm) (No. 24 GSG) if galvanized, or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

7.2 Access panels that need to be removed for normal service and accessibility shall be constructed to permit removal and replacement repeatedly without causing damage or impairing any required insulating value.

7.3 A removable panel through which air is drawn for combustion shall be so constructed as to prevent it from being attached in a manner that may cause unsafe performance of the boiler assembly.

7.4 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same boiler when interchange may allow unsafe operation of the boiler assembly.

7.5 The casing of a boiler assembly for installation on combustible flooring shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor.

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8 Radiation Shields or Liners

8.1 A radiation shield or liner shall be so constructed, formed, and supported as to ensure proper positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the boiler assembly is tested in accordance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the boiler assembly is tested under these requirements.

8.2 Thermal insulation which is not adequately self-supporting shall be applied to solid surfaces in a manner so as to prevent sagging. The insulating value of the material shall be unimpaired when the boiler assembly is tested under these requirements.

8.3 An adhesive for attaching insulating material shall retain its adhesive qualities at any temperature the adhesive may attain when the unit is tested under these requirements and at 0°F (minus 17.8°C).

9 Combustion Chamber

9.1 A combustion chamber and flueway shall be constructed of cast iron, sheet steel, or of a material equivalent in mechanical properties and corrosion resistance. Plain carbon sheet steel, if used, shall be at least 0.042 inch (1.07 mm) (No. 18 MSG) thick.

9.2 Combustion chamber or fire box lining material, if used, shall be durable, adequately held in place, and accessible for replacement with equivalent lining material.

10 Baffles

10.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be constructed and disposed in a manner to provide for reasonable life and shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to ANSI C1010 hot-rolled sheet steel having a minimum thickness of 0.042 inch (1.07 mm) (No. 18 MSG) unless its deterioration will not cause excessive temperatures or deleterious performance characteristics when the boiler assembly is tested in accordance with these requirements.

10.2 A flue baffle shall be accessible for cleaning. A flue baffle which is removable for cleaning shall be such as to facilitate its removal and permit replacement only in a safe position.

11 Flue collar

11.1 A flue collar shall be constructed and arranged to permit the secure attachment of the chimney connector to the boiler assembly.

12 Damper and Draft Regulator

12.1 An adjustable damper shall be equipped with minimum and maximum operating stops. The minimum operating stop for such damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

12.2 An automatically operated damper shall be designed to maintain a safe damper opening at all times and be arranged to prevent starting of the burner unless the damper is in a safe position for starting.

12.3 A boiler assembly to be equipped with a barometric draft regulator shall be designed so as not to require the regulator to be installed in a false ceiling, in a different room, or in any manner that will permit a

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difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

13 Controls

13.1 Application

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

13.1.2 It is the intent of the requirement in 13.1.1 that a short circuit or combination of short circuits to ground will not render a safety control or protective device inoperative. Safety control circuit arrangements other than described in 13.1.1 may be considered if they accomplish the intent of this requirement.

13.1.3 The requirement of 13.1.1 does not apply to a circuit within a safety control or to the extension of a circuit to a separate element of the control, such as a flame-sensing device.

13.1.4 A control circuit shall be arranged so that it may be connected to a power-supply branch circuit that can be fused at not more than the value appropriate for the rating of any control included in the circuit.

13.1.5 All safety controls shall be accessible.

13.1.6 A safety control and its sensing element shall be supported in such a manner to remain in proper position. It shall be possible to determine by observation or test whether or not each control is in its proper location.

13.1.7 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or to allow firing of the boiler assembly without the protection of each of the required safety controls.

13.1.8 A burner not equipped to provide safe automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and after restoration of an interrupted power supply.

13.1.9 A boiler assembly shall be provided with operating controls that regulate the fuel supply so as not to exceed the rated operating temperature or pressure as specified in 13.1.10 – 13.1.12.

13.1.10 A steam boiler shall be provided with at least one steam pressure actuated control that will shut off fuel supply to the burner when the steam pressure in the boiler reaches a preset maximum operating pressure. This requirement does not preclude the use of additional operating controls, if required.

13.1.11 A water boiler shall be provided with at least one temperature actuated control to shut off the fuel supply to the burner when the temperature of the water in the boiler reaches a preset operating temperature. This requirement does not preclude the use of additional operating controls, if required.

13.1.12 If a boiler assembly is equipped with an operating control that only regulates the fuel input between high and low values of steam pressure or water temperature, an additional operating control set to shut off the equipment at a value below the set point of the limit control is required.

13.1.13 An operating control need not be factory-installed provided the wiring diagram and instructions furnished with the boiler indicate that an operating control of an appropriate type and setting is to be furnished by the installer. See 48.3.

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13.2 Limit controls

13.2.1 A boiler shall be provided with limit controls that operate to shut off fuel and cause safety shutdown in case of a low water condition and excessive temperature or excessive pressure, as specified in 13.2.2 – 13.2.4 and 13.4.1 – 13.6.1. The limit controls shall be in addition to any operating controls specified in 13.1.9 – 13.1.13.

13.2.2 With respect to 13.2.1, safety shutdown may be provided either by employing manual reset type limit controls or it may be affected remotely by utilizing the manual reset feature of another control, such as the primary safety control. For systems where the reset feature is remote from the limit control, means shall be provided to indicate the limit control has operated when it causes safety shutdown.

Exception No. 1: An automatic reset temperature limit control may be employed in lieu of a manual reset type limit control for a water boiler that has a main flame hourly input of not more than 400,000 Btus per hour (117 kW) or 2.85 gallons of oil per hour (10.8 L/h).

Exception No. 2: An automatic reset pressure limit control may be employed in lieu of a manual reset type limit control for a low pressure steam boiler that has a main flame hourly input of not more than 400,000 Btu/hr (117 kW) or 2.85 gallons of oil per hour (10.8 L/h).

13.2.3 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.

13.2.4 The purpose of the requirement in 13.2.3 is to avoid interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to prevent. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the safety circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls or to interrupt a multiphase circuit.

13.2.5 The limit control for a boiler for alcove or closet installation shall be factory-located on the assembly or its location shall be factory-predetermined.

13.3 Primary safety control

13.3.1 An oil-fired boiler assembly shall be provided with a primary safety control to program and monitor the burner operation in accordance with 13.3.2 – 13.3.7 and Table 13.1. The primary safety control may be integral with the oil burner or it may be integrated into the boiler assembly.

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

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Table 13.1
Required programming and timings for burners based on maximum fuel input rating

	Maximum Input		
Operation	3 gph (11.4 L/h) or less	Above 3 to 20 gph (above 11.4 to 75.7 L/h)	Above 20 gph (above 75.7 1/h)
	Approximately 400,000 Btu/h (117 kW)[a] or less	Above approximately 400,000 Btu/h to approximately 3,000,000 Btu/h (879 kW)	Above approximately 3,000,000 Btu/h
Prepurge	Not required	Up to 7 gph (26.5 L/h) not required Over 7 gph required if oil pump operates independently of the burner. See 13.7.1.	Four air changes at 60 percent damper opening and with proven air flow. See 13.7.2.
Postpurge timing	Not required	Not required	15 seconds minimum
Pilot type and flame establishing period[b]	Not applicable	Interrupted, 10 seconds maximum	Interrupted, 10 seconds maximum
Main burner flame establishing period			
Ignited by pilot	Not applicable	15 seconds maximum[c]	10 seconds maximum for Nos. 2 and 4 oil, 15 seconds maximum for Nos. 5 and 6 oil[d]
Direct ignition	90 seconds maximum	15 seconds maximum	Not permitted except for low fire start up to 20 gph, in which case 15 seconds maximum[e]
Flame failure reaction time[f]			
Ignited by pilot	Not applicable	4 seconds maximum	4 seconds maximum
Direct ignition	90 seconds maximum	15 seconds maximum for inputs up to 7 gph 4 seconds maximum for inputs over 7 gph	4 seconds maximum
Fuel valve closing time after de-energization	Not Applicable	5 seconds maximum	1 second maximum
Action required on flame failure	One relight attempt permitted; if flame not proved shall lock out	One recycle permitted if flame failure response time does not exceed 4 seconds.	Safety shutdown required.
Proven low fire start	Not required	Not required	Required with direct ignition if total input exceeds 20 gph.
Combustion air proving	Not applicable	Required if fan is not mounted on burner motor shaft	Required
Action required on loss of combustion air	Not applicable	Safety shutdown except may recycle once. See 13.7.4.	Safety shutdown
Oil pressure supervision	Not applicable	Not required	Required if oil pump is remote from burner motor. See 13.7.6.
Low atomizing media pressure supervision	Not applicable	Required unless atomization is accomplished by oil pump mounted on burner motor shaft. See 13.7.7.	Required. See 13.7.7.
Oil temperature supervision	Not applicable	High and low temperature supervision required on preheated oil. Excessive temperature shall cause safety shutdown.	

[a] Oil burners used for inputs up to 3 gph normally employ direct ignition of oil at fuel input. They are not required to employ any interlocks for monitoring of oil pressure or temperature, pressure of atomizing media or for proving combustion air. Therefore, the requirements included in this table for such operations are not applicable to these burners.

Table 13.1 Continued on Next Page

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Table 13.1 Continued

	Maximum Input
[b] Continuous and intermittent pilots are permitted if only the main burner flame is monitored during the burner operation. See 13.3.2. [c] Use of pilot for igniting the main flame is optional for inputs of 20 gph or less. See 13.3.7. [d] If it can be demonstrated by tests that a burner equipped to fire No. 5 or 6 oil needs more than 15 seconds for the main burner flame establishing period in order to avoid nuisance shutdown, the period may be extended to 30 seconds provided not more than 15 seconds of unburned fuel can be discharged during an attempt to establish the main flame. [e] See 13.3.7. [f] The flame failure reaction timing is to be based on the burner's maximum input. The flame-failure reaction time for burners having inputs in excess of 3 gph it is to be considered the interval between the actual flame extinguishment and the time the safety shutoff device (such as an oil valve) is de-energized. For burners having inputs of 3 gph or less the timing may be considered the interval measured from the time the flame sensing device (detector) first detects the loss of flame, to the time the safety shutoff device is de-energized.	

13.3.3 For a boiler having an input exceeding 3 gph (11.41 L/h), loss of flame at the point of supervision shall result in the shutting off of all fuel to the burner. For a boiler having:

a) An input not exceeding 3 gph; and

b) Interrupted spark ignition, the ignition may be reactivated in not more than 0.8 second following the flame failure for an attempt to relight the burner.

If flame is not established, safety shutdown shall occur. See 13.3.4 and 13.3.5 for action required with other inputs.

13.3.4 With respect to 13.3.3, for a boiler having an input not exceeding 20 gph (75.7 L/h) and that is equipped to provide prepurge, on flame failure one additional attempt may be made to ignite the burner after a prepurge in accordance with 13.7.2. If flame is not established, safety shutdown shall occur.

13.3.5 With respect to 13.3.3, for a boiler having an input in excess of 20 gph (75.7 1/h), on flame failure no additional attempts to relight the burner shall be made and safety shutdown shall occur.

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

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

Exception: Direct ignition may be used on a boiler assembly having an input in excess of 20 gph if:

a) The initial ignition is accomplished at a input not exceeding 20 gph; and

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

13.3.8 A primary safety control shall be constructed and tested in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use – Part 2: Particular Requirements for Burner Ignition Systems and Components, UL 372.

13.4 Liquid level limit controls

13.4.1 A water boiler shall be provided with at least one low water cut-off or combination low water cut-off and water feed control that operates to open the burner circuit and cause safety shutdown before the

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water falls below the lowest visible part of the gage glass or the equivalent visual permissible level as specified by the manufacturer.

Exception No. 1: A low-water fuel cutoff control is not required to be furnished on a water boiler that has a main flame hourly input of not more than 400,000 Btu's per hour (117 kW) or 2.85 gallons per hour (10.8 L/h).

Exception No. 2: A water tube or coil type boiler that requires forced water circulation to guard against excessive temperatures (see 13.6.1), may employ a water flow sensing device instead of a low water cut-off.

13.4.2 Low pressure and high pressure steam boilers shall be provided with at least two low water cut-offs or combination low water cut-off and water feed controls. Both controls shall be wired electrically so that operation of either control causes fuel cut-off to the burner before the water level falls below the lowest visible part of the gage glass or the equivalent visual permissible level specified by the manufacturer. However, one control shall be set to operate at a lower water level than the other. The control set lower shall cause safety shutdown, requiring a manual reset to restore burner operation.

Exception No. 1: A low pressure steam boiler that has a main flame hourly input of not more than 400,000 BTU/hr (117 kW) or 2.85 gallons/hr (10.8 L/hr) shall be provided with at least one low water cut-off control that is allowed to employ automatic reset to restore burner operation.

Exception No. 2: A boiler that does not exceed any of the following limits may be provided with only one low water cut-off:

a) Maximum working pressure – 100 psig (689.5 kPa);

b) Maximum inside diameter of shell– 16 inches (406.4 mm);

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

d) Gross volume, exclusive of casing and insulation – 5 cubic feet (0.142 m^3). See 13.4.3.

13.4.3 With reference to the exception to 13.4.2, the gross volume is considered to be the volume of a rectangular or cylindrical enclosure into which all the pressure parts of the boiler could be fitted in their final assembly including gas passages that are integral with the assembled pressure parts. Projecting nozzles or fittings need not be considered in this volume.

13.4.4 With respect to 13.4.1 and 13.4.2, safety shutdown may occur simultaneously with the operation of the low water cut-off to shut down the burner or it may incorporate a time delay. The time delay for safety shutdown shall not exceed the boiler manufacturer's recommended time or 90 seconds, whichever is less.

13.4.5 A liquid level limit control shall comply with the Standard for Limit Controls, UL 353 or the requirements for protective controls in the Standard for Automatic Electrical Controls – Part 2-15, Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls, UL 60730-2-15.

13.5 Pressure limit controls

13.5.1 Each low pressure and high pressure steam boiler shall be provided with a pressure operated control that operates to shut off all fuel to the burner and cause safety shutdown in case of excessive steam pressure in the boiler. The control settings shall be in accordance with 13.5.2 and 13.5.3, as appropriate.

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13.5.2 The maximum setting of a limit control on a low-pressure steam boiler shall limit the steam pressure in the boiler to 15 psig (103 kPa). On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop.

13.5.3 The limit control for a high pressure steam boiler shall limit the steam pressure in the boiler to the maximum allowable working pressure of the boiler. On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop.

13.6 Temperature limit controls

13.6.1 A water boiler shall be provided with at least one temperature-operated limit control that operates to shut off all fuel to the burner and cause safety shutdown before the water temperature in the boiler exceeds the maximum rated operating temperature. For a low pressure hot water boiler safety shutdown shall occur before the water temperature in the boiler exceeds 250°F (121°C).

13.7 Purge and combustion air monitoring controls

13.7.1 A boiler assembly having an input rating in excess of 7 gph (26.5 L/h) but not exceeding 20 gph (75.7 L/h) shall be equipped to provide prepurge of sufficient length to assure four air changes in the combustion chamber and associated flue passages. The purging shall be accomplished with either proven air flow in not less than 90 seconds or at a damper opening of not less than 60 percent with both the air flow and the damper position proven.

13.7.2 A boiler assembly having an input rating in excess of 20 gph (75.7 L/h) shall be equipped to provide a prepurge of sufficient length to assure four air changes in the combustion chamber and associated flue passages. The purging shall be accomplished at a damper opening of not less than 60 percent with both the air flow and the damper position proven. Such a boiler shall also be equipped to provide a postpurge period of not less than 15 seconds.

13.7.3 The purging periods required by 13.7.1 and 13.7.2 shall either be provided as part of the primary safety control programming or by a separate device, arranged so that the ignition of the burner cannot be initiated if the device has failed in a manner that will not provide purging in accordance with 13.7.1 and 13.7.2.

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

13.7.5 For convenient reference, the requirements for purge and action required on loss of combustion air are also included in Table 13.1.

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

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

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

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

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

13.7.8 High and low temperature interlocks shall be provided for systems that fire preheated oil. An oil temperature in excess of the limit established by the burner manufacturer shall result in safety shutdown. If the oil temperature falls below the predetermined limit, the interlock shall operate to stop fuel delivery to the burner and allow circulation of the oil until the temperature increases to permit firing. Preheaters supplied as part of the boiler shall comply with the Standard for Electric Oil Heaters, UL 574 and interlocks shall comply with the Standard for Limit Controls, UL 353.

13.7.8.1 A control device provided as an interlock, as described in 13.7.6 – 13.7.8, shall be constructed and tested in accordance with the Standard for Limit Controls, UL 353.

13.7.9 With respect to 13.7.5 – 13.7.7, for convenient reference the requirements for temperature and pressure switches are also included in Table 13.1.

13.8 Safety shut-off valves

13.8.1 The oil fuel train of each boiler assembly having an input in excess of 3 gph (11.4 L/h) shall be provided with two oil safety shut-off valves or one safety shut-off valve and a nozzle cut-off valve. The closing times of the shut-off valves shall not exceed the timings specified in Table 13.1. The pressure rating of the shut-off valves shall not be less than the maximum pump pressure.

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

13.8.3 Automatic safety shutoff valves shall be constructed and tested in accordance with the Standard for Electrically Operated Valves, UL 429 or equivalent nationally recognized automatic valve safety standard.

13.8.4 Manually operated valves shall be constructed and tested in accordance with the Standard for Valves for Flammable Fluids, UL 842, or equivalent nationally recognized manual valve safety standard.

14 Installation of External Controls and Fittings

14.1 If a low water cutoff is installed external to a low pressure or a high pressure steam boiler utilizing a water column, the connecting piping and fittings to the column shall not be smaller than 1-inch NPS and no shutoff valves of any type shall be placed in the piping between the boiler and the cutoff. A cross or equivalent fitting shall be used in the piping connections at every right angle to facilitate cleaning and inspection.

14.2 A low water cutoff that embodies a separate chamber shall incorporate a vertical drainpipe and a blowoff valve not smaller than 3/4-inch NPS, located at the lowest point of the chamber or water-equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the low water cutoff can be tested for operation.

14.3 A low water cutoff or a combination cutoff and water feed control for a low pressure steam boiler may be installed in the tapped openings provided for attachment of a water gage glass directly to the boiler. For such installation, the connections shall be made with nonferrous "T" or "Y" fittings for the low water cutoff connections. The ends of any nipples used shall be hollowed to full size of the internal diameter.

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14.4 For a hot water heating boiler, the low water cutoff may be installed external to the boiler. Under low water conditions, the chamber in which the cutoff is located shall drain so as to maintain the same water level as in the boiler, and if flow occurs in the chamber, it will be in the upward direction.

14.5 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.

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

14.7 Each steam pressure limit control shall be protected with a siphon or equivalent means of maintaining a water seal between the steam and the inlet to the control. The size of the siphon shall not be less than 1/4-inch NPS. Tubing of adequate temperature and pressure rating and of equivalent inside diameter may be substituted for pipe.

14.8 If a steam pressure limit control that incorporates a mercury switch is mounted on a siphon, the loop of the siphon shall be in a plane that is 90 degrees (1.57 rad) from the plane of the mercury switch.

14.9 The steam pressure connections to the steam pressure limit control shall not be:

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

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

c) More than 1-inch NPS for ferrous materials over 5 feet in length.

Tubing of adequate temperature and pressure rating and of equivalent internal diameter may be substituted for pipe.

14.10 When multiple pressure controls (i.e. pressure limit and pressure operator controls) are fed from a common manifold, the manifold and common source connection feeding the manifold shall be one NPS pipe size larger than the NPS pipe size used to connect the pressure limit control for compliance with 14.9. A suitable sized reducing bushing may be used in the piping connection between the manifold and the pressure limit control.

15 Field Wiring

15.1 General

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

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

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

15.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that indicated in Table 15.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

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Table 15.1
Size of junction boxes

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

15.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 15.2.

15.1.6 Wiring exterior to a boiler assembly between the burner assembly and a limit control, a primary safety control, or a motor controller, that can be done readily using the following wiring methods in accordance with the National Electrical Code, ANSI/NFPA 70, need not be furnished by the manufacturer as part of the boiler assembly if adequate instructions for installing such wiring are furnished with each boiler assembly. See 16.1.4.

a) Type T wire enclosed in conduit that complies with the Standard for Flexible Metal Conduit, UL 1 or the Standard for Electrical Rigid Metal Conduit – Steel, UL 6, as applicable, electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel, UL 797 or the Standard for Extruded Insulating Tubing, UL 224;

b) Metal-clad cable that complies with the Standard for Metal Clad Cable, UL 1569 in accordance with these requirements; or

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

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

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

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

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

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

15.1.8 A box or enclosure in which field installed conductors are to be connected as indicated in 15.1.5, 15.1.6, 15.1.7, and 15.1.9 shall be so located that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for a wire having a 60°C (140°F) temperature rating when the boiler assembly is tested in accordance with these requirements.

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15.1.9 Except as otherwise permitted by 16.1.4, wiring to be done in the field between the boiler and devices not attached to the boiler assembly or between separate devices which are field installed and located, shall conform to these requirements if done with a 60°C (140°F) rated wire using the following wiring methods:

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

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

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

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

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

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

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

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Table 15.2
Trade size of conduit in inches

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	3/4	1	1-1/4	1-1/4
4	(21.2)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1	1-1/4	1-1/2	1-1/2
2	(33.6)	1	1	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
0	(53.5)	1-1/4	1-1/4	2	2	2-1/2
2/0	(67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	1-1/2	2	2-1/2	2-1/2
4/0	(107.2)	2	2	2-1/2	2-1/2	3

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

15.1.10 The wiring of the appliance may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 15.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm)

for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, ANSI/NFPA 70, shall be included unless:

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

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

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

15.2 Leads and Terminals

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

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

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

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

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

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

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

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

15.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 15.2.5.

Exception: 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.

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

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

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

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

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

15.2.13 A wire binding screw shall thread into metal.

16 Internal Wiring

16.1 General

16.1.1 The wiring of high-voltage circuits shall conform to the requirements in this Section.

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

16.1.3 Except as indicated in 15.1.6, the wiring for each boiler assembly circuit shall be furnished by the manufacturer as part of the boiler assembly. If the boiler assembly is not assembled and wired at the factory, such wiring shall be furnished as harness with each boiler and be arranged to facilitate attachment when the boiler is assembled; and a pictorial diagram showing the exact arrangement of the wiring shall be included with each boiler assembly.

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

Methods

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16.1.5 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.

16.1.6 Except as permitted by 16.1.19, conductors shall be:

a) Enclosed within conduit, electrical metallic tubing, metal raceway electrical enclosure;

b) Within metal-clad cable; or

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

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

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

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

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

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

a) It is not practical to do the wiring in accordance with 16.1.6;

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

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

16.1.7 Group A of Table 16.1 includes some wiring materials suitable for use if enclosed as indicated in 16.1.6.

16.1.8 Flexible metal conduit, if used, shall be not smaller than 3/8 inch (9.5 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads. See 4.1.

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

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

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16.1.11 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.

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

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

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

16.1.15 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which wiring materials, as specified in Group A of Table 16.1, may be employed. Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

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

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Table 16.1
Typical wiring materials

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

Table 16.1 Continued on Next Page

Table 16.1 Continued

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

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

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

16.1.19 Cords or appliance wiring material as referenced in Group B of Table 16.1 may be employed if the wiring is enclosed by a casing or compartment conforming to all of the following:

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

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

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

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

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

16.1.20 With reference to 16.1.19(e), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

16.1.21 Cords and other wiring material permitted in accordance with 16.1.19 shall be arranged to avoid being physically damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

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

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

16.1.24 To provide an acceptable unbushed opening in sheet metal, not requiring a bushing, usually requires roll or extrusion of the metal around the opening, or both, or the insertion of a grommet conforming to 16.1.22.

16.2 Short-circuit protection

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

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

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

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

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

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

17 Separation of Circuits

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

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

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

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

b) Uninsulated live parts of any other circuit; and

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c) Any uninsulated live parts whose short-circuiting may permit operation of the appliance that may result in a risk of fire, electric shock, or injury to persons.

Exception: A construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that conductors having insulation at least equivalent to those referenced in group A of Table 16.1 are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

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

a) 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 17.3, that the conductors entering each opening will be connected to the terminals opposite the opening; and

b) 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 live parts connected to a different circuit is to be investigated.

17.5 To determine if an appliance complies with the requirements of 17.3, 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.

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

17.7 A metal barrier shall have a thickness at least as great as that required by Table 21.1 or Table 21.2, whichever applies, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

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

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

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18 Bonding for Grounding

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

18.2 Except as indicated in 18.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, etc., are to be bonded for grounding if they may be contacted by the user or serviceman.

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

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

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

c) Panels and covers which do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover; 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 inch (0.8 mm) thick.

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

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

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

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

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

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

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

18.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 18.11 under any degree of compression permitted by a variable clamping

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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.

18.10 Where the bonding means depend on screw threads, two or more screws or two full threads of a single screw engaging metal is considered in compliance with 18.8.

18.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 18.12 – 18.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 18.1 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.

Table 18.1
Duration of current flow, bonding-conductor test

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

18.12 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 18.11, the size of the conductor or strap shall be in accordance with Table 18.2.

Table 18.2
Bonding wire conductor size

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

[a] Or equivalent cross-sectional area.

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

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

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

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

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

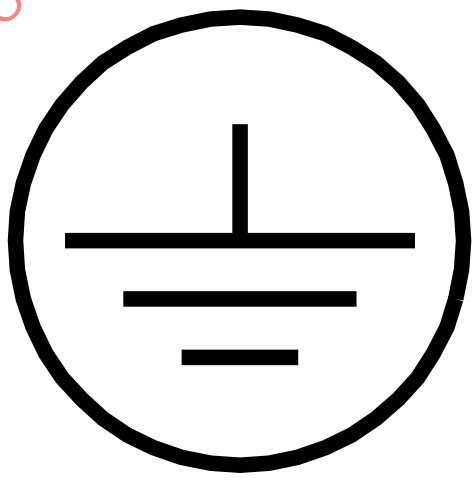
18.16 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application, in accordance with the National Electrical Code, ANSI/NFPA 70.

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

18.18 The terminal for the connection of the equipment grounding conductor shall be a green not readily removable terminal screw with a hexagonal head, a green, hexagonal, not readily removable terminal nut, or a green pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the words "GREEN" "GROUND"; the letters "G", "GR"; a grounding symbol such as Figure 18.1; 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 18.1

Grounding symbol



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

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

ELECTRICAL COMPONENTS

19 General Components and Devices

19.1 Electrical equipment and wiring shall be arranged so that during periods of normal use or when uncoupling of a connection is required for servicing they will not be contacted by water or oil.

19.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may allow unsafe operation of the equipment.

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

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

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

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

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

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

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

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

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

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

20 Mounting of Electrical Components

20.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 20.2 and 20.3.

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

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

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

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

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

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

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

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

21 Electrical Enclosures

21.1 General

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

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

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

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

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging according to the requirements in the Standard for Polymeric Material - Use in Electrical Equipment Evaluations, UL 746C. An enclosure complying with the requirements of the Standard for Industrial Control Panels, UL 508A, would be considered to comply with the requirements of 21.1.2(a) – (f).

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

21.1.4 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 21.1.3.

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

21.1.6 The thickness of a sheet metal enclosure shall be as indicated in Table 21.1 or Table 21.2.

Exception: An individual enclosure thinner than specified in Table 21.1 or Table 21.2 may be employed, if the design and location of components and the strength and rigidity of the outer cabinet warrant.

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

21.1.8 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.

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Table 21.1
Minimum thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)	–	(24)	–
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)	–	(22)	–
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.032	(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	(63.4)	31.0	(78.7)	35.0	(88.9)	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)
42.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)	–	(12)	–

Table 21.1 Continued on Next Page

Table 21.1 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					
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Uncoated (MSG)		Metal coated (GSG)	
52.0	(135.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.80)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)	–	(11)	–
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)	–	(10)	–

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes single sheet with single formed flanges (formed edges); a single sheet which is corrugated or ribbed; and 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.

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Table 21.2
Minimum thickness of sheet metal for enclosures – aluminum, copper or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)		
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Minimum thickness		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)	AWG
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(0.58)	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.7)	9.5	(24.1)	–	–	–
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.2)	–	–	–
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)	(18)
6.5	(16.5)	8.0	(20.4)	15.0	(38.1)	18.0	(45.7)	–	–	–
8.0	(20.4)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	–	–	–
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	–	–	–
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)	(12)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	–	–	–
25.0	(63.4)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	–	–	–
40.0	(94.0)	Not limited		87.0	(221.9)	Not limited		0.122	(3.10)	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	–	–	–
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)	(6)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	–	–	–

Table 21.2 Continued on Next Page

Table 21.2 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		Minimum thickness		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)	AWG

[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 single sheet with single formed flanges (formed edges); a single sheet which is corrugated or ribbed; and 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.

21.1.9 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 the National Electrical Code, ANSI/NFPA 70.

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

a) An opening between the box and motor frame having a dimension exceeding 1/2 inch (12.7 mm) does not permit a flat feeler gauge, 5/64- by 1/2-inch (2.0 by 12.7 mm) wide to enter; and

b) An opening between the box and motor frame having no dimension exceeding 1/2 inch (12.7 mm) does not permit the entrance of a 13/64 inch (5.2 mm) diameter rod.

21.2 Accessibility of uninsulated live parts and film-coated wire

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

a) A part of the enclosure that may be opened or removed by the user without using a tool, (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed;

b) Insulated brush caps are not required to be additionally enclosed;

c) The probes shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure; and

d) The probes shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

21.3 Boilers having an input in excess of 3 gph (11.4 L/h)

21.3.1 The criteria for judging an opening in an electrical enclosure of a boiler having an input in excess of 3 gph (11.4 L/h) are given in the following items and the related figures:

a) An opening that will not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:

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1) A probe as illustrated in Figure 21.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 21.2 cannot be made to touch film-coated wire when inserted through the opening;

b) An opening that will permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 21.3.

Figure 21.1

Probe for uninsulated live metal parts

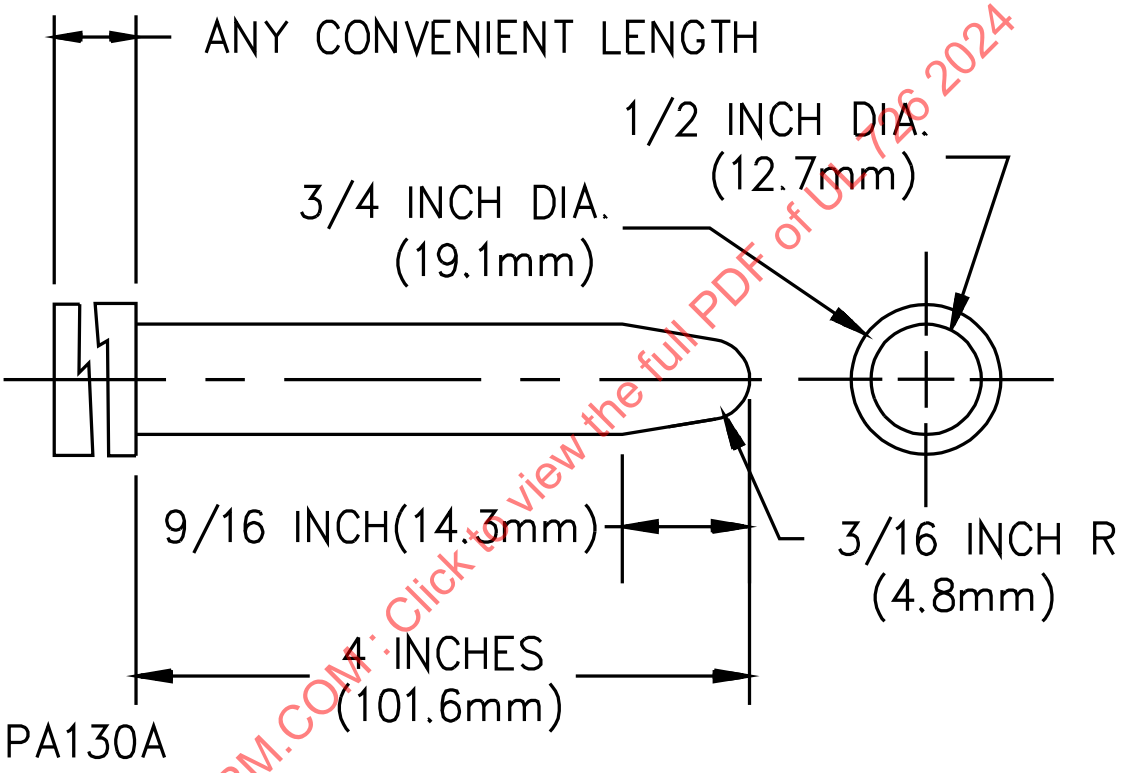

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Figure 21.2

Probe for film-coated wire

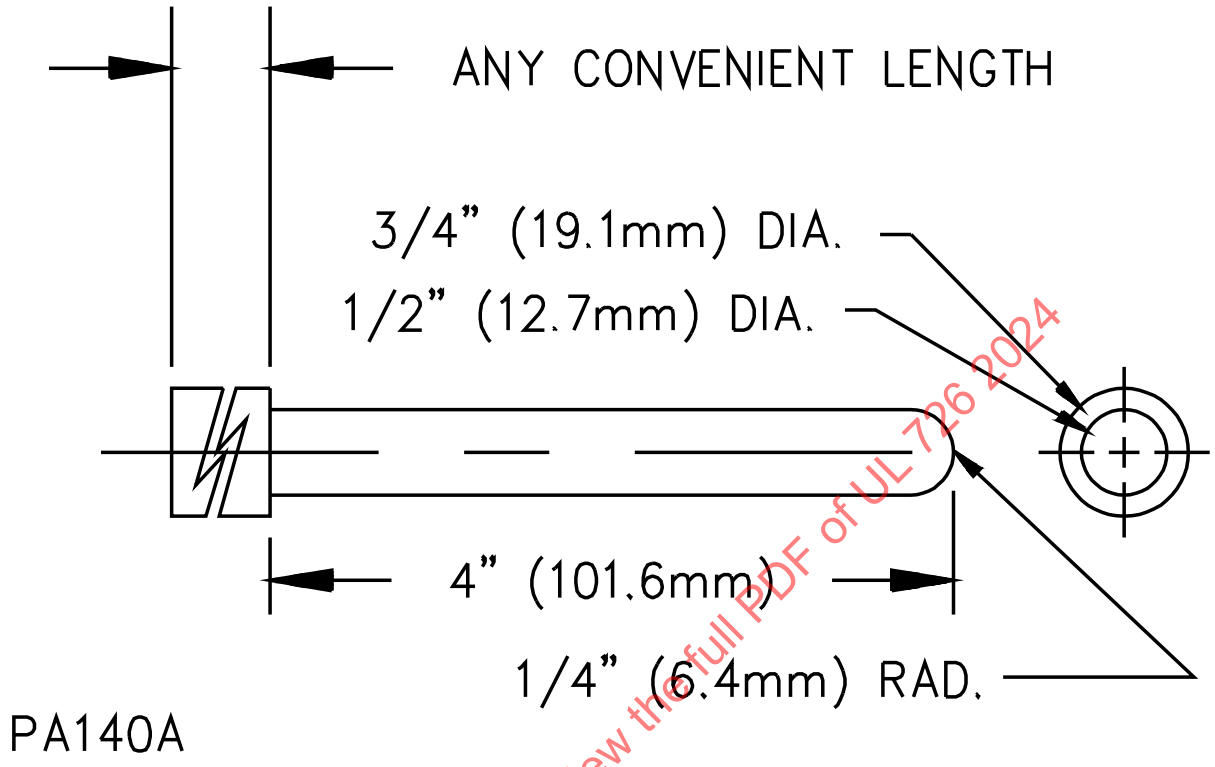

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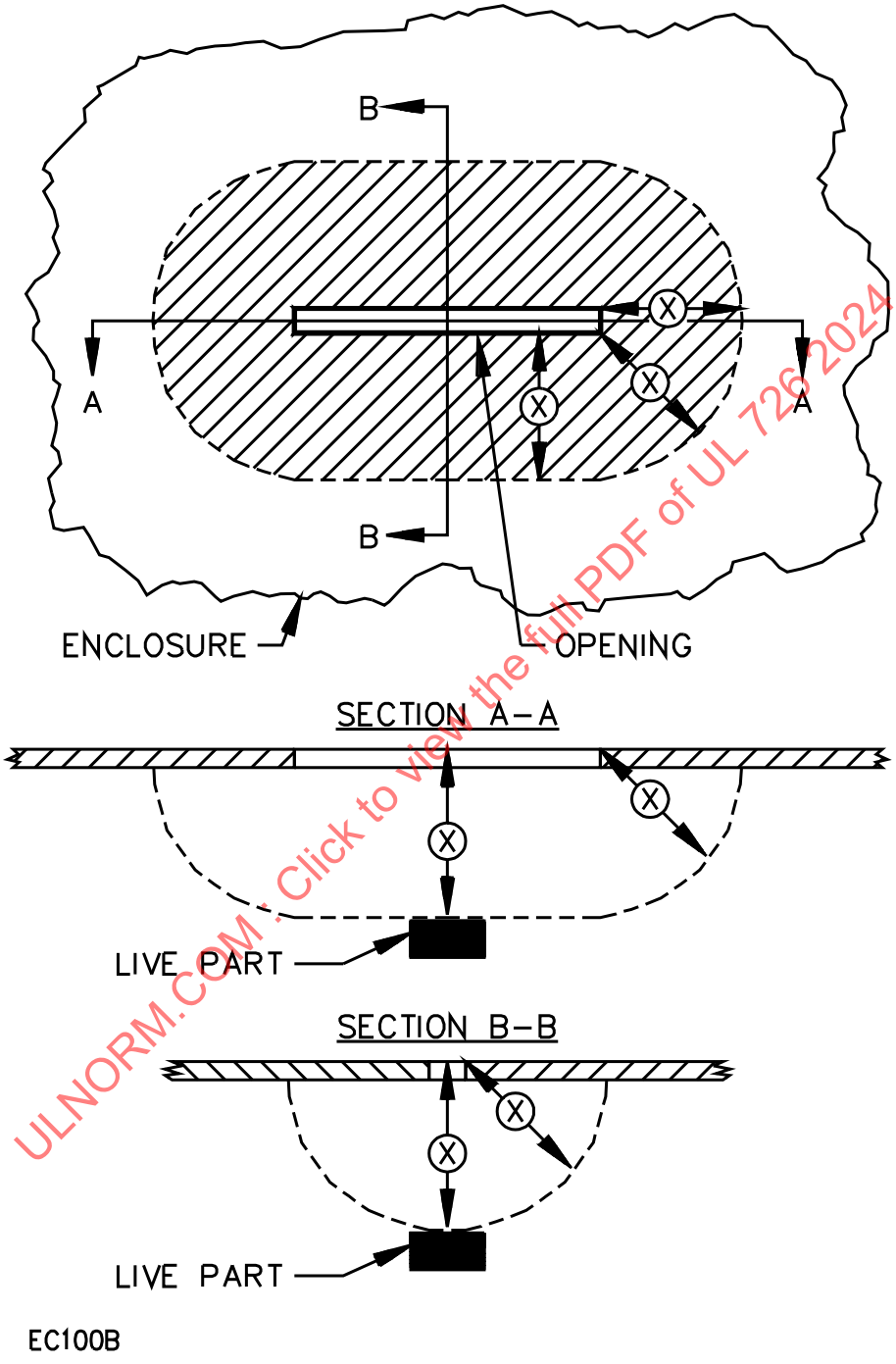
Figure 21.3

Opening in enclosure



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

a) Less than X inches (mm) from the perimeter of the opening; as well as

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane.

X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

21.4 Boilers having an input of 3 gph (11.4 L/h) or Less

21.4.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire an opening in an enclosure shall comply with either (a) or (b):

a) For an opening that has a minor dimension (see 21.4.3) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 21.4; or

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 21.3.

Exception: An opening in an integral enclosure of a motor need not comply with these requirements if it complies with the requirements in 21.4.2.

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Figure 21.4

Articulate probe with web stop

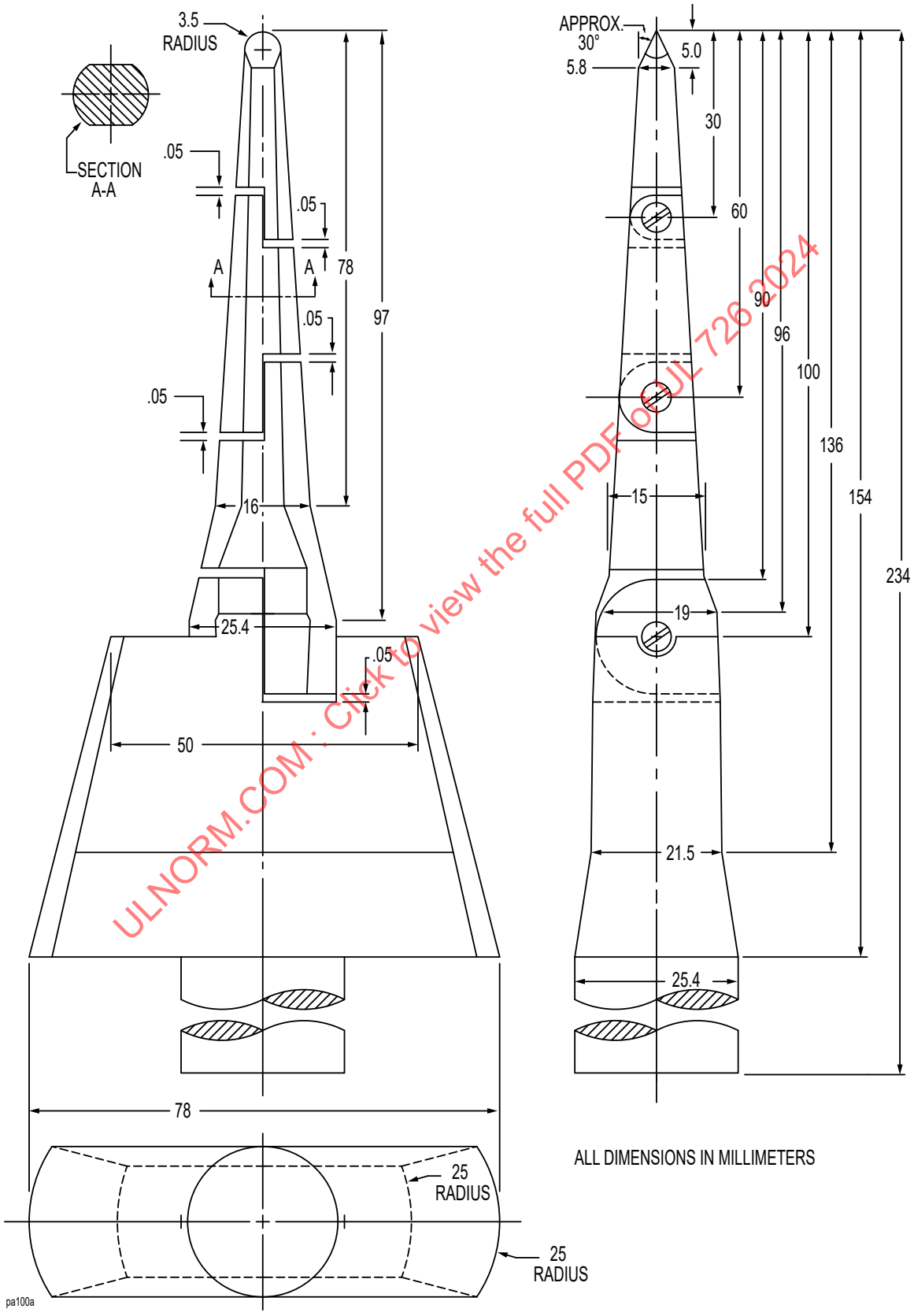

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Table 21.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening		Minimum distance from opening to part	
Inches	(mm)[b]	Inches	(mm)[b]
3/4[c]	(19.1)	4-1/2	(114.0)
1[c]	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(41.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
	d	30	(762.0)

[a] See 21.4.3.

[b] Between 3/4 inch and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.

[c] Any dimension less than 1 inch applies to a motor only.

[d] 8 more than 2-1/8 inches, but not more than 6 inches (152.0 mm).

21.4.2 With respect to a part or wire as mentioned in 21.4.1, in an integral enclosure of a motor as mentioned in the Exception to 21.4.1:

a) An opening that has a minor dimension (see 21.4.3) less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 21.2;

2) In a directly accessible motor (see 21.4.4), an uninsulated live part cannot be contacted by the probe illustrated in Figure 21.5; or

3) In an indirectly accessible motor (see 21.4.4), an uninsulated live part cannot be contacted by the probe illustrated in Figure 21.1.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 21.3.

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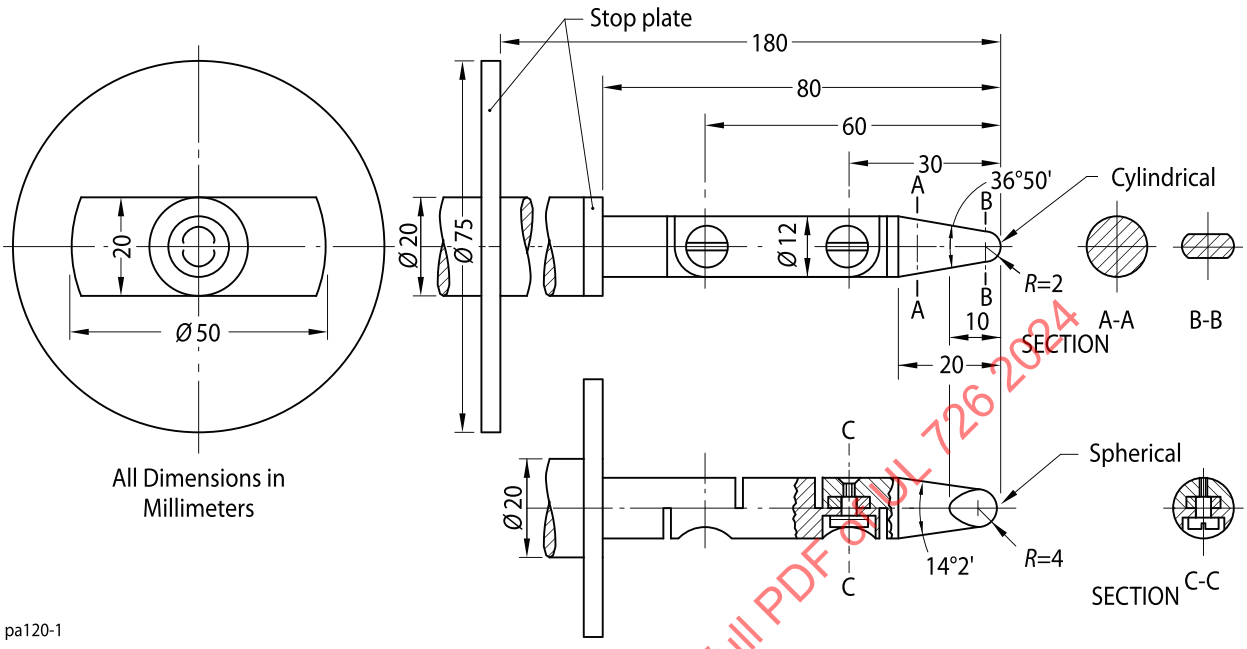
Figure 21.5

IEC articulate probe



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21.4.3 With reference to the requirements in 21.4.1 and 21.4.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

21.4.4 With reference to the requirements in 21.4.2, an indirectly accessible motor is a motor:

a) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool; or

b) That is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

21.4.5 A directly accessible motor is a motor:

a) That can be contacted without opening or removing any part; or

b) That is located so as to be accessible to contact.

21.4.6 The probes illustrated in Figure 21.4 and Figure 21.5 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

21.5 Doors and covers

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

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

21.5.3 The assembly incorporating overcurrent protective devices shall be arranged so that fuses can be replaced and manual-reset devices can be reset, as applicable, without removing parts other than a service cover or panel and a cover or door enclosing the device. See 21.5.7.

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

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

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

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

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

a) Control-circuit fuses of 2 amperes or less, provided the fuses and control-circuit loads, other than a fixed control-circuit load, such as pilot lamp, are within the same enclosure; or

b) Extractor-type fuses each with its own enclosure; or

c) Fuses in low-voltage circuits.

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

21.5.9 A spring latch, a magnetic latch, a dimple or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open, is an acceptable means for holding the door in place as required in 21.5.8.

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

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

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

a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimensions; and

b) 0.027 inch (0.68 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimensions.

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

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

21.6 Field wiring system connection

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

21.6.2 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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

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

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

22 Motors and Motor Overload Protection

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

22.2 "Overcurrent protective device" as referred to in 22.1 means those that conform to the requirements of the National Electrical Code, ANSI/NFPA 70, as follows:

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

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

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

3) All other motors, 115 percent.

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

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

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

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

3) All other motors, 130 percent.

22.3 An integral thermal protective device shall comply with the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Thermally Protected Motors, UL 1004-3.

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

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

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

b) Thermal protectors, combination of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide proper protection under primary single-phase failure conditions when supplied from transformers connected Wye-Delta or Delta-Wye.

Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phase conditions. This marking may be a paper sticker, decal, or an attached wiring diagram.

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

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

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

22.9 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short-Circuit Test.

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

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

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

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

22.14 Conformance to 22.13 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

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

22.16 The requirement in 22.15 will necessitate the use of a barrier of nonflammable material under an open type motor unless:

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

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

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load below which the motor will run without causing the protector to cycle and from becoming more than 150°C (302°F) with the rotor of the motor locked; or

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

22.17 The barrier mentioned in 22.16 shall be horizontal, located as indicated in Figure 22.1 , and have an area not less than that described in that illustration. Openings for drainage, ventilation, and the like, may be employed in the barrier provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

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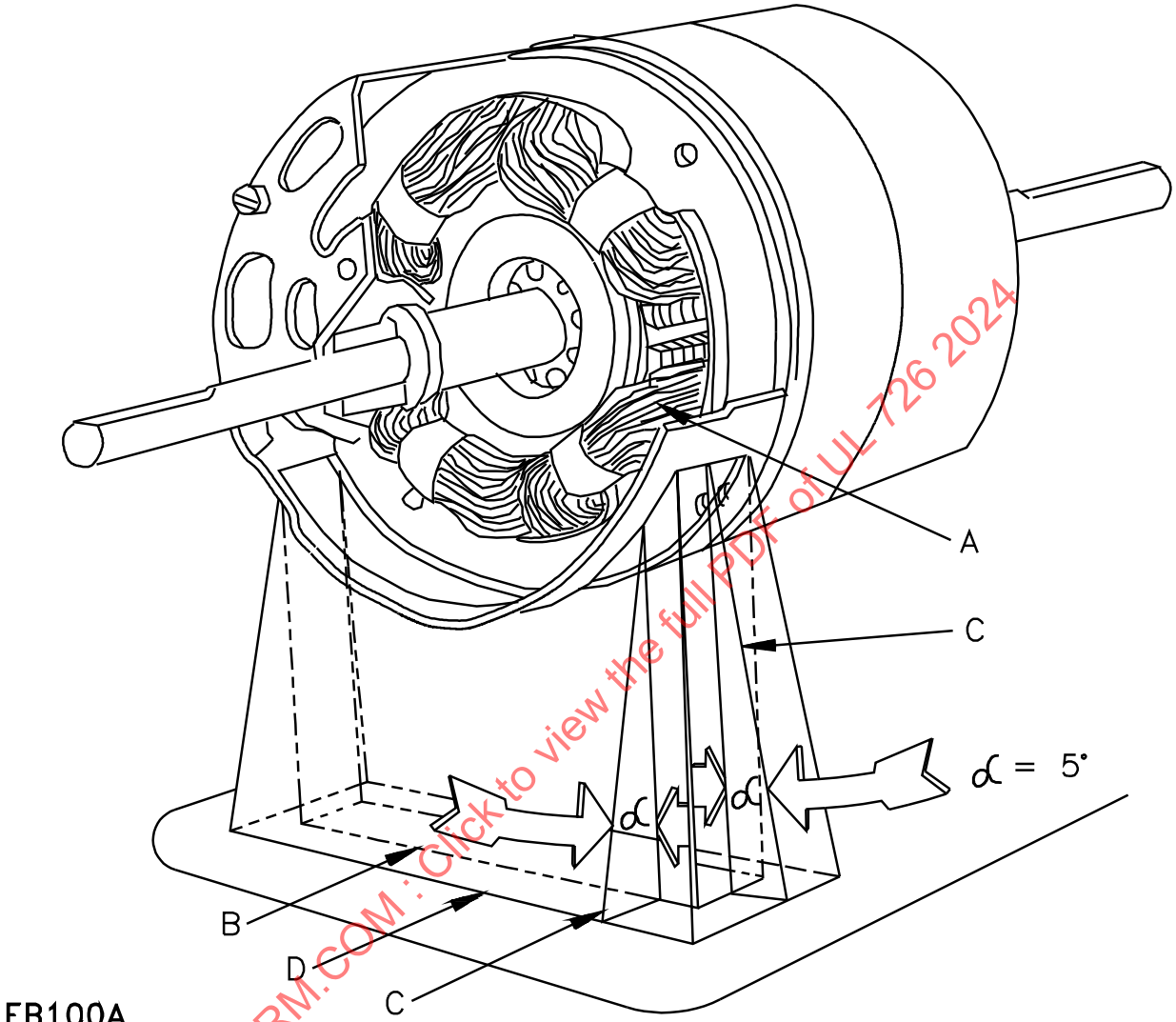
Figure 22.1

Location and extent of barrier



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

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

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always:

1) Tangent to the motor winding;

2) Five degrees from the vertical; and

3) So oriented that the area traced out on a horizontal plane is maximum.

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

22.18 Motors shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

23 Overcurrent Protection of High-Voltage Control-Circuit Conductors

23.1 General

23.1.1 For the purpose of the requirements in 23.2.1 – 23.4.2, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 24, for additional requirements.

23.2 Direct-connected high-voltage control circuit

23.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 47.9.

23.3 Tapped high-voltage control circuits

23.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the burner on the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 23.3.3 – 23.4.2.

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

23.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 23.1.

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

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 41.1.

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

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

a) This protection is in accordance with the requirements specified in Overcurrent Protection of Transformers, Section 24; and

b) The rating of the device does not exceed the applicable value specified in Table 23.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

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Table 23.1
Overcurrent protective device rating for control circuit conductors

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

[a] Includes copper-clad aluminum.

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

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

23.4 Overcurrent-protective devices

23.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 23.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 47.7.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 23.1.

23.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 23.3.3; and

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

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

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 41.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 47.8.

24 Overcurrent Protection of Transformers

24.1 High-voltage transformers

24.1.1 A transformer, other than as described in 24.2.1 and 24.2.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 24.1.2; or

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b) Be protected by an overcurrent device or devices in accordance with the requirements in 24.1.4; or

3) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 43.

24.1.2 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High-Voltage Transformers, Section 42.

Exception: If the thermal-overload-protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test, High-Voltage Transformers, Section 43.

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

24.1.4 Each overcurrent device that protects a high-voltage transformer shall comply with the requirements specified in 24.1.5, 24.1.6 and 24.2.3 – 24.2.5.

24.1.5 A high-voltage transformer shall be protected by an overcurrent device, or devices, that is located in the primary circuit and that is rated or set as indicated in Table 24.1 for the primary. See 24.1.6 and 24.2.3.

24.1.6 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device rated or set as indicated in Table 24.1 for the secondary.

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Table 24.1
Maximum rating of transformer overcurrent protective device

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

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

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

24.2 Low-voltage transformers

24.2.1 Except as specified in 24.2.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 24.2.3.

24.2.2 A transformer that directly supplies a Class 2 circuit (see 3.28(b)) shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

24.2.3 Overcurrent protection in the primary circuit of a transformer, as described in 24.1.5 and 24.2.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 24.1.5 or 24.2.1, as applicable.

24.2.4 Overcurrent protection in the secondary circuit of a transformer, as required by 24.1.6 shall be provided as part of the appliance. If a fuse is used, the appliance shall be marked in accordance with 47.7.

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

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 24.1.5 – 24.2.1, as applicable; and

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

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

Exception: If a transformer supply is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 41.1. The product shall be marked in accordance with 47.8.

25 Switches and Controllers

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

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

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

25.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 47.10 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

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

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

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

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

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

25.9 As applicable, switches shall comply with the Standard for Enclosed and Dead Front Switches, UL 98, the Standard for General-Use Snap Switches, UL 20, the Standard for Special Use Switches, UL 1054 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

25.10 Controllers shall comply with the following, as applicable:

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

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

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1A; or

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

26 Capacitors

26.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 26.2 and 26.3, the container shall be of metal providing strength and protection not less than that of uncoated steel 0.020 inch (0.51 mm) thick.

26.2 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 boiler assembly, and provided that such box, case, or the like, is acceptable for the enclosure of current-carrying parts.

26.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead-metal parts in accordance with Table 28.1.

26.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 41.

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

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

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27 Insulating Material

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

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

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

SPACINGS

28 High-Voltage Circuits

28.1 Except as noted in 28.2 – 28.4, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead-metal part shall be not less than the values indicated in Table 28.1.

Table 28.1
Minimum Spacings

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

[a] See 27.3.

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

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

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

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

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

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28.3 The spacing requirements in Table 28.1 do not apply to the inherent spacings of a component which is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, shall be those indicated.

28.4 All uninsulated live parts connected to different circuits, except subdivided or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated in 28.1 – 28.3 and shall be judged on the basis of the highest voltage involved.

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

29 Low-Voltage Circuits

29.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons shall comply with 29.2 – 29.4.

29.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 28.4.

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

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

29.5 The spacings in low-voltage circuits that do not contain devices such as indicated in 29.1 are not specified.

PROTECTION OF USERS AND SERVICE PERSONNEL

30 General

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

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

a) Adjusting the setting of temperature controls with or without marked dial settings;

b) Resetting control trip mechanism;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

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

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30.3 The requirements of 30.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

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

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

b) Are not located within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

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

30.6 Accessibility and protection from a risk of fire, electric shock, or injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through the access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 30.1:

a) The components are located with respect to the access opening in the cabinet so that the farthest component in the control assembly is not more than 14 inches (356 mm) from the plane of the access opening;

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

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

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

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

1) There is unimpeded access to these components through the access opening in the outer cabinet; and

2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

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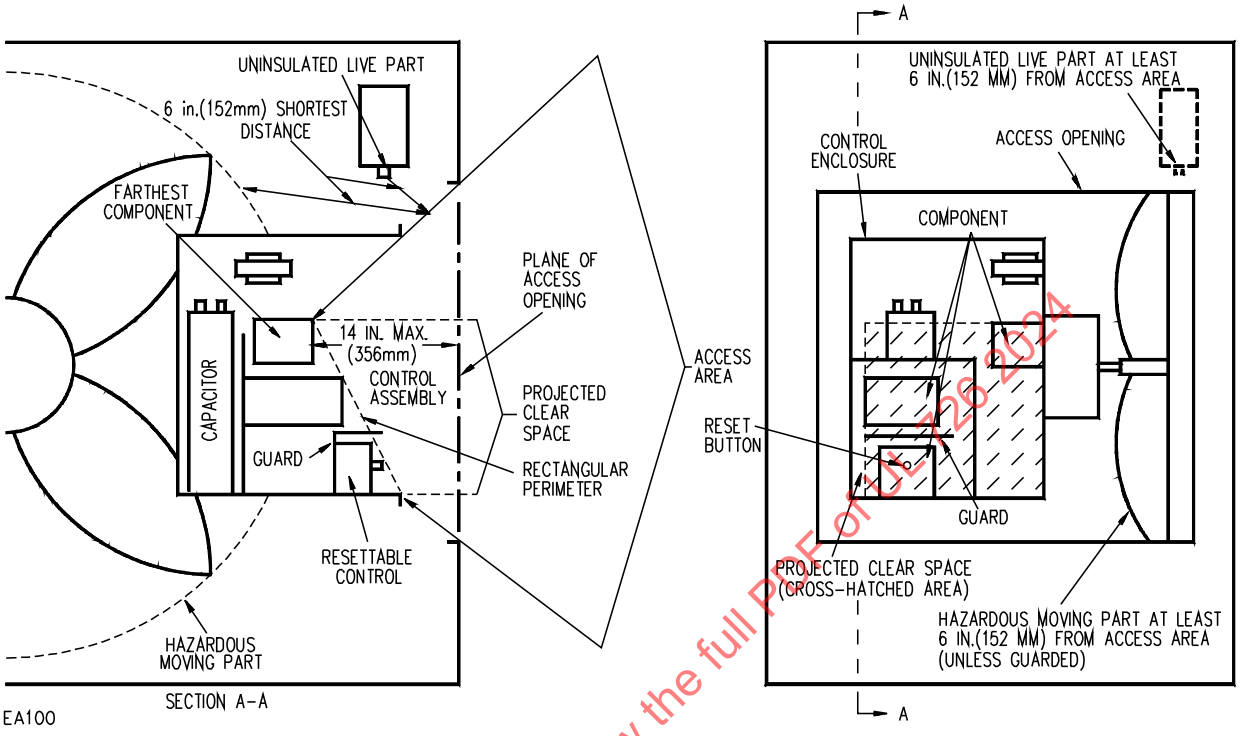
Figure 30.1

Accessibility and protection



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30.7 Components in a low-voltage circuit shall comply with the requirements of 30.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

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

a) Coils of controllers;

b) Relays and solenoids;

c) Transformer windings, if the coils and windings are provided with insulating overwraps;

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wires.

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

a) The opening or removal of the door, panel or shield shall require the use of tools;

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).

30.10 The distance from an opening in a required guard or enclosure to the moving part mentioned in 30.9 shall be in accordance with Table 30.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 30.1
Dimensions of openings

Minor dimensions of opening		Minimum distance from opening to moving part	
Inches	(mm)	Inches	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)
2	(50.8)	14-1/2	(368)
Over 2 inches	(Over 50.8)	30	(762)

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

30.11 A moving part is not to be considered when judging compliance with 30.1 and 30.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

PERFORMANCE

31 General

31.1 A boiler assembly shall meet the applicable requirements when tested as described herein. An assembly of a type not described specifically herein is to be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed herein that an assembly will not continue to meet the requirements in normal usage so as to assure continued safe performance, such supplementary tests shall be conducted as deemed necessary to assure safe service.

31.2 A boiler assembly is to be tested normally as suitable for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than indicated in Table 31.1. Such a boiler assembly is categorized under Form II, Form III, or Form IV, depending on its physical size and/or operating pressure as noted in Table 31.1. At the option of the manufacturer, a boiler assembly operating at not more than 50 psi (345 kPa) pressure may be tested as suitable for installation on combustible floors and when so tested is categorized under Form IIa or Form IIIa, depending on its physical size.

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Table 31.1
Standard clearances

Type of Boiler	Minimum clearance, inches (mm)											
	A		B		C		D		E		F	
	Above		Front		Chimney connector		Rear		Sides		Below	
Form II	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	NC	
Form IIa	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	C	
Form III	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	NC	
Form IIIa	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	C	
Form IV	48	(1219)	96	(2438)	36	(914)	36	(914)	36	(914)	NC	
Form IVa	48	(1219)	96	(2438)	36	(914)	36	(914)	36	(914)	C	

Where:

C – Combustible.

NC – Noncombustible.

Form II – Water walled types - hot water boilers, low pressure steam boilers, not larger than 100 cubic feet (2.8 m^3) in size excluding burner - not equipped with draft hood.

Form IIa – Warm Air Furnace, horizontal forced, not larger than 100 cubic feet (2.8 m^3) in size excluding blower compartments and burner and installed at zero below clearance - not equipped with draft hood. And, same as Form II boilers except installed on combustible flooring.

Form III – Low Heat Industrial Device, Floor mounted type furnaces and heaters and not classified under Forms I (furnaces) or XI (furnaces and heaters) and, hot water boilers and steam boilers operating at not more than 1000°F (537°C) flue gas temperature not classified under Form II or XII.

Form IIIa – Same as Form III except installed on combustible flooring.

Form IV – Medium Heat Industrial Devices, steam boilers operating in excess of 1000°F (537°C) flue gas temperature.

Form IVa – Same as Form IV except installed on combustible flooring.

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31.3 At the further option of the manufacturer, a boiler assembly may be tested with clearances less than those indicated in Table 31.1. A boiler assembly of the type categorized under Forms II and IIa, see Table 31.1, equipped with an integral limit control may be tested as suitable for installation in an alcove or closet.

31.4 If a boiler assembly is to be tested in a partial enclosure at clearances less than those designated as standard in Table 31.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are to be at least 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 31.1, the connector arrangement is to be as specified in 33.2.3 and Figure 33.2. Except for those modifications of the enclosure and as otherwise provided herein, tests are to be conducted in the manner described for standard clearances.

31.5 The minimum standard clearances designated in Table 31.1 are based on the boiler assembly being installed in a room that is large compared to the size of the assembly. All clearances designated in Table 31.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

31.6 Additional performance requirements are specified in 8.1, 8.2 and 25.8.

31.7 When a boiler assembly is intended to fire a fuel oil/biodiesel blend comprised of greater than twenty percent biodiesel (i.e. >B20 biodiesel), the boiler assembly shall be tested in accordance with this standard with No. 2 fuel oil. In addition, the Range of Fuels test described in 36A.1 shall be conducted immediately following the Combustion Test – Burner and Boiler as described in Section 36.

32 Test Installation for Standard Clearances

32.1 Enclosure

32.1.1 A boiler assembly is to be placed in a partial enclosure in the as-received condition, as described in 32.1.2 – 32.1.5. Except as permitted by 31.3, the distance from the back, side, and top of the assembly and from the chimney connector to the walls and ceiling of the enclosure is to be as indicated in Table 31.1. If one side of the assembly may create a higher wall temperature than the other, that side of the assembly is to be directly opposite one wall. A boiler assembly categorized under Forms IV and IVa need not be placed in a partial enclosure unless it is to be tested at clearances less than those designated as standard in Table 31.1.

32.1.2 As an alternative to 32.1.1, when tested at clearances designated as standard in Table 31.1, the partial test enclosure may be eliminated and thermocouples attached to the outer casing panels as specified by 34.5.4 – 34.5.6. The temperature at points on external surfaces of the appliance, except within 9 inches (229 mm) of the flue collar or any inspection or relief opening, shall not exceed the values specified in Table 39.1.

32.1.3 The boiler assembly is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the boiler assembly the minimum allowable distance above the floor.

32.1.4 The partial enclosure is to be formed by two walls of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. See Figure 32.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to be such as to obtain the minimum clearance above the boiler assembly specified in Table 31.1 and in accordance with 31.3. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the boiler assembly. Except as permitted by 31.3, the walls are to be the minimum distance specified in Table 31.1 from the side and back of the boiler assembly, except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 32.2.1.

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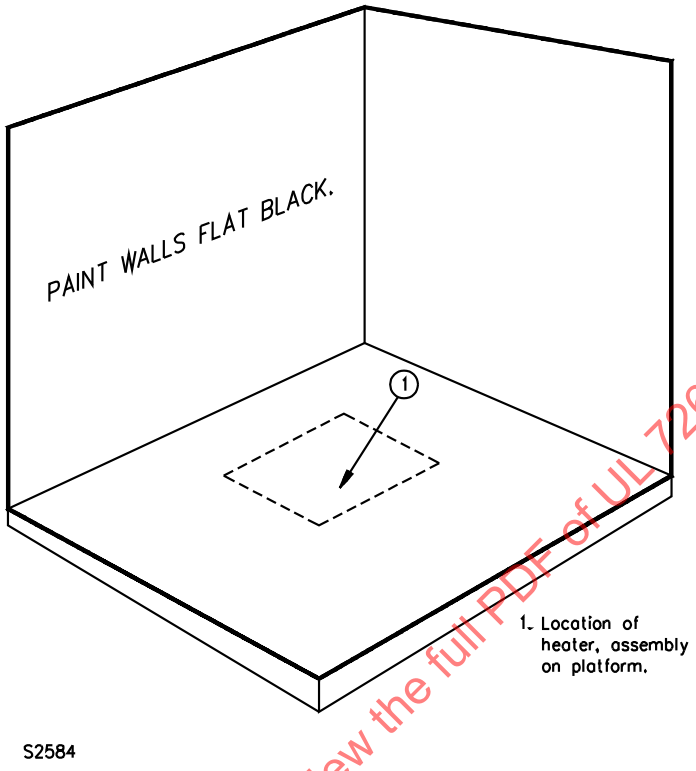
Figure 32.1

Test enclosure for standard clearances



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32.1.5 If the boiler is intended for direct installation on combustible flooring, the floor beneath the boiler assembly is to be 1 inch (25.4 mm) white pine flooring covered with one thickness of building paper, and then by 3/4 inch (19.1 mm) thick plywood, unpainted or finished with a clear sealer.

32.1.6 If the boiler is intended to be insulated in service, it may be tested with the covering furnished by the manufacturer as standard equipment. If the boiler covering is not furnished as part of the boiler assembly, the assembly may be tested with plastic magnesia or equivalent insulation 1-1/2 inches (38.1 mm) thick.

32.1.7 If the boiler covering is not furnished by the manufacturer or if the covering is furnished by the manufacturer but not factory assembled on the boiler, the manufacturer is to specify such covering as is specified in 32.1.6 or the manner in which the separately packaged factory furnished covering is to be installed. This information is to be furnished in conjunction with the clearance information to appear on the boiler assembly. Such information should also be included with the instructions furnished with the boiler assembly.

32.1.8 The limit control, if furnished separately for mounting in the field, is to be located as specified in the installation instructions furnished with the boiler assembly.

32.1.9 The inlet air temperature is to be measured by a thermocouple, not heavier than 24 AWG (0.21 mm^2), shielded from direct radiation and located centrally 24 inches (610 mm) in front of the boiler assembly and 24 inches above the floor of the test enclosure.

32.2 Chimney connector

32.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the boiler. Galvanized stovepipe not heavier than 0.023 inch (0.58 mm) (No. 24 GSG) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure, directly connected to and extended vertically above a vertical flue outlet, and connected to a horizontal flue outlet by using a 90 degree sheet metal elbow at the bottom of the vertical section. See Figure 32.2.

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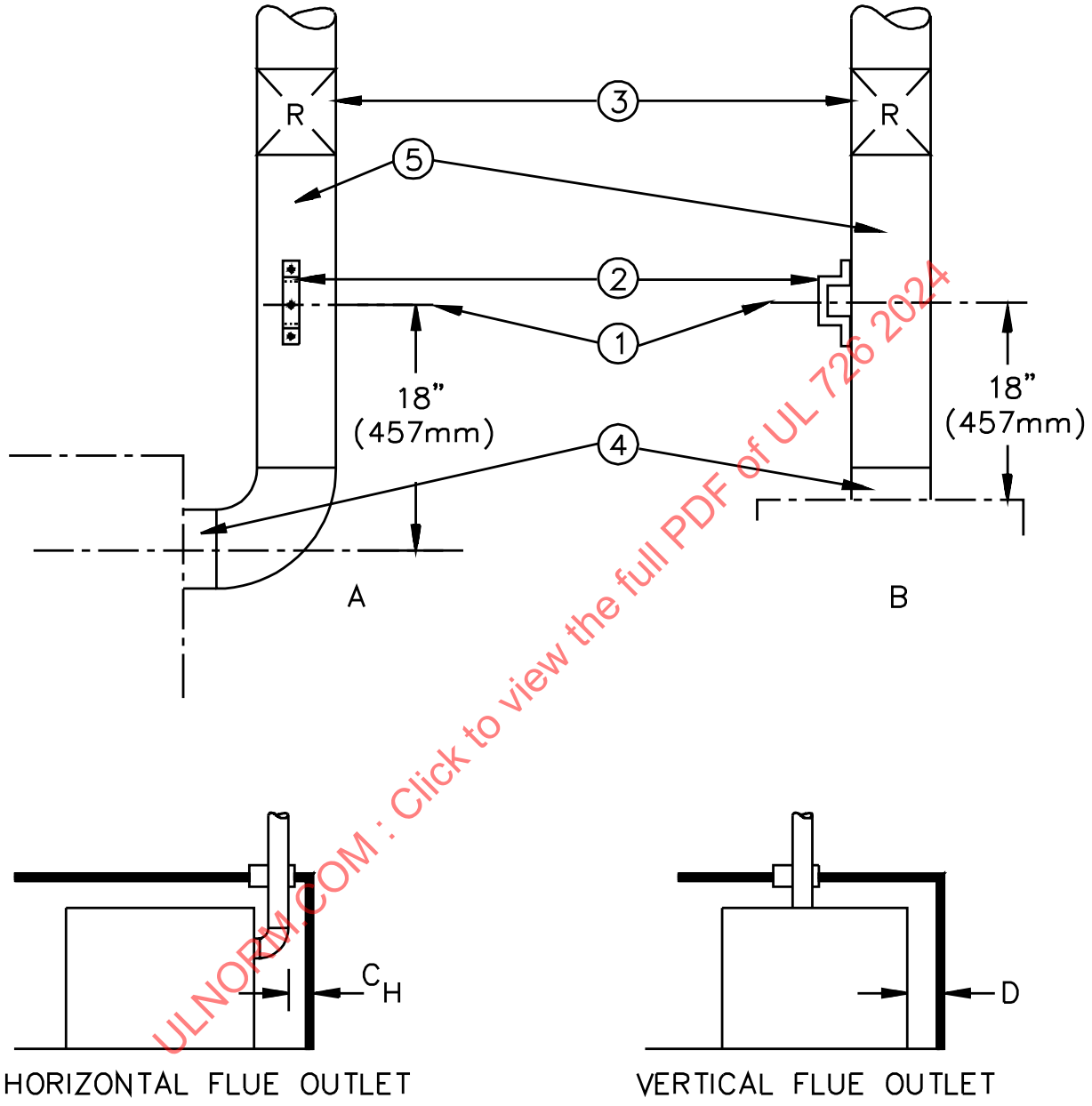
Figure 32.2

Chimney connectors – standard clearance test



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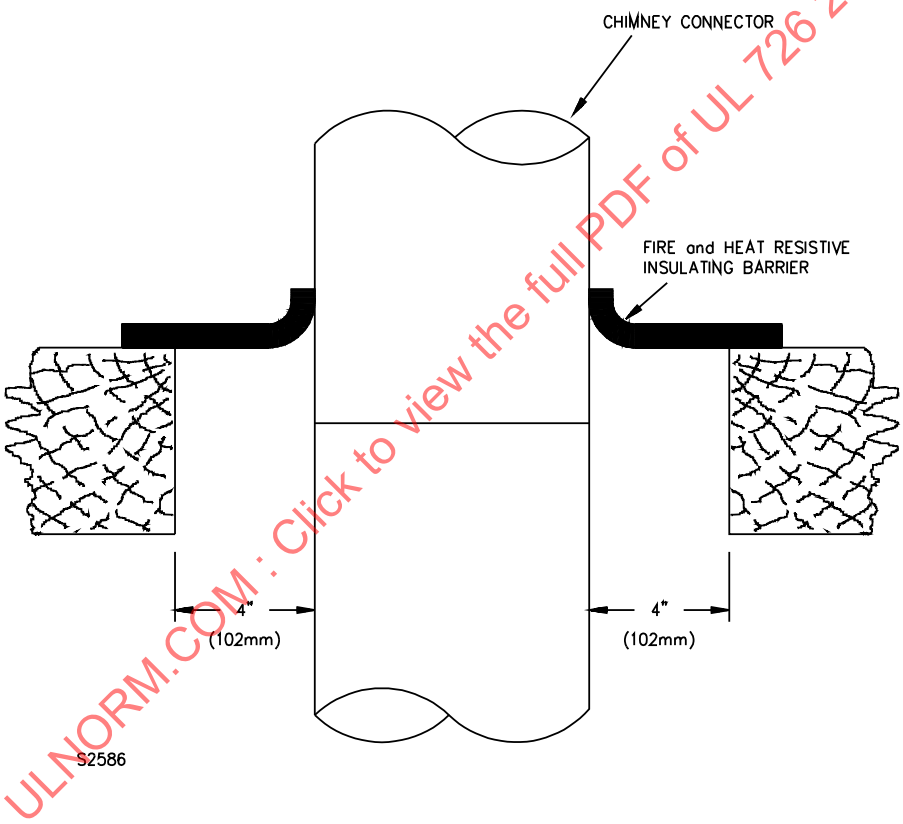
1. Centerline of thermocouple.
2. Support bracket.
3. Draft Regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.

32.2.2 For a boiler assembly tested in a partial enclosure (see Figure 32.1) at clearances less than those designated as standard in Table 31.1, the clearances from the chimney connector are to be not less than 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 31.1, the chimney connector arrangement is to be as specified in 33.2.3 and Figure 33.2.

32.2.3 Where the chimney connector pierces the enclosure, an opening 8 inches (203 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 32.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50.8 mm) from the outer edge of the annulus.

Figure 32.3

Sealing of annulus around chimney connector



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32.2.4 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2 of Figure 32.2.

32.2.5 The primary safety control, if furnished separately for mounting in the chimney connector exterior to the boiler assembly, may be located at any appropriate point either within or exterior to the test enclosure. No temperature measurements in or on a control so located are to be made during tests for standard clearances.

32.2.6 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 32.2.

32.2.7 Any built-in draft regulator included as part of the boiler assembly is to be fixed in the position allowing maximum draft.

32.2.8 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

33 Test Installation for Alcove or Closet

33.1 Enclosure

33.1.1 The boiler assembly is to be installed in an enclosure as described in 33.1.2– 33.1.4 and Figure 33.1, in the as-received condition, with clearances in integral inches as selected by the manufacturer to walls and ceiling of the test enclosure. The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the boiler assembly to the ceiling specified by the manufacturer, but in no case is the ceiling height to be more than 7 feet, 6 inches (2.25 m). See Figure 33.1.

33.1.2 The walls and ceiling of the enclosure are to be made of 1 inch nominal thickness wooden boards or 3/4 inch (19.1 mm) thick plywood. The walls are to be vertical and at right angles. The interior surfaces of the walls and ceiling are to be finished in flat black. All joints in the enclosure are to be sealed. The floor is to be of combustible or noncombustible material, as selected by the manufacturer for testing purposes. Combustible floors are to be made of 1 inch (25.4 mm) flooring covered with one thickness of building paper superimposed by 3/4 inch thick plywood, unpainted or finished with clear sealer.

33.1.3 For the alcove installation test, the enclosure is to be open opposite the front of the boiler assembly. The side walls and ceiling are to extend 18 inches (457 mm) beyond the front of the boiler assembly, and a wall is to be placed opposite the open side of the enclosure at a distance of 48, 36, or 24 inches (1.22, 0.91, or 0.6 m, respectively), as specified by the manufacturer for testing purposes.

33.1.4 For the closet installation test, a simulated door is to be provided for the enclosure. The door is to have two openings located so that the lower edge of the lower opening is 6 inches (152 mm) above the floor level of the enclosure and the other is located so that its upper edge is 6 inches below the ceiling of the enclosure. The height of each opening is to be one-half the width. The free area of each of the two openings is to be at least 1 square inch (6.4 cm^2) per 1000 Btu per hour (293 W) of the boiler input rating but not more than an area equivalent to 20 percent of the total area of the simulated door. Both openings are to be centered on vertical center lines in accordance with the instructions furnished with the boiler assembly.

33.1.5 The boiler is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the boiler the minimum allowable distance above the floor.

33.1.6 If the boiler is intended to be insulated in service, it may be tested with the insulation furnished by the manufacturer as standard equipment with each boiler.

33.1.7 The inlet air temperature is to be measured by a thermocouple not heavier than 24 AWG (0.21 mm^2) and shielded from direct radiation. For alcove installation, the thermocouple is to be placed centrally 24 inches (610 mm) in front of the boiler and 24 inches (610 mm) above the floor of the test enclosure. For closet installation, the thermocouple is to be placed in the center of the lower ventilating opening into the closet.

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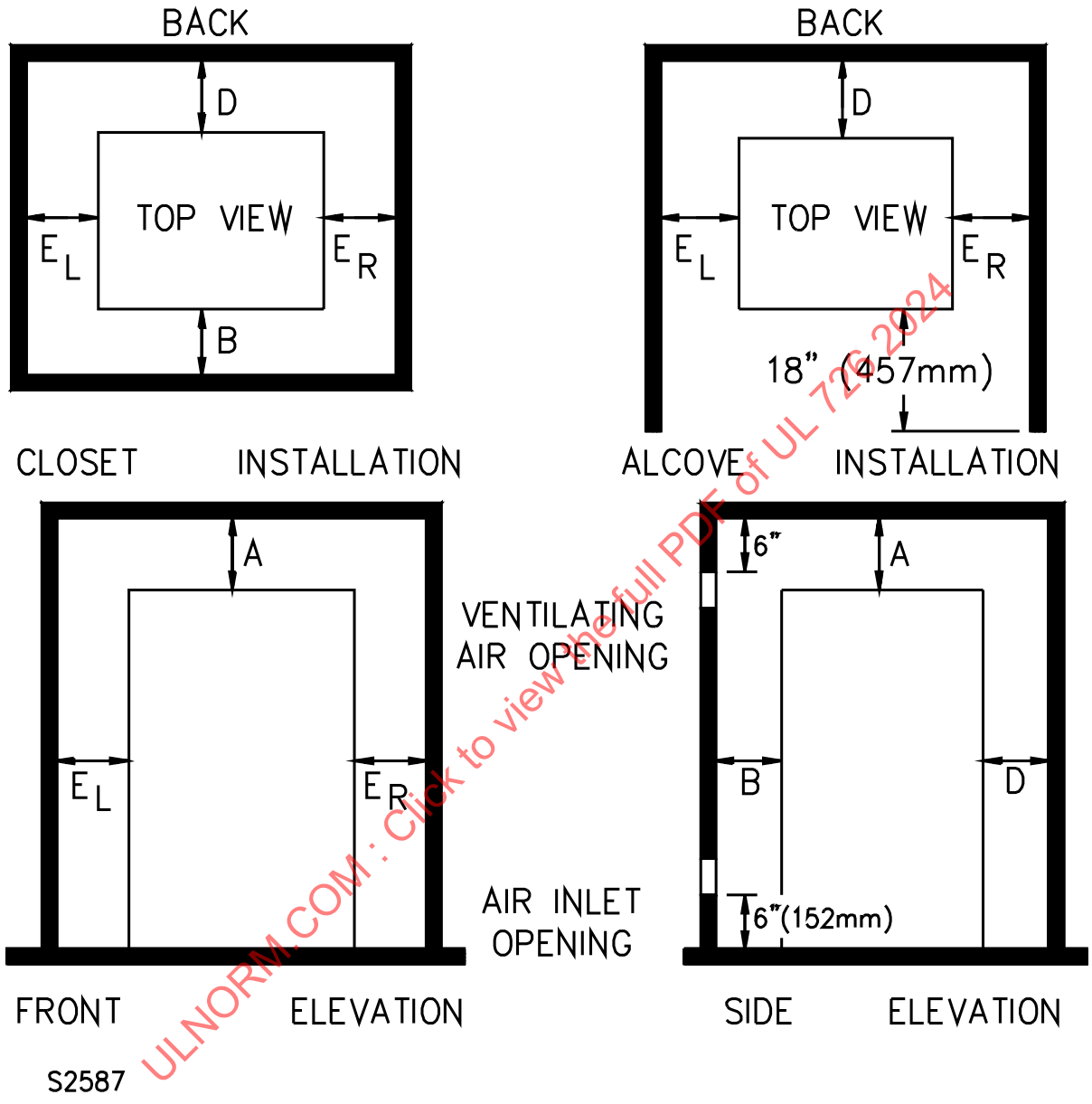
Figure 33.1

Test enclosure for alcove or closet installation



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A – From top of boiler assembly.

B – From front of boiler assembly.

C^H – From chimney connector, measured horizontally or below connector. See Figure 33.3.

C^V – From chimney connector, measured vertically above connector. See Figure 33.3.

D – From back of boiler assembly.

E_L – From left side of boiler assembly.

E_R – From right side of boiler assembly.

33.2 Chimney connector

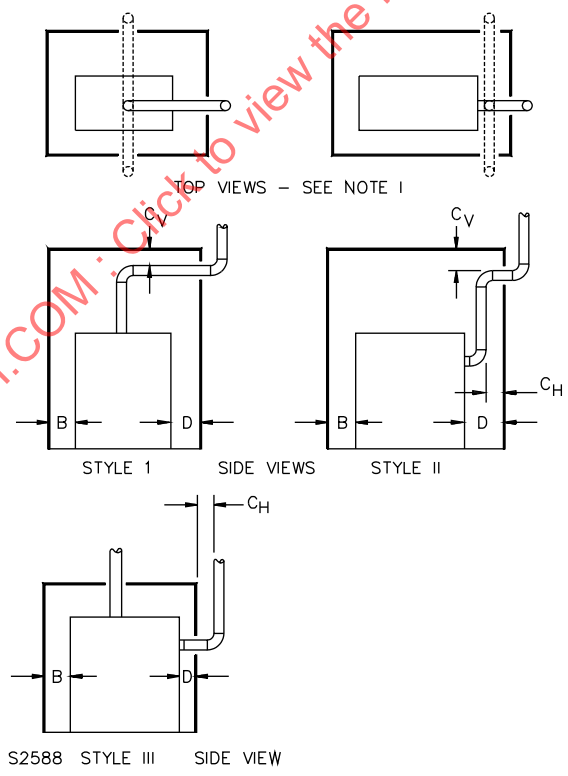
33.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the boiler assembly. Galvanized stovepipe not heavier than 0.023 inch (0.58 mm), No. 24 GSG, is to be used.

33.2.2 The clearance between the nearest surfaces of the chimney connector and the walls and ceiling is to be not less than 9 inches (229 mm) nor more than 18 inches (457 mm), with the following exception: If the construction of the boiler assembly is such that when installed with the clearances selected by the manufacturer, the clearance between the chimney connector and the interior walls of the test enclosure is less than 9 inches, the test may be conducted with such lesser clearance from the walls with portions of the wall located within 9 inches of the chimney connector that is protected, in which case directions that such surfaces shall be so protected are to be included in the instructions furnished with the boiler assembly.

33.2.3 A boiler assembly with vertical flue outlets is to be tested with two chimney connector arrangements, Styles I and III, and a boiler assembly with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III as indicated by Figure 33.2, unless the manufacturer elects to specify the minimum clearance from the boiler assembly as that obtained when tested with the chimney connector arranged in accordance with Style I or II only.

Figure 33.2

Chimney connectors arrangement for alcove and closet installation



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33.2.4 Where the chimney connector pierces the enclosure, an opening having a diameter 8 inches (203 mm) larger than the diameter of the chimney connector is to be cut and the chimney connector centered in the opening. The annulus thus formed is to be sealed by a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick, placed on the exterior surface. See Figure 32.3. Temperatures on the surfaces

surrounding the chimney connector are not to be determined at points located less than 2 inches (50.8 mm) from the outer edge of the annulus.

33.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2 of Figure 33.3.

33.2.6 The primary safety control, if furnished separately for mounting in the chimney connector, is to be located with its element in a plane perpendicular to the axis of the flue-gas flow, 6 inches (152 mm) downstream from the flue collar or, if an elbow is attached directly to the flue collar, 6 inches downstream from the downstream end of the elbow. See item 6 of Figure 33.3.

33.2.7 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 33.3.

33.2.8 Any built-in draft regulator included as part of the boiler assembly is to be fixed in the position allowing maximum draft.

33.2.9 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

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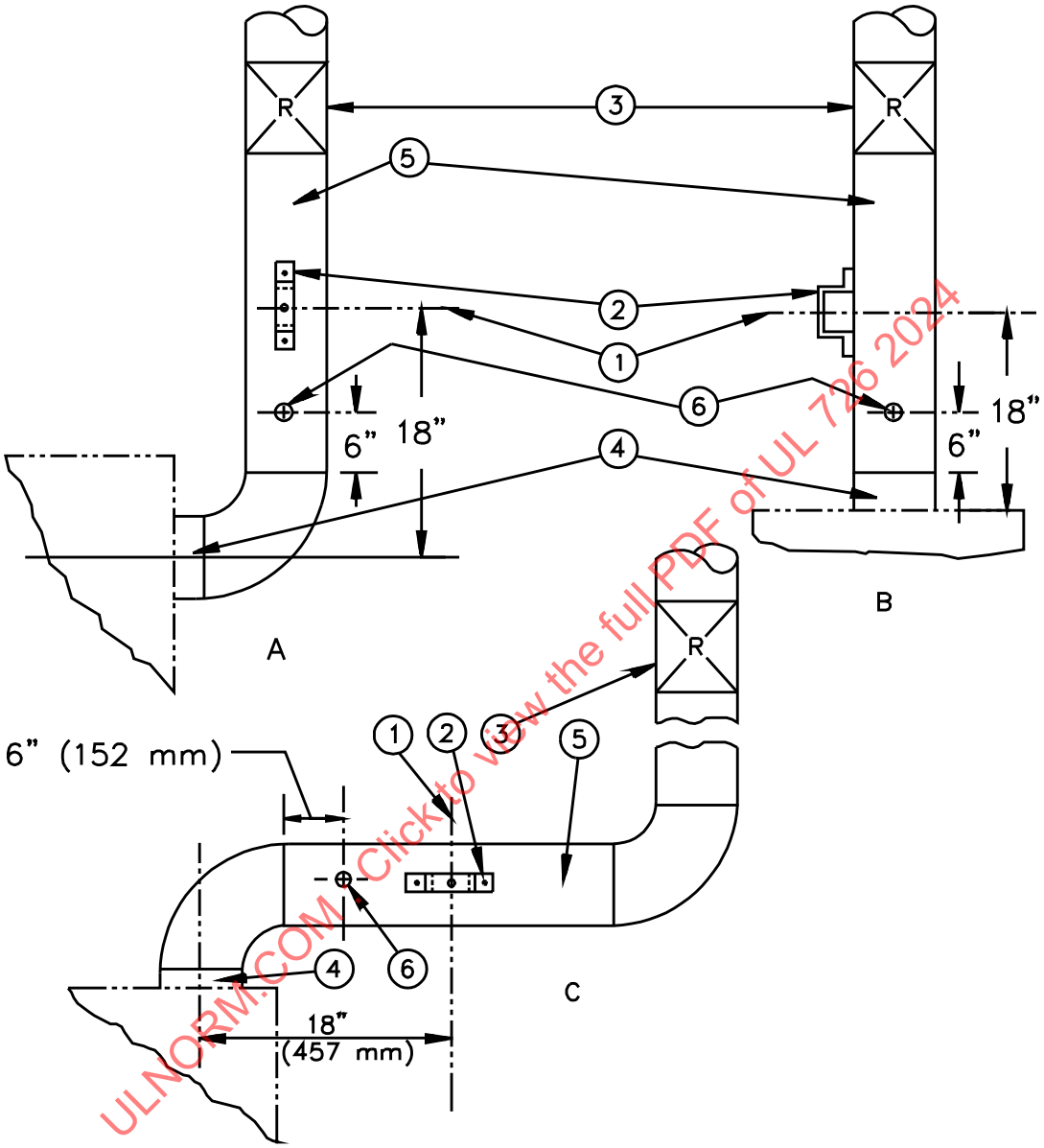
Figure 33.3

Chimney connectors – alcove and closet test



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1. Center line of thermocouple.
2. Support bracket.
3. Draft regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.
6. Location of stack element of safety control.

34 Instrumentation

34.1 Draft

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

34.2 Fuel input

34.2.1 The fuel input rate to a burner during a test is to be determined by a scale accurate to 0.01 pound (4.54 g) or a burette capable of the same resultant accuracy.

34.3 Power measurement

34.3.1 The total electrical input to a boiler assembly is to be measured in amperes.

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

34.4 Speed measurement

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

34.5 Temperature measurement

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

34.5.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 39.1.

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

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

34.5.5 Thermocouples are to be attached to surfaces other than as described in 34.5.3 and 34.5.4 by being cemented or taped to the surface in a manner to assure good thermal contact with the surface.

34.5.6 The flue-gas temperature is to be measured by a thermocouple such as illustrated by Figure 34.1 inserted into the chimney connector as shown on Figure 34.2. There is to be no draft control between the

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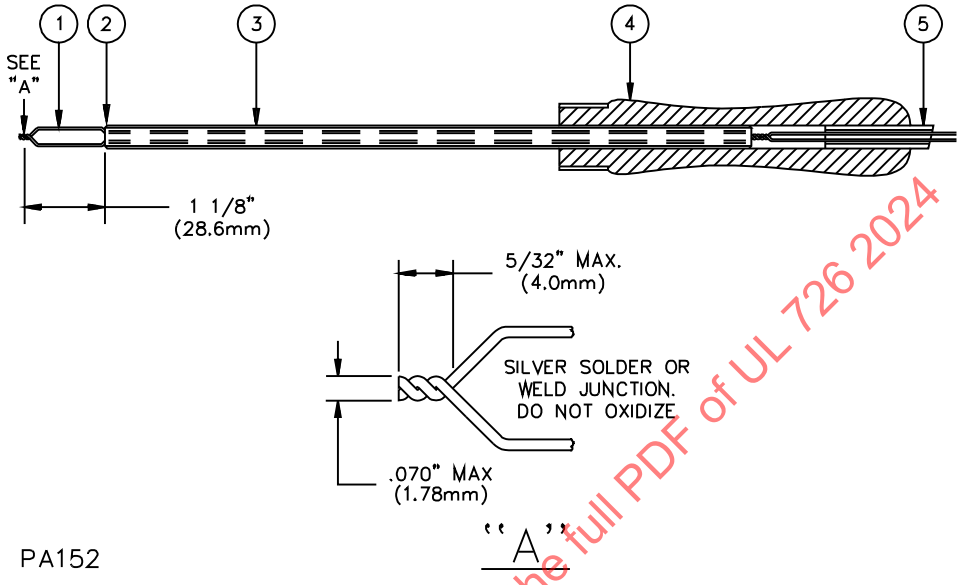
boiler and the point where the flue-gas temperature is measured. If a draft control is incorporated in the boiler assembly, it is to be dependably sealed in the position allowing maximum draft during all tests.

Figure 34.1

Standard thermocouple for flue-gas temperature



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

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

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

4. 1 – Small wooden handle.

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

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

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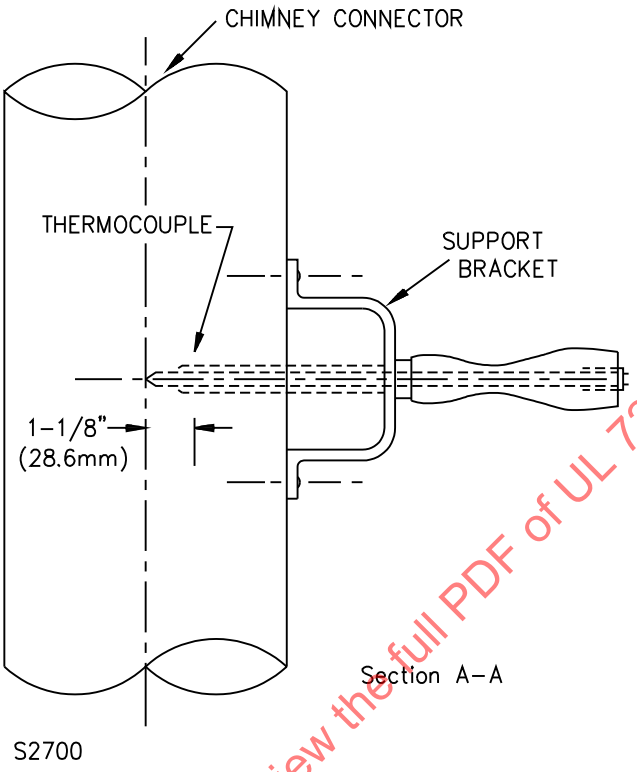
Figure 34.2

Flue-gas thermocouple and support bracket



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

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

35 Initial Test Conditions

35.1 The boiler assembly is to be set up for test in the appropriate enclosure and manner described in Test Installation for Standard Clearances, Section 32.

35.2 Unless otherwise specified in the paragraphs describing the tests, boiler assemblies are to be tested at the potentials indicated in Table 35.1.

Table 35.1
Test voltages

Rated voltage	Normal test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600
Other	Rated

35.3 The boiler assembly is to be fired at its rated Btu per hour (W) input, ±2 percent, with a grade of fuel for which the burner is rated. The draft at the flue collar is to be as recommended by the manufacturer but not more than 0.06 inch (1.5 mm) water column for burners fired at 5 gallons (18.9 L) per hour or less and not more than 0.09 inch (2.29 mm) for burners fired at rates from 5 to 16 gallons (18.9 to 60.6 L) per hour.

36 Combustion Test – Burner and Boiler

36.1 When tested at steady state conditions as described in 36.2:

a) The smoke in the flue gases shall not exceed that indicated by a number 2 spot for boilers firing a distillate fuel and a number 4 spot for boilers firing a residual type fuel as indicated on the Shell-Bacharach Scale with the Model RDC Smokemeter; and

b) The stack loss for a boiler assembly shall not exceed 25 percent.

36.2 For the test specified in 36.1 the boiler is to be installed and adjusted in accordance with the manufacturer's instructions, and fired at rated input and operated until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established. The current input to the assembly is to be measured during this test.

36A Range of Fuels Test – Burner and Boiler

36A.1 In accordance with 31.7, this test shall be conducted on a boiler assembly intended to fire a fuel oil/biodiesel blend comprised of greater than twenty percent biodiesel (i.e. >B20 biodiesel) or biodiesel (B100).

36A.2 The boiler assembly is to be set up as defined in the Combustion Test – Burner and Boiler in Section 36, as applicable.

36A.3 The boiler assembly shall be fired with the highest percentage fuel oil/biodiesel blend (minimum B21) or B100, the burner excess air, flue gas CO_2, or flue gas oxygen shall be adjusted to a level specified by the manufacturer in their instructions shipped with the burner for the manufacturer's rated fuel oil/biodiesel blend or B100. If the manufacturer's instructions do not specify an excess, flue gas CO_2, or flue gas oxygen level when operating with the rated fuel oil/biodiesel blend, the burner air/fuel ratio shall be adjusted to provide 11.5 % flue gas CO_2.

36A.4 Without any other adjustment to the burner the fuel supply shall be changed from the rated fuel oil/biodiesel blend or B100 to No. 2 fuel oil. When operating at steady state, in accordance with 36.2, with No. 2 fuel oil, the boiler assembly shall meet all requirements of the Combustion Test – Burner and Boiler described in Section 36.

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37 Operation Tests

37.1 The limit control for a low-pressure boiler when adjusted to its maximum setting allowed by a fixed stop shall function when the temperature of the water in a hot-water heating boiler is not more than 250°F (121°C) and when the pressure in a steam heating boiler is not more than 15 psi (103 kPa), when the boiler assembly is tested as described herein. The limit control for a high-pressure boiler shall function when the pressure is not more than the designed working pressure of the boiler, or when the water temperature in a hot-water boiler is not more than the temperature of saturated steam at the designed working pressure of the boiler, when the boiler assembly is tested as described herein. See Limit Control Cutout Test.

38 Limit Control Cutout Test

38.1 The boiler is to be filled to the intended level with water. A steam or a hot-water boiler is to be provided with a pressure-relief valve.

38.2 The limit control, if adjustable, is to be adjusted to the highest temperature or pressure setting, as applicable. Any modulating type operating control provided to regulate the fuel input between high and low fire values is to be by-passed to permit the appliance to operate on high fire. The on-off type operating control, set to cut out at a value below the set point of the limit control, is also to be bypassed during this test.

38.3 The water temperature obtained in a hot-water boiler is to be measured as described in 34.5.7. The inlet and outlet water valves are to be adjusted so that hot water passes the thermocouple bead during the test.

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

38.5 The boiler is to be fired at rated input and the water or steam valves adjusted to raise the temperature or pressure until the limit control functions. Neither the maximum water temperature in the boiler nor the pressure is to exceed the values indicated in 13.5.2 and 13.6.1.

39 Temperature Tests

39.1 When a boiler assembly is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to impair intended operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause in creeping, distortion, sagging, or similar damage if such damage to the material or part may cause the boiler assembly to introduce a risk of fire, electric shock, or injury to persons. The temperature rises at specific points shall be not greater than those specified in Table 39.1, unless otherwise indicated. Water temperature or steam pressure shall not be excessive. See Continuous Operation Test.

39.2 Motors shall not exceed the temperature rises indicated in Table 39.1 when tested as described herein.

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