UL 730

STANDARD FOR SAFETY

Oil-Fired Wall Furnaces

UL Standard for Safety for Oil-Fired Wall Furnaces, UL 730

Fifth Edition, Dated August 29, 2003

Summary of Topics

This revision of UL 730 dated August 19, 2022 is being issued to remove the ANSI logo and approval from the title page. No other changes have been made.

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

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UL 730

Standard for Oil-Fired Wall Furnaces

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August 29, 2003

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

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INTRODUCTION

1 Scope

1.1 These requirements apply to oil-fired, vented, fan-type wall furnaces. Requirements for the installation and use of oil-burning equipment are included in the Standard for the Installation of Oil-Burning Equipment, NFPA 31.

1.2 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 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.

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

3.7 BASE – The main supporting frame or structure of the wall furnace, exclusive of legs.

3.8 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 burners.

3.9 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.

3.10 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.

3.11 BURNER, VAPORIZING TYPE – A burner consisting of an oil vaporizing bowl or other receptacle to which liquid fuel may be fed in controllable quantities; the heat of combustion being used to vaporize the fuel, with provision for admitting air and mixing it with the oil vapor in combustible proportions.

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

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

3.14 CHIMNEY CONNECTOR – The pipe which connects a solid or liquid fuel burning appliance to a chimney.

3.15 COMBUSTIBLE MATERIAL – Combustible material as pertaining to materials adjacent to or in contact with heat producing appliances, chimney connectors and vent connectors, 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 though flame-proofed, fire-retardant treated, or plastered.

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

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

3.18 COMBUSTION (FLAME) SAFEGUARD – A safety combustion control.

3.19 CONSTANT LEVEL VALVE – A device for maintaining within a reservoir a constant level of fuel for delivery to the burner.

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

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

3.22 CONTROL, SAFETY – Automatic controls, including relays, switches, and other auxiliary equipment used in conjunction therewith to form a safety control system, which are intended to prevent unsafe operation of the controlled equipment.

3.23 CONTROL, PRIMARY SAFETY – The automatic safety control intended to prevent abnormal discharge of oil at the burner in case of ignition failure or flame failure.

3.24 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.

3.25 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.

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

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

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

3.29 ELECTRICAL CIRCUITS:

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

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak or direct current) and supplied by a primary battery or by a standard Class 2 transformer or other suitable transforming device, or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

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

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

3.31 FLUE – The general term for the conduit or passageway through which flue gases pass from the combustion chamber to the outer air.

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

3.33 FLUE GASES – Combustion products and excess air.

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

3.35 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, and held in close contact with the combustion chamber walls. It is a self-contained combustion and heat transfer device, hence a direct heat transfer device.

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

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

3.38 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.

3.39 LIMIT CONTROL – See Control, Limit – 3.21.

3.40 LINER – See Radiation Shield – 3.46.

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

3.42 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, and the like. 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.

e) Replacing igniter cable.

3.43 OIL-FIRED WALL FURNACE – A wall furnace 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 complete unit. This definition does not include oil stoves.

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

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

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

3.47 RADIATOR – Auxiliary heat transfer surfaces within the casing, connected between the combustion chamber and the flue collar.

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

3.49 SAFETY CONTROL – See Control, Safety – 3.22.

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

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

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

3.53 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.

3.54 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.

3.55 VENTED APPLIANCE – An indirect fired appliance provided with a flue collar to accommodate a flue pipe for conveying flue gases to the outer air.

3.56 WALL FURNACE – A self-contained indirect-fired appliance intended for incorporation in, insertion into, or permanent attachment to a wall or partition, and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing.

3A Undated References

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.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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.

CONSTRUCTION – MECHANICAL

5 Assembly

5.1 A wall furnace shall be factory built as a group assembly and shall include all the essential components necessary for its normal function when installed as intended. A wall furnace may be shipped as two or more major subassemblies.

5.2 A wall furnace, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated readily into the final assembly without requiring alteration, cutting, drilling (except to the extent indicated in 5.3), threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe installation or operation of the furnace, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other, without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

5.3 To be in accordance with 5.2, major subassemblies of a wall furnace are deemed to be the:

a) Burner;

b) Heat exchanger, including its base, combustion chamber, casing, and safety controls;

c) Blower assembly, including the base, filters, and casing; and

d) Blower motor if not included as part of the blower assembly.

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:

a) Assembled as part of the furnace;

b) Part of a subassembly that must be attached to the furnace for its normal operation; or

c) Such that the furnace cannot be assembled for operation without first attaching a required shield or baffle in its proper position.

5.5 The design of a wall furnace 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 wall furnace shall afford convenient operation by the user of those parts requiring attention or manipulation by him in normal usage.

5.7 Adjustable or movable parts shall be provided with locking devices to prevent accidental 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	(39.5)
7/16 inch	(11.1)	550	(62.1)
1/2 inch	(12.7)	800	(90.3)
9/16 inch	(14.3)	1200	(135.5)

5.9 A wall furnace shall be such that no portion of the products of combustion nor any portion of the heated circulating air or air from the space being heated will be discharged into spaces within walls, floor, or ceiling. Openings in the jacket, top, or sides, through which the chimney connector extends, shall be sufficiently close fitting to comply with this requirement.

5.10 A wall furnace shall be constructed to provide a constant circulation of heated air at all times during normal operations.

5.11 A wall furnace with a single warm air register shall not be equipped with a shutter to restrict the flow of warm air from the heater.

5.12 A wall furnace having more than one warm air register, when equipped with a shutter, shall be such that at least one warm air register will be open at any position of the shutter.

5.13 The bottom of the heater shall provide an oil-tight pan with an upturned flange not less than 1/2 inch (12.7 mm) high around the periphery and around any openings through the pan. All oil handling parts, including the fuel supply line connection, shall be directly above the pan.

5.14 The construction of a wall furnace shall provide for maintaining the minimum clearance required between the bottom, sides, and top of the furnace and concealed surfaces of the wall or partition in which or to which the furnace is to be installed. Spacers shall be of such strength and bearing surface as to maintain required clearance from building material.

5.15 The requirement of 5.14 does not apply to unconcealed portions of a furnace extending beyond the wall or partition into a readily accessible space such as an alcove, closet, or room. The clearance from such portions of the furnace to combustible construction may be as specified in integral inches by the manufacturer in the instructions for installation and as marked on the unit. See 54.1.

5.16 If the chimney connector is located within the wall or partition structure when the furnace is installed as intended, the furnace shall be designed for direct connection to a chimney or venting system when the furnace is placed directly adjacent to or beneath the chimney or venting system. Any special connection or extension required shall be provided as part of the furnace.

5.17 Any external door providing access into the combustion chamber of a wall furnace shall be self-closing.

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

5.19 A wall furnace equipped with an anti-flooding device shall be such that, when the furnace is level, the minimum distance between the intended maximum normal oil level maintained by the oil control device and the level of the lowest point at which overflow may occur is not less than 3/4 inch (19.1 mm).

6 Servicing

6.1 General

6.1.1 A wall furnace shall be built to allow cleaning of parts such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers, without major dismantling of the wall furnace or removal of parts required by 5.2 to be factory assembled.

6.1.2 The removal of access panels, burners, blowers, caps, plugs, and the like intended to permit ready removal and replacement for servicing, are not considered major dismantling as defined by 6.1.1.

6.1.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the wall furnace 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 wall furnace to the user.

6.1.4 The requirements of 33.1 are not applicable to mechanical service functions that are not intended to be performed while the equipment is energized.

6.2 Moving parts

6.2.1 Moving parts such as fan blades, blower wheels, pulleys, belts, and the like, which may cause injury shall be enclosed or guarded.

6.2.2 If the removal of doors, panels, or shields will expose such moving parts:

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

b) An interlocking device shall shut off the mechanism; or

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

DANGER – To Avoid Injury From Moving Parts, Shut Off The (Equipment) Before (Removing-Opening) This (Cover-Door).

6.2.3 The distance from an opening in a required guard or enclosure to the moving part mentioned in 6.2.2 shall be in accordance with Table 6.1, 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 (22.5 N).

Table 6.1
Dimensions of openings

Minor Dimensions of Opening,		Minimum Distance from Opening to Moving Part,	
Inches[a]	(mm)	Inches	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)
2	(50.8)	14-1/2	(369)
Over 2 Inches (over 50.8)		30	(762)

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

6.2.4 A moving part is not to be considered when judging compliance with 33.1 and 6.2.2 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

7 Disposal of Combustion Products

7.1 The construction of a wall furnace shall not allow the products of combustion to become mixed with the circulating air.

8 Casing

8.1 The outer casing or jacket shall be made of steel or equivalent material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) (No. 24 MSG), 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), and all surfaces shall be protected against corrosion. The finish on the outer casing or jacket of the wall furnace shall not be damaged by heat during any of the tests.

8.2 The casing of a wall furnace shall allow the access of sufficient air for combustion and for a draft regulator enclosed within the casing.

8.3 A wall furnace shall have all cold air inlet and warm air outlet openings blanked out at the factory where fabricated. These openings shall be fitted with grilles or registers attached to the casing or installed at the ends of stub ducts which shall be not more than 10 inches (254 mm) in length except as provided in 8.4. Where such ducts are provided, they are to be supplied by the manufacturer as an integral part of the appliance and tested as such in accordance with these requirements.

8.4 When a wall furnace with multiple warm air outlet openings is intended for installation and use with fewer as well as with all such openings, all except the minimum number of warm air outlets found acceptable by test shall have suitable covers supplied at the factory to close openings in liners and casings which may not be used at the installation.

8.5 Access panels which may be removed for normal service and accessibility shall permit ready removal and replacement without causing damage or impairing any required insulating value.

8.6 A removable panel through which air is drawn for combustion shall be such as to prevent it from being attached in a manner that may cause unsafe performance of the heater.

8.7 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same wall furnace when interchange may allow unsafe operation of the heater.

9 Radiation Shields

9.1 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. See 10.4 and 10.5. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperatures when the wall furnace is tested in accordance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the furnace is tested under these requirements.

10 Materials in Air Handling Compartment

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

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

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

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

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

e) Molded or formed components made of polymeric materials, not liners, in such quantity that the total surface area of such materials in the compartment does not exceed 10 square feet (0.92 m^2). See 10.7.

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

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

10.4 Thermal or acoustic insulating material shall be securely positioned if loosening may reduce or block air flow to cause temperatures in excess of those acceptable during testing as specified in Sections 43 – 47 and 49, or if loosening will result in reduction of electrical spacings below the required values, short-circuiting, or grounding. Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air, such as by butting edges of insulation against bulkheads.

10.5 A mechanical fastener for each square foot (0.09 m^2) of exposed surface is considered to securely position insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Rigid or semirigid sheets of insulating material may not require fastening to the extent needed for less rigid material or protection of leading edges if the material possesses inherent resistance to damage.

10.6 An adhesive required for securing insulation shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the performance requirements of this standard and at minus 17.8°C (0°F) or minus 29°C (minus 20°F) for outdoor use equipment.

10.7 Polymeric materials exempted by 10.1(e) shall not have a flame spread rating exceeding 25, or shall comply with the requirements specified in Section 52, Flammability Test.

11 Air Filter

11.1 A filter, if supplied as a part of the wall furnace, shall be accessible for inspection or replacement without the use of special tools and without dismantling the wall furnace.

12 Combustion Chamber

12.1 A combustion chamber and flueway within the air handling compartment shall be constructed of cast iron, sheet steel, or other equivalent material. Sheet steel, if used, shall have the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a minimum thickness of 0.032 inch (0.81 mm).

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

13 Radiator

13.1 A radiator shall be made of material not lighter than that specified in 12.1 for a combustion chamber and shall be capable of being cleaned as intended.

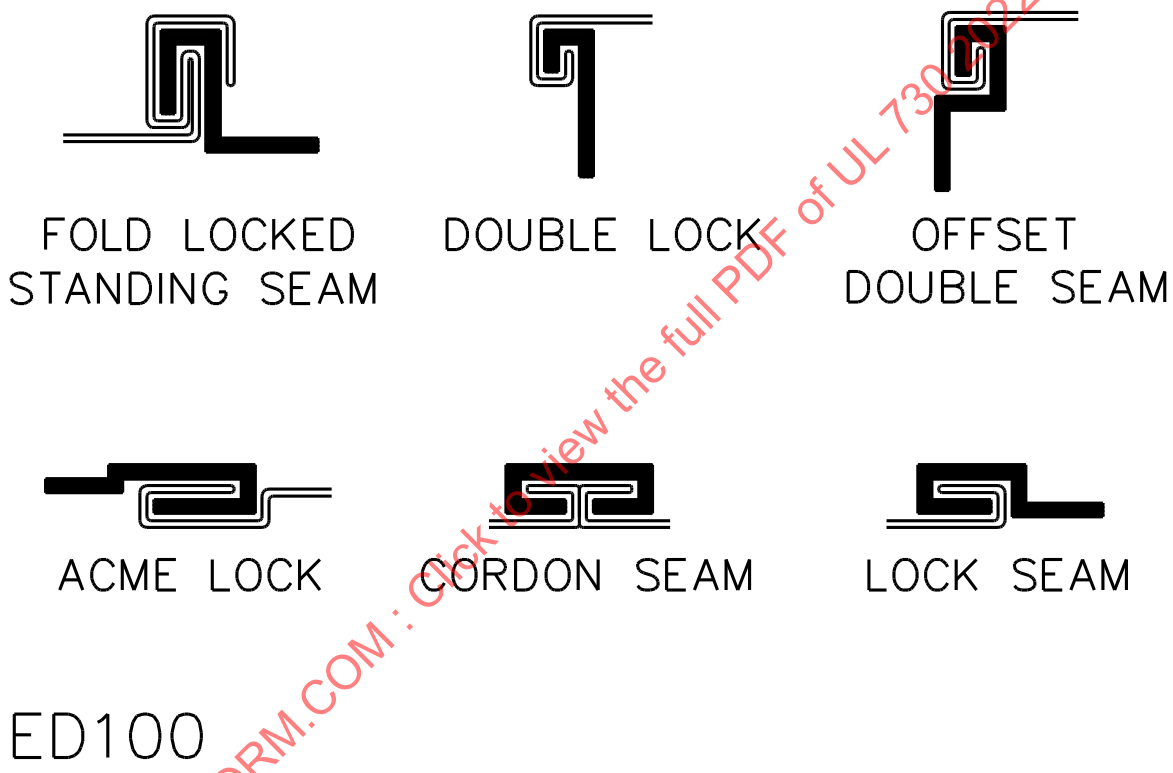
14 Heating Surface Joints

14.1 Joints in heating surfaces shall be tight, to the degree afforded by being welded, lock-seamed, machined and bolted, riveted, and the like. A joint shall be equivalent to that afforded by lock-seaming and shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

14.2 Examples of some acceptable lock-seams are illustrated by Figure 14.1.

Figure 14.1

Types of acceptable lock-seams



15 Baffles

15.1 A baffle in a flue gas passage or otherwise exposed to combustion products shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI 1010 hot-rolled sheet steel having a minimum thickness of 0.032 inch (0.81 mm) unless its deterioration will not cause temperatures in excess of those specified when the wall furnace is tested as specified in the Temperature Tests, Section 43; and Continuous Operation Temperatures, Section 44.

15.2 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall be such as to facilitate its removal and permit replacement only in its intended position.

16 Flue Collar

16.1 A flue collar shall be designed and arranged to permit the secure attachment of the chimney connector.

16.2 A flue collar or flue collector parts within the air handling compartment shall have the rigidity, heat resistance, and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.032 inch (0.81 mm).

17 Damper and Draft Regulator

17.1 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.

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

17.3 A furnace to be equipped with a barometric draft regulator shall not require that the regulator be installed in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

17.4 A draft regulator for a wall furnace to be installed within a concealed space shall be within the confines of the wall furnace casing and shall be accessible.

CONSTRUCTION – ELECTRICAL

18 Controls

18.1 Application

18.1.1 A safety control or protective device shall interrupt the ungrounded conductors.

18.1.2 The requirement in 18.1.1 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.

18.1.3 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.

18.1.4 All safety controls shall be accessible.

18.1.5 A safety control shall be supported so that it and its sensing element will remain in their intended position. It shall be possible to determine by observation or test whether or not each control is in its intended location.

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

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

18.2 Limit control

18.2.1 A furnace shall be provided with a limit control to prevent temperatures in excess of those specified in Sections 45 – 47, and 49.

18.2.2 The maximum setting of a limit control allowed by a fixed stop shall permit an outlet air temperature of not more than 250°F (121°C).

18.2.3 A limit control that functions to interrupt 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.

18.2.4 The purpose of the requirement specified in 18.2.3 is to avoid interposing in the limit control circuit other controls, the malfunction 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 that, 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.

18.2.5 A furnace equipped with a vaporizing burner shall be constructed to avoid pooling of the burner upon functioning of the limit control.

18.3 Primary safety control

18.3.1 A wall furnace shall be equipped with a primary safety control.

18.3.2 A constant level device shall maintain the oil level to within ±1/32 inch (0.8 mm) of the intended oil level during operation of the furnace.

19 Field Wiring

19.1 General

19.1.1 Provision shall be made for connection of a power supply wiring system conforming with the National Electrical Code, ANSI/NFPA 70.

19.1.2 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.

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

19.1.4 The size of a junction box in which field installed conductors are to be connected by splicing shall be not less than that specified in Table 19.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 19.1
Size of junction boxes

Size of conductors		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)

19.1.5 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 19.2.

Table 19.2
Trade size of conduit in inches[a,b]

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

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

[b] Conversion factors: 1/4 inch = 6.4 mm, 1 inch = 25.4 mm.

19.2 Leads and terminals

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

19.2.2 Leads may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead can cause a risk of fire or electric shock.

19.2.3 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 withstand a pull of 10 pounds (44.5 N) for 1 minute without damage to the assembly.

19.2.4 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.

19.2.5 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. Open slot-type connector shall not be used unless they are intended to prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing or the equivalent; if the required spacings may be reduced as a result of loosening of the clamping means, the thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

19.2.6 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.

19.2.7 Terminal parts by which field wiring connections are made shall consist of soldering lugs or pressure terminal connectors, secured in place in accordance with 19.2.12, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

19.2.8 A wire binding screw at a high-voltage wiring terminal for field connection shall be not smaller than No. 10 (4.8 mm diameter) except that a No. 8 (4.2 mm diameter) screw may be used for the connection of a conductor not larger than 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of 16 or 18 AWG (1.3 or 0.82 mm^2) control circuit conductors.

19.2.9 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; and in either case there shall be not less than two full threads in the metal.

19.2.10 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.

19.2.11 A wire binding screw shall thread into metal.

19.2.12 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 method.

19.2.13 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 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.

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

19.2.15 A box or enclosure in which field installed conductors are to be connected as indicated in 19.2.14 and 19.2.16 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 rated 60°C (140°F) when the furnace is tested in accordance with these requirements.

19.2.16 Except as otherwise permitted by 20.1.4, wiring to be done in the field between the furnace and devices not attached to the furnace, or between separate devices which are field installed and located, shall comply with these requirements if done with a 60°C (140°F) rated wire enclosed in conduit or with metal-clad cable.

20 Internal Wiring

20.1 General

20.1.1 The wiring of high-voltage and safety-control circuits shall conform to the requirements specified in 20.1.2 – 20.3.2.

20.1.2 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).

20.1.3 The wiring for all furnace circuits shall be furnished by the manufacturer as part of the furnace. If the furnace is not assembled and wired at the factory, such wiring shall be furnished as a harness with each furnace and be arranged to facilitate attachment when the furnace is assembled; in which case a pictorial diagram showing the exact arrangement of the wiring shall be included with each furnace.

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

20.2 Methods

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

20.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 20.2.15 and 20.2.16.

20.2.3 Group A of Table 20.1 includes some wiring materials recognized for use if enclosed as indicated in 20.2.2.

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

20.2.5 If flexible metal conduit is used it shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (0.03 m) on each side of every junction box except for lengths not over 36 inches (914 mm) where flexibility is necessary.

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

Table 20.1
Typical wiring materials

Group	Type of wire, cord, cable, or appliance wiring material with insulation thicknesses shown at the right corresponding to wire sizes indicated	Wire size		Insulation thickness	
		AWG	mm^2	Inch	mm
A	FF-2, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, THW, XHHW, MTW, THWN, TW 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	26.7	4/64	1.6
		2	33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.0	5/64	2.0
B	SO, ST, SJO, SJT,or appliance wiring material with thermoplastic or neoprene insulation	18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.3	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 recognized for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, and flammability.				

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

20.2.8 Splicing devices, such as fixture-type splicing connectors, pressure wire connectors, and the like, may be employed if they have insulation suitable for the voltage to which they are subjected. Thermoplastic tape wrapped over a sharp edge is not acceptable.

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

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

20.2.11 A splice is considered adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which high-voltage wiring materials, as specified in Group A of Table 20.1, 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.

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

20.2.13 A wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and insure 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.

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

20.2.15 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 20.2.3.

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

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

20.2.16 Cords or appliance wiring material as referenced in Group B, Table 20.1 may be employed if the wiring is enclosed by a furnace casing conforming to all of the following:

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

b) 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.

c) 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.

d) Where combustible material other than electrical insulation is located within the compartment the wiring is separated from such material and the material has self-extinguishing characteristics specified in 20.2.17. An air filter may be employed within the enclosure.

20.2.17 With reference to 20.2.16(d), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with 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.

20.2.18 Factory wiring of a low-voltage safety circuit may be done as described in 20.2.16 when such wiring is located in a cavity or compartment of a heater, but conformance to (a) – (d) is not required; however, such wiring is to be adequately shielded from harm.

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

20.2.20 A fiber bushing shall be not less than 3/64 inch (1.2 mm) in thickness with a minus tolerance of 1/64 inch (0.4 mm), 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.

20.2.21 To provide an acceptable unbushed opening in sheet metal usually requires rolling and/or extrusion of the metal around the opening, or the insertion of a grommet conforming to 20.2.19.

20.3 Short circuit protection

20.3.1 Except as indicated in 20.3.2, conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected, wired for connection to one supply line shall withstand the conditions of a Short Circuit Test, Section 50, without creating a fire or shock hazard.

20.3.2 Conductors which conform to the following are considered acceptable without test:

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

b) Conductors which are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length provided the appliance will be protected by a 60 ampere fuse or smaller; See Short Circuit Test, Section 50. This applies to any of the wiring materials specified in this standard, including those enclosed in raceways; or

c) Conductors which serve as jumper leads between controls providing the length of the leads does not exceed 3 inches (76.2 mm) or the conductors are located in a control panel.

21 Separation of Circuits

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

21.2 Segregation of insulated conductors as required in 21.1 may be accomplished by clamping, routing, or an equivalent means that provides permanent separation from insulated or uninsulated live parts of a different circuit.

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

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

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting may permit operation of the appliance that could cause risk of fire, electric shock, or injury to persons, except that a construction in which field installed conductors may make contact with wiring terminals is acceptable, provided that wiring materials as specified in Group A of Table 20.1 will be employed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

21.4 Segregation of field installed conductors from other field installed conductors and from uninsulated live parts of the wall furnace 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 the intended wiring of the wall furnace and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 21.3 that the conductors entering each opening will be connected to the terminals opposite the opening.

b) If more than the minimum number of openings are provided, the investigation is to consider the possibility of conductors entering at points other than opposite the terminals to which they are

intended to be connected and contacting insulated conductors or uninsulated current carrying parts connected to a different circuit.

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

21.6 A metal barrier shall have a thickness at least as great as that required by Table 26.1 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.

21.7 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.

22 Bonding for Grounding

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

22.2 Except as indicated in 22.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like, are to be bonded for grounding if they may be contacted by the user or serviceman.

22.3 Metal parts need not be grounded when of the types described below:

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

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

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

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

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

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

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

22.7 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.

22.8 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.

22.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 22.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

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

22.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 22.12 – 22.15, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time specified in Table 22.1 twice the current equal to the rating of the branch circuit overcurrent device required to protect the equipment; and

b) During the Short Circuit Test, Section 50, in series with a fuse of the required rating. See Short Circuit Test, Section 50.

Table 22.1
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
201 – 400	10
401 – 600	12

22.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be gaged on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 22.11, the size of the conductor or strap shall be in accordance with Table 22.2.

Table 22.2
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.

22.13 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component or components within the enclosure.

22.14 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 to be sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

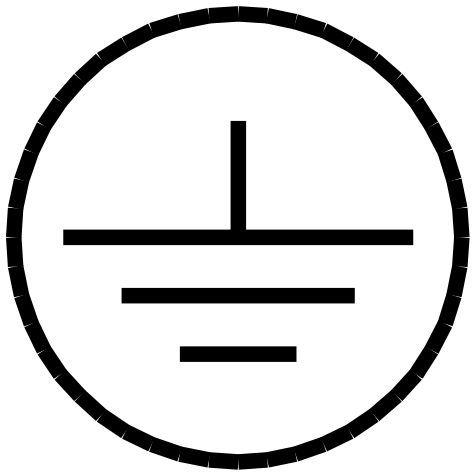
22.15 The equipment grounding terminal or lead shall be located in the field wiring compartment and shall be rated for connection of an equipment-grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70, for the rating of the power supply circuit to be connected.

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

22.17 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked "G", "GR", "GROUND", "GROUNDING", by the symbol in Figure 22.1, or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be so located that it is unlikely to be removed during normal servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply, a marking shall be additionally provided indicating "EQUIPMENT GROUND" and/or identifying the connector by a green color.

Figure 22.1

Grounding symbol



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

23 Servicing and Adjustment

23.1 Service functions that may have to be performed while the equipment is energized include:

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

b) Resetting the 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.

23.2 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts or hazardous moving parts 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.

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

23.4 Components in a low-voltage circuit are to comply with the requirements of 23.3 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

24 Electrical Components

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

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

25 Mounting of Electrical Components

25.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 25.2 – 25.5.

25.2 The requirement specified in 25.1 that a switch shall be prevented from turning may be waived if all of the following conditions are met:

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

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

25.3 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.

25.4 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.

25.5 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.

26 Electrical Enclosures

26.1 General

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

26.1.2 Sheet metal complying with Table 26.1 and Table 26.2, whichever applies, is acceptable for the individual enclosure of electrical components.

26.1.3 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 all conditions of use.

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging.

26.1.4 Where the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 26.1 or Table 26.2, whichever applies, may be employed.

26.1.5 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.

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

26.1.7 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.

26.1.8 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal and the construction of the device shall be such that a conduit bushing can be attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

Table 26.1
Minimum thickness of sheet metal for electrical 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	Metal coated
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	(MSG)	(GSG)
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	(63.5)	31.0	(78.7)	35.0	(89.0)	43.0	(109.2)	(15)	(15)
25.0	(63.4)	Not limited		39.0	(99.1)	Not limited		0.067 (1.70)	0.070 (1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)	(14)
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080 (2.04)	0.084 (2.13)
35.0	(89.0)	47.0	(119.4)	54.0	(137.1)	66.0	(167.6)	(13)	(13)
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093 (2.36)	0.097 (2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)	(12)
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108 (2.74)	0.111 (2.80)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)	(11)
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123 (3.12)	0.126 (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:

1) Single sheet with single formed flanges (formed edges);

2) A single sheet which is corrugated or ribbed; and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

Table 26.2
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	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
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	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.7)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.2)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.4)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.4)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.4)	Not limited		60.0	(152.4)	Not limited		0.095	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(6)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)	

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

1) Single sheet with single formed flanges (formed edges);

2) A single sheet which is corrugated or ribbed; and

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

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

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

26.1.11 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.

26.1.12 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 (0.35 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 dimension; and

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

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

26.1.13 The enclosure shall prevent 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.

26.1.14 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.

26.1.15 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 26.1.13.

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

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

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.

26.1.17 The criteria for judging an opening in an electrical enclosure are given in Section 33.

26.1.18 During the examination for conformance with the requirements of 26.1.17, a part of the enclosure, including air filters, which may be removed without the use of tools, is to be removed.

26.2 Doors and covers

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

26.2.2 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 vibration so as to cause risk of injury to persons by the panel or cover, or by moving parts or uninsulated live parts likely to cause risk of injury to persons.

26.2.3 The assembly shall be arranged so that an overcurrent protective device, such as a fuse, whose protective functioning requires renewal, can be replaced and manual-reset devices can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device. See 26.2.7.

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

26.2.5 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 such part.

26.2.6 A fuseholder shall be constructed, installed, or protected so 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 similar material employed for this purpose shall be not less than 0.028 inch (0.71 mm) in thickness.

26.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the protective functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manual reset overload protective device, except as indicated in 26.2.8.

26.2.8 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.

26.2.9 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.

26.2.10 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open it is considered to be an acceptable means for holding the door in place as required in 26.2.9.

26.2.11 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.

26.2.12 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 (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

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

27 Motors and Motor Overcurrent (Overload) Protection

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

27.2 Overcurrent protective devices as referred to in 27.1 mean overcurrent protective devices conforming to the requirements of the National Electrical Code, ANSI/NFPA 70, as follows:

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

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

2) Motors with a marked temperature rise not over 40°C – 125 percent; or

3) All other motors – 115 percent.

Each winding of a multispeed motor is to be considered separately and the motor is to be protected at all speeds.

b) If the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses 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 temperature rise not over 40°C – 140 percent; or

3) All other motors – 130 percent.

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

27.4 Separate overcurrent devices, except when included as part of magnetic motor controller, shall be assembled as part of the equipment, and shall be readily identifiable as such after assembly to the equipment. Such protection shall not include means for manually interrupting the motor circuit if such interruption may allow operation of the equipment that could cause risk of fire, electric shock, or injury to persons.

27.5 With reference to the requirement specified in 27.4, motors, such as direct-drive fan motors that are not subjected to overloads during intended operation and that are determined to be acceptably protected against overheating due to locked-rotor current by a thermal or overcurrent protective device, are acceptable if it is determined that the motor will not overheat under actual conditions of use.

27.6 Impedance protection may be accepted for motors which are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under actual conditions of use, except that impedance protection is not to be accepted where the motors are installed in compartments handling air for circulation to the conditioned space.

27.7 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.

27.8 Motors shall not exceed the temperature rises indicated in Table 43.1 when tested as described herein.

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

27.10 In no case shall interruption of the circuit to a motor by the overcurrent or thermal protective device result in unsafe operation of the equipment or the hazardous discharge of fuel. If a burner depends solely upon an electric 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.

27.11 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 unsafe operation of the equipment.

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

27.13 Conformance to 27.12 may be provided by the motor frame or by other enclosure, structure, or shield, or by a combination of two or more such items, and is to be determined with the motor applied to the assembly.

27.14 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.

27.15 The requirement in 27.14 will necessitate the use of a barrier of noncombustible material under an open type motor unless:

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

b) The motor overload protection device provided with a single-phase motor is such that no burning insulation or molten material falls to the surface that supports the 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

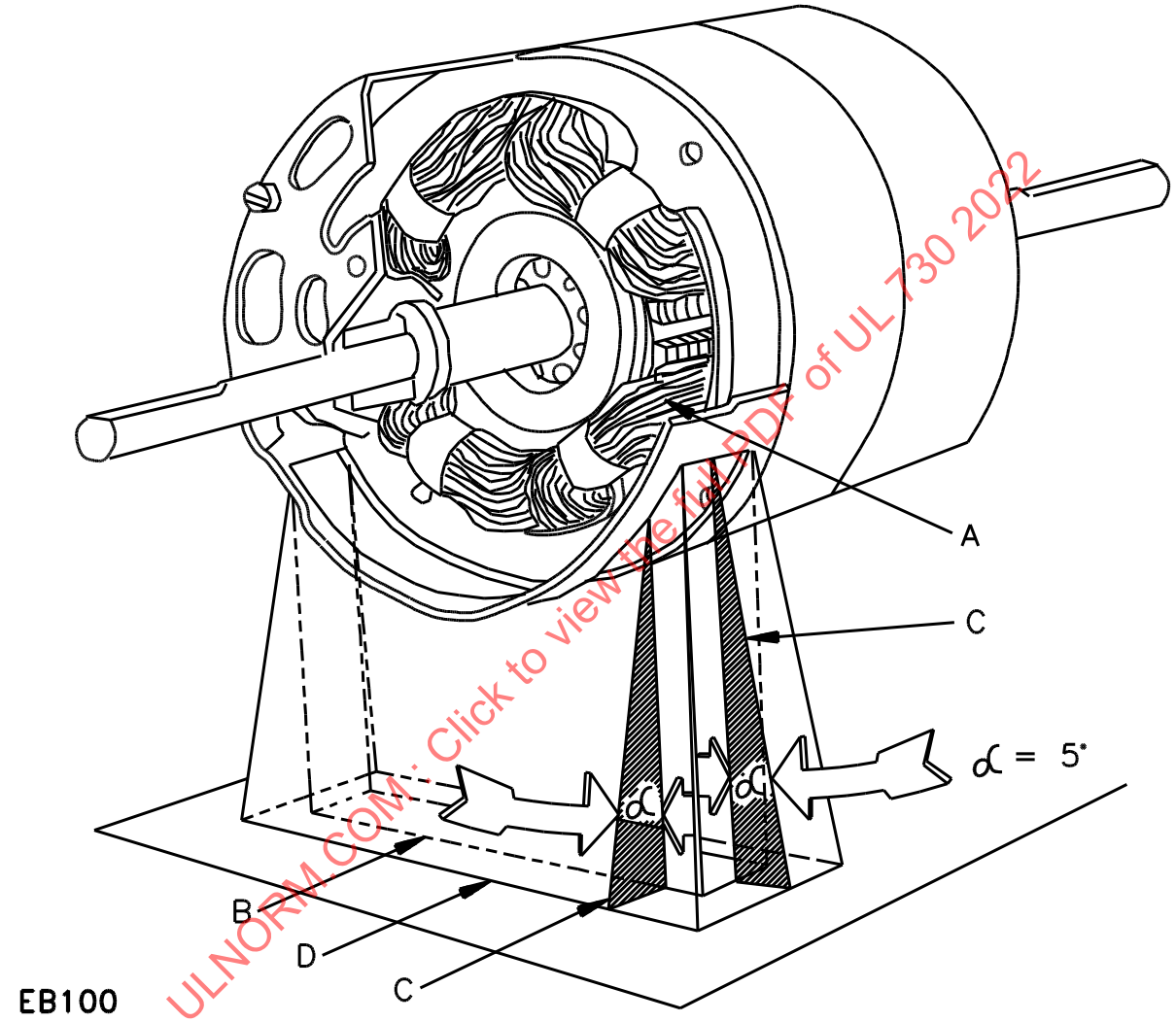
4) Capacitor shorted, permanent split capacitor type; or

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 under 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.

27.16 The barrier mentioned in 27.15 shall be horizontal, shall be located as indicated in Figure 27.1 and shall have an area not less than that described in that illustration. Openings for drainage, ventilation, and the like may be employed in the barrier, provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 27.1

Location and extent of barrier



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

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

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

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.

27.17 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short Circuit Test, Section 50.

28 Switches and Controllers

28.1 Except as indicated in 28.2, a controller(s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

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

28.3 A single controller may control more than one motor if the controller is rated for the combined load controlled.

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

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

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

28.7 With reference to 28.6, 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 failure. The endurance test is to be of a duration equivalent to that required for the overload device and at an equivalent rate.

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

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

28.10 If the marked maximum fuse size of the furnace does not exceed the maximum size suitable 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 normal conditions of service which might be encountered.

29 Capacitors

29.1 A motor starting or running capacitor shall be housed within an enclosure or container which will protect the plates against mechanical damage and which will prevent the emission of flame or molten material resulting from failure of the capacitor. Except as noted in 29.2 and 29.3, the container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm) (No. 24 MSG).

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

29.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts by moisture-resistant insulation not less than 0.028 inch (0.71 mm) thick, except as indicated in 25.5. Otherwise, it shall be separated from dead metal parts by spacings in accordance with Table 26.1.

29.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 50.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 50.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

30 Insulating Material

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

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

31 Spacings – High Voltage Circuits

31.1 Except as noted in paragraphs below, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 31.1.

31.2 The through air and over surface spacings at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load or loads 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 that controls only a motor are judged on the basis of the volt-amperes of the motor. A component that controls loads in addition to the motor is similarly judged on the basis of the sum of the volt-amperes of the loads so controlled; however a component that independently controls separate loads is judged on the basis of the volt-amperes of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

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

31.4 The spacing requirements in Table 31.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component that is judged on the basis of the requirements for the component. However, the electrical clearances resulting from the installation of a component, including clearances to dead metal or enclosures, are to be those indicated in the table.

31.5 All uninsulated live parts connected to different circuits, except subdivided circuits 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 above and shall be judged on the basis of the highest voltage involved.

Table 31.1
Minimum spacings

Ratings		Minimum spacings[a], inch (mm)					
		Through air		Over surface		To enclosure[d]	
Volt-amperes	Volts	inch	mm	inch	mm	inch	mm
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] 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.

[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 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.

32 Spacings – Low-Voltage Circuits

32.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device shall comply with the requirements specified in 32.2 – 32.7 if operation of the product having a short or grounded circuit results in a risk of fire, electric shock, or injury to persons.

32.2 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 31.5.

32.3 Spacings shall be not less than 1/4 inch (6.4 mm) between wiring terminals, regardless of their polarity, or 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.

32.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part (other than the enclosure) 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 allows spacings to be maintained.

32.5 The spacings in low-voltage circuits that do not contain devices such as those indicated in 32.2 are not specified.

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

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

33 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

33.1 An uninsulated high-voltage part and moving parts that can cause injury to persons shall be located, guarded, or enclosed so as to reduce the risk of unintended contact by personnel performing service functions while the equipment is energized.

33.2 Accessibility and protection from shock and accident hazard may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 33.1.

a) The components are located with respect to the access opening in the outer cabinet so that the farthest component in the control assembly is not more than 14 inches (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 hazardous moving parts are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

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

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

e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that there is unimpeded access to these components through the access opening in the outer cabinet and so that they are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

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

a) Coils of controllers;

b) Relays and solenoids;

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

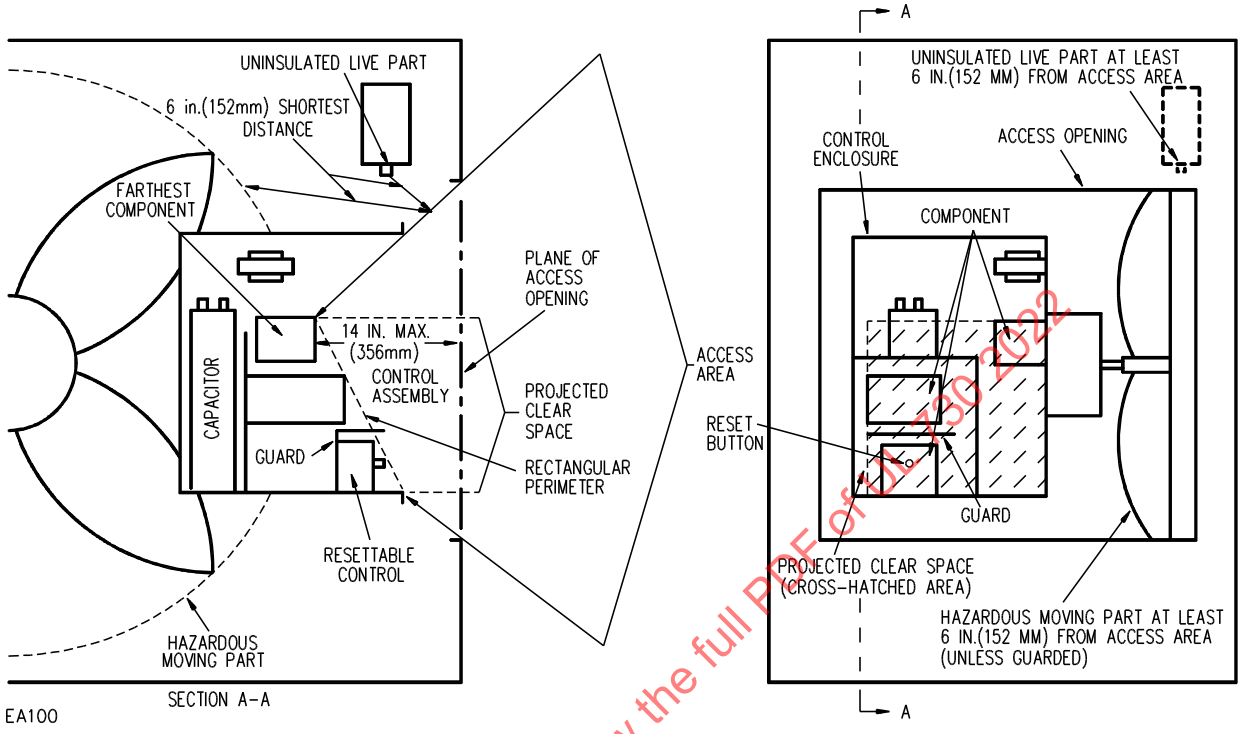
d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wire.

Figure 33.1

Accessibility and protection



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

a) For an opening that has a minor dimension (see 33.8) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 33.2; and

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 33.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 33.5.

Figure 33.2

Probe for uninsulated live parts

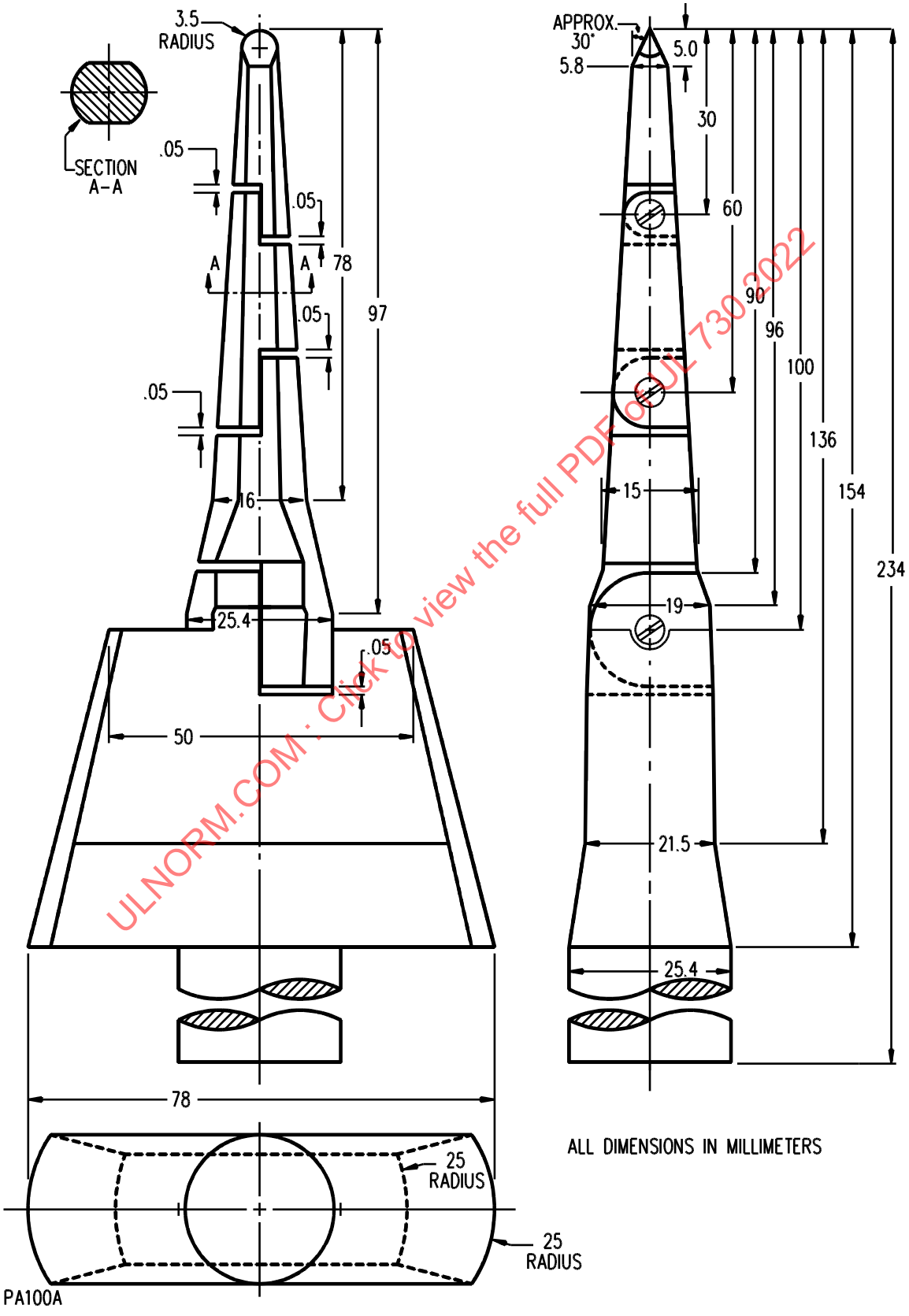


Table 33.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening,		Minimum distance from opening to part	
Inches	(mm)	Inches	(mm)[b]
3/4	(19.1)[c]	4-1/2	(114)
1	(25.4)[c]	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
d		30	(762)

[a] See 33.8.

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

33.5 With respect to a part or wire as mentioned in 33.4, in an integral enclosure of a motor as mentioned in the exception to 33.4:

a) An opening that has a minor dimension (see 33.8) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 33.3;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 33.4;

3) In a directly accessible motor (see 33.9), an uninsulated live part cannot be contacted by the probe illustrated in Figure 33.5; and

4) In an indirectly accessible motor (see 33.9), an uninsulated live part cannot be contacted by the probe illustrated in Figure 33.3.

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 33.1.

Figure 33.3

Probe for moving parts and uninsulated live parts

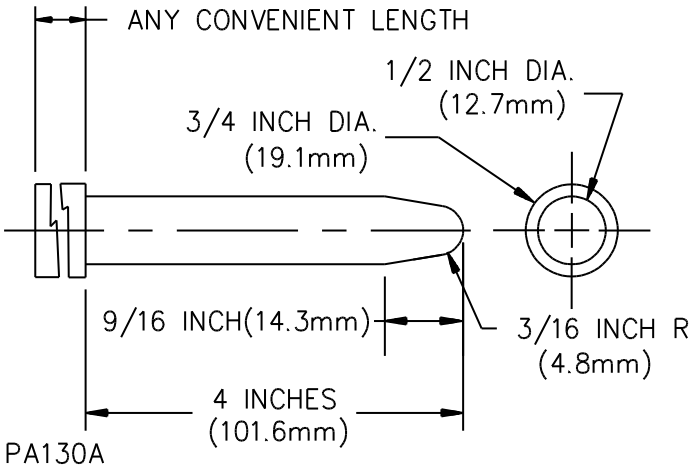


Figure 33.4

Probe for film coated wire

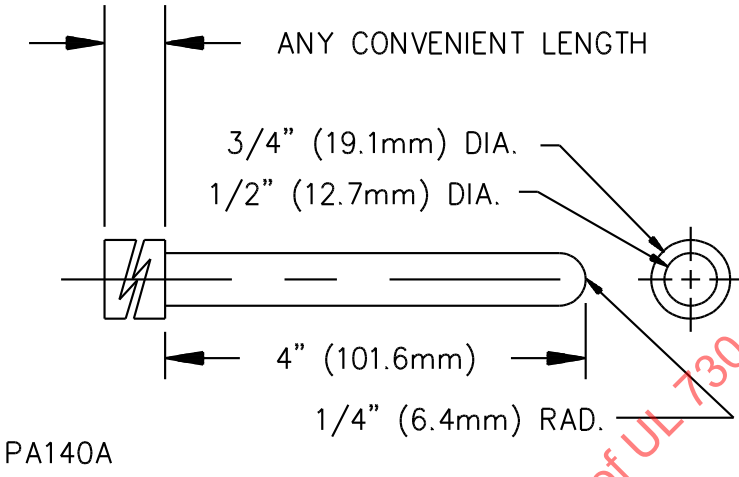
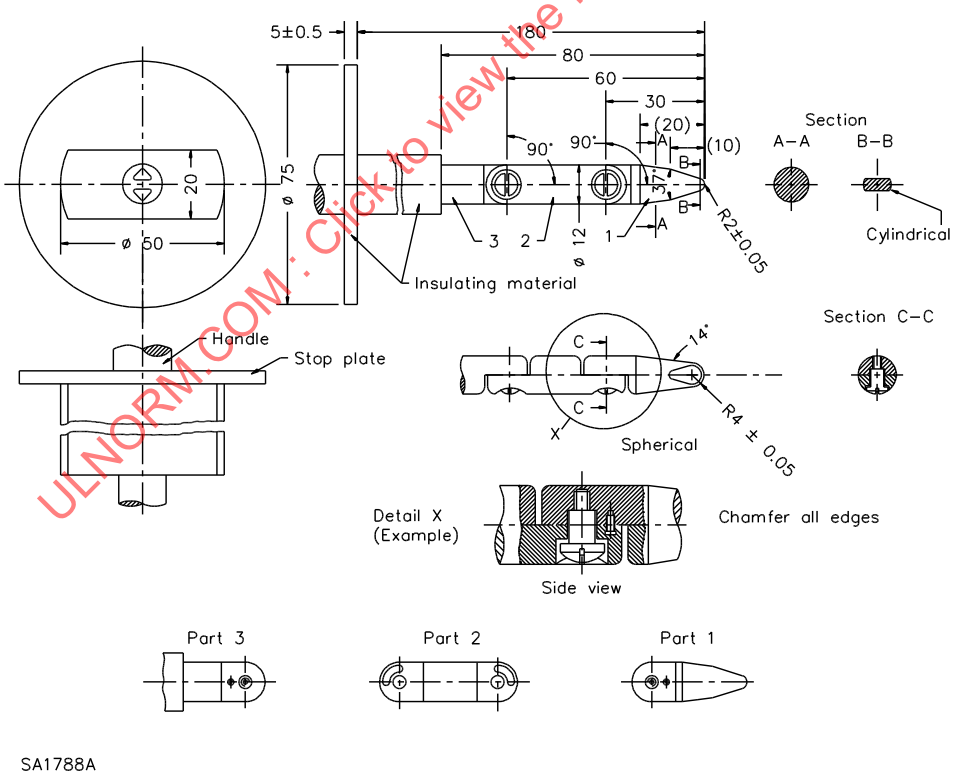


Figure 33.5

IEC articulate probe



33.6 The probes mentioned in 33.4 and 33.5 and illustrated in Figure 33.2 – Figure 33.5 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. The probes illustrated in Figure 33.2 and Figure 33.5 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

33.7 The probes mentioned in 33.6 and 33.8 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 are to be applied with the minimum force necessary to determine accessibility.

33.8 With reference to the requirements in 33.4 and 33.5, 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.

33.9 With reference to the requirements in 33.5, 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.

A directly accessible motor is a motor that can be contacted without opening or removing any part, or that is located so as to be accessible to contact.

33.10 During the examination of a product to determine whether it complies with the requirements in 33.4 or 33.5, a part of the enclosure that may be 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.

33.11 With reference to the requirements in 33.4 and 33.5, insulated brush caps are not required to be additionally enclosed.

PERFORMANCE

34 General

34.1 A wall furnace shall comply with the applicable requirements when tested as described herein. A wall furnace of a type not specifically described shall be tested in accordance with the intent of these requirements. If any indications are observed during the tests that a furnace 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.

35 Test Installation – Built-In Style Furnaces

35.1 Enclosure

35.1.1 A furnace intended for placement within a cavity in a wall or partition with all surfaces except the face of the inlet and outlet air grilles encompassed by the wall or partition structure is to be tested in a structure similar to that illustrated in Figure 35.1. The test wall section is to be constructed in accordance with commonly accepted building practices upon wood flooring equivalent to two layers of 1 inch (25.4 mm) flooring with one thickness of building paper between layers. The top layer is to be tongue-and-groove flooring finished with clear varnish.

35.1.2 The test wall structure is to be built of nominal 2 by 4 inch (50.8 by 102 mm) clear lumber sheathed with 3/4 inch (19.1 mm) thick interior grade plywood. Clear lumber, having a nominal thickness of 1 inch (25.4 mm) may be used in place of plywood. The height of the structure from the floor surface to the under surface of the ceiling is to be 7 feet 6 inches (2.28 m). The width of the two end stud spaces is to be 16 inches (406 mm) center to center of the studs, when a furnace with a vertical-flue outlet and no boots is to be tested. When a furnace with a horizontal-flue outlet is to be tested, the width of the stud space in which the flue is located may be increased sufficiently to accommodate the flue, as illustrated in Figure

35.2. When a boot is provided, the end section is to be built to accommodate the boot, as illustrated in Figure 35.2. The width of the center stud space is to be such as to accommodate the cavity for the furnace.

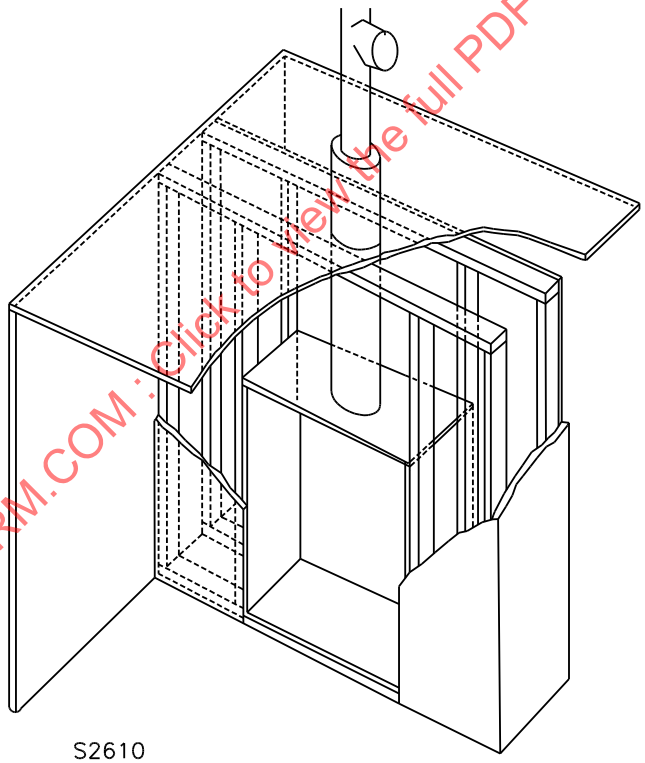
35.1.3 The portion of the furnace normally located in the wall structure is to be enclosed on sides, top, and bottom by 3/4 inch (19.1 mm) plywood of sufficient width to encompass all such surfaces. That enclosure and the studding are to be in contact with any portion of the flue outlet external to the flue if the design of the furnace permits such contact. Surfaces of the front and back of the furnace intended to be enclosed are to be covered with plywood, 3/4 inch thick.

35.1.4 The simulated ceiling and side wall perpendicular to the test wall section are to be plywood, 3/4 inch (19.1 mm) thick and are to extend 4 feet (1.22 m) beyond each face of the test wall section.

35.1.5 All exterior surfaces of the test structure and those surfaces viewing any part of the furnace are to be painted flat black. All joints in the test structure are to be sealed.

Figure 35.1

Test structure for built-in style wall furnace



35.2 Venting

35.2.1 A section of factory built chimney sufficient to extend above the test structure is to be provided for the flue collar of the furnace. See Figure 35.1 and Figure 35.2. For test purposes, the outlet of the factory built chimney is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

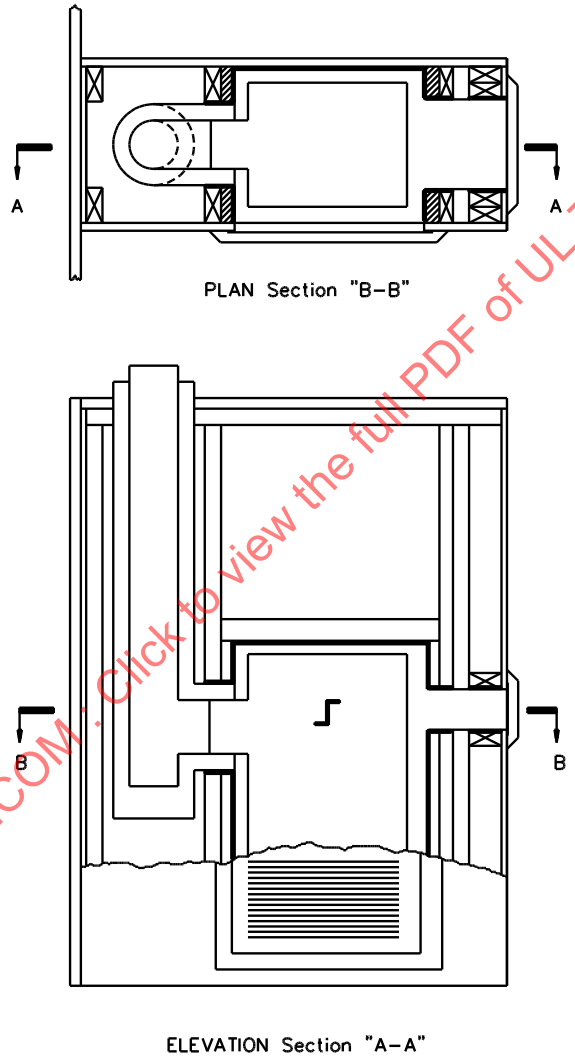
35.2.2 Provision is to be made for inserting a thermocouple similar to that illustrated by Figure 37.1, into the chimney at the relative location indicated by Figure 36.4(1).

35.2.3 A draft regulator is to be provided for test purposes and shall be located outside the test enclosure.

35.2.4 Any built-in draft regulator included as part of the furnace is to be fixed in the position allowing maximum draft.

Figure 35.2

Built-in style wall furnace with horizontal flue outlet



36 Test Installation – Extended Style Furnaces

36.1 Enclosure

36.1.1 A wall furnace intended for installation with a portion extending into an accessible space such as an alcove, closet, or room is to be tested in a test structure similar to that illustrated in Figure 36.1. The structure is to be constructed in accordance with commonly accepted building practices upon wood flooring equivalent to two layers of 1 inch (25.4 mm) flooring with one thickness of building paper between layers. The top layer is to be tongue-and-groove flooring finished with clear varnish.

36.1.2 The wall sections, that is, front and side walls in Figure 36.1 of the test structure enclosing the heater are to be built of trade size 2 by 4 inch [nominal 1-3/4 by 3-3/4 inch (44 by 95 mm)] clear lumber sheathed on both sides with 3/4 inch (19.1 mm) thick interior plywood. Clear lumber having a nominal thickness of 1 inch (25.4 mm) may be used instead of plywood. The height of the structure is to be that required to obtain the clearance from the top of the furnace to the ceiling specified by the manufacturer, but in no case is the ceiling height to be more than 7 feet 6 inches (2.28 m) above the floor of the test structure. The width of the two end stud spaces of the front wall is to be 16 inches (406 mm) center to center of the studs. The width of the center stud space is to be such as to accommodate the furnace grille frame. The portion of the furnace and any boots that protrude through a wall are to be enclosed on sides, top, and bottom by trade size 2 by 4 inch [nominal 1-3/4 by 3-3/4 inch (44 by 95 mm)] lumber and the wall surface structure.

36.1.3 The ceiling is to cover the entire test structure and is to extend beyond the front of the front wall a distance of 4 feet (1.22 m). A wall (designated end wall in Figure 36.1) is to be placed perpendicular to the end of the front wall and is to extend 4 feet beyond the front of the front wall. The ceiling and end wall are to be plywood at least 3/4 inch (19.1 mm) thick.

36.1.4 For closet installation test, a simulated door is to be placed opposite the back or side of the furnace that does not contain an air outlet. The simulated door is to be made of 3/4 inch (19.1 mm) thick plywood. Two ventilating openings are to be provided in the simulated door and be 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 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 not more than an area equivalent to 20 percent of the total area of the simulated door. Both openings are to be centered on the vertical center line of the enclosure.

36.1.5 The ventilating openings may be omitted if all the air for combustion and for a barometric draft regulator is obtained from the same space exterior to the closet. See 17.3 and 17.4.

36.1.6 For alcove installation test, the enclosure is to be open opposite the back or a side of the furnace that does not contain an air-outlet boot, but the walls are to extend at least 18 inches (457 mm) beyond the back or that side of the furnace.

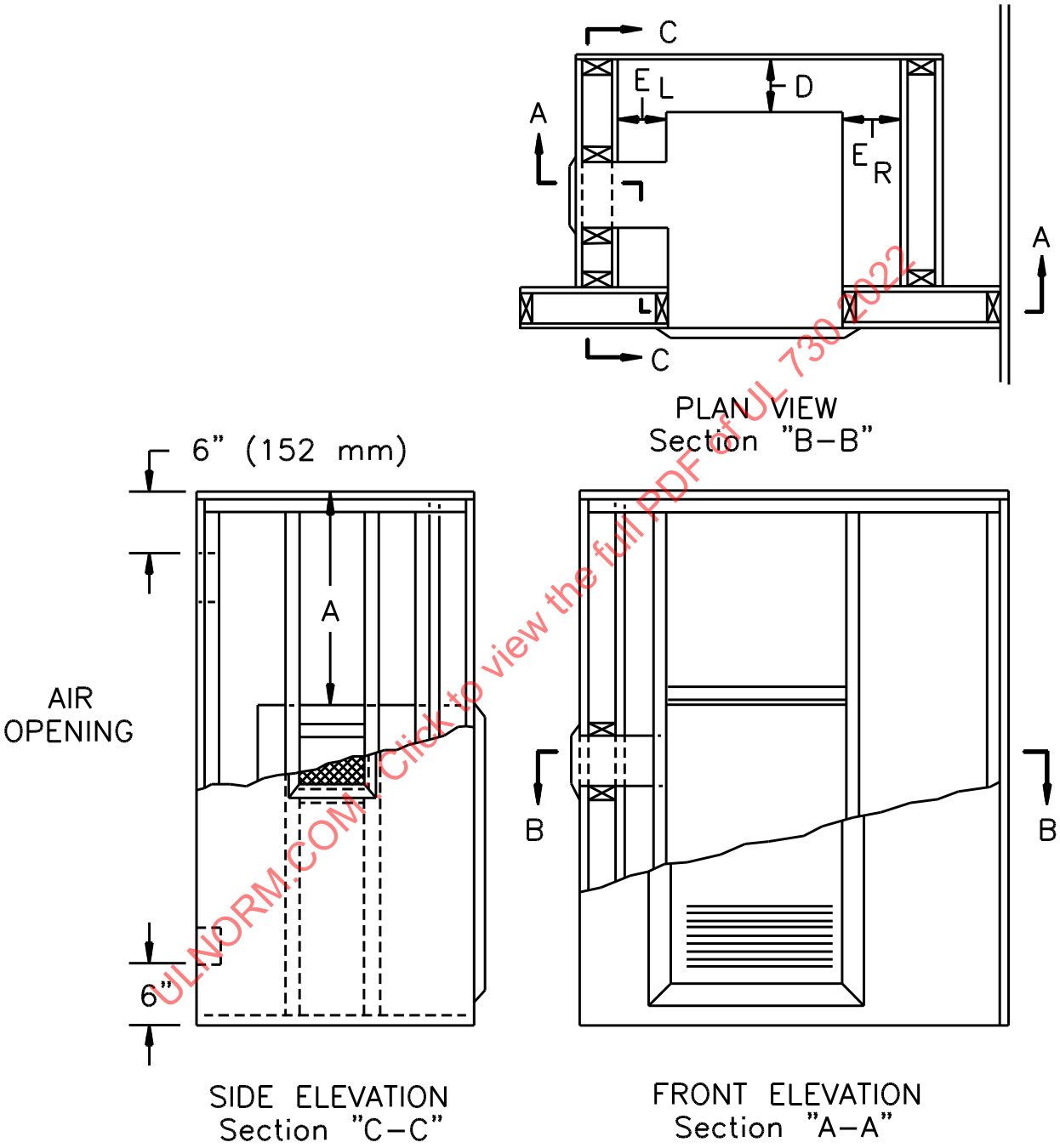
36.1.7 The interior dimensions of the test enclosures are to be as required to provide the clearances in integral inches as selected by the manufacturer for test purposes.

36.1.8 The furnace is to be placed on the floor of the test enclosure. The furnace 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 furnace the minimum allowable distance above the floor.

36.1.9 All exterior surfaces of the walls through which a grille or boot extend, the surface of the end wall viewing the furnace grille, and all enclosure surfaces viewing any part of the furnace or the flue pipe are to be painted flat black. All joints are to be sealed.

Figure 36.1

Test structure for extended style wall furnace



36.2 Chimney connector

36.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe not heavier than 0.023 inch (0.58 mm) is to be used.

36.2.2 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 furnace 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 (229 mm), the test may be conducted with such lesser clearance from the walls with portions of the wall located within 9 inches (229 mm) of the chimney connector protected in a recognized manner; in which case directions that such surfaces shall be so protected are to be included in the instructions furnished with the furnace.

36.2.3 A furnace with vertical flue outlet is to be tested with two chimney connector arrangements, Styles I and III, and a furnace with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III, as indicated by Figure 36.2 unless the manufacturer elects to specify the minimum clearance from the furnace as that obtained when tested with the chimney connector arranged in accordance with Style I or II only.

36.2.4 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 36.3. 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.

36.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by Figure 36.4(2).

36.2.6 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 Figure 36.4(6).

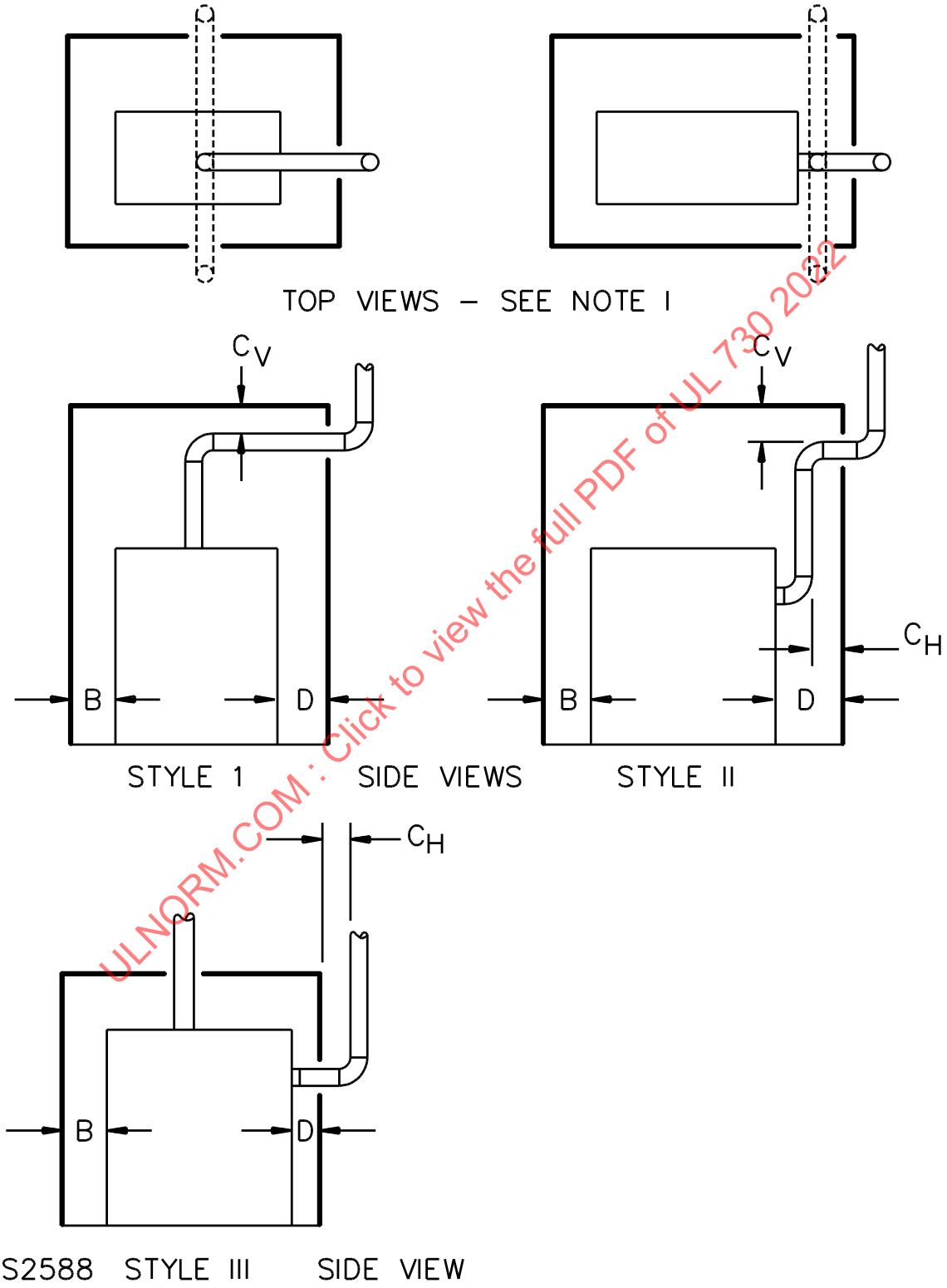
36.2.7 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 36.4.

36.2.8 Any built-in draft regulator included as part of the furnace is to be fixed in the position allowing maximum draft.

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

Figure 36.2

Chimney connector arrangement for alcove and closet installation



Note: With chimney connector arrangement, Styles I and II, the horizontal run is to pierce the back or a side wall, whichever is farthest from the vertical run.

Figure 36.3

Sealing of annulus around chimney connector

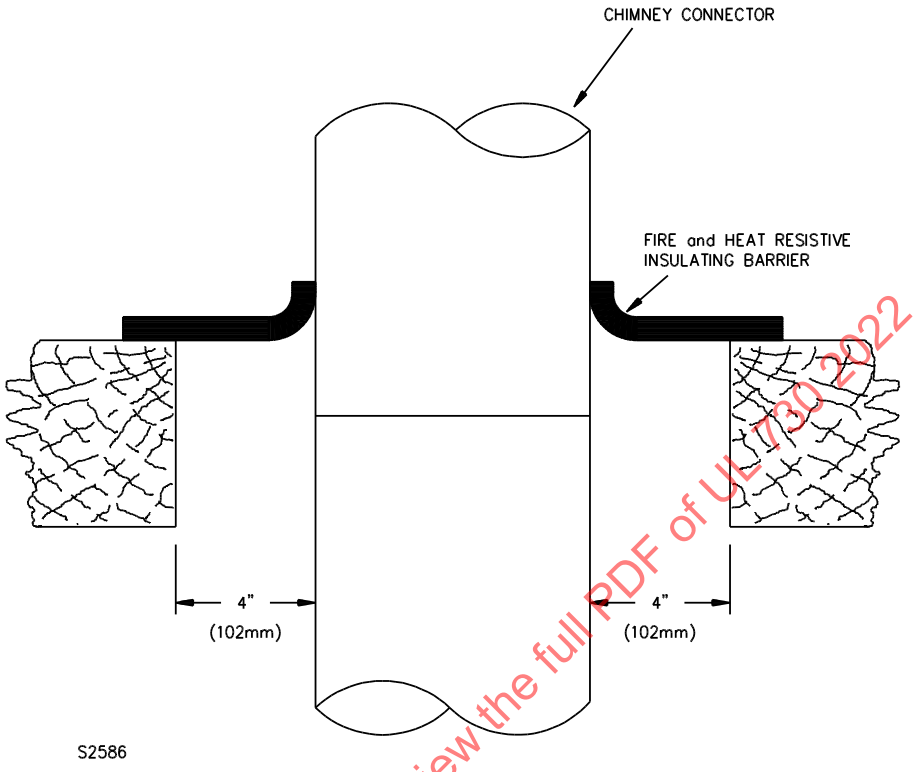
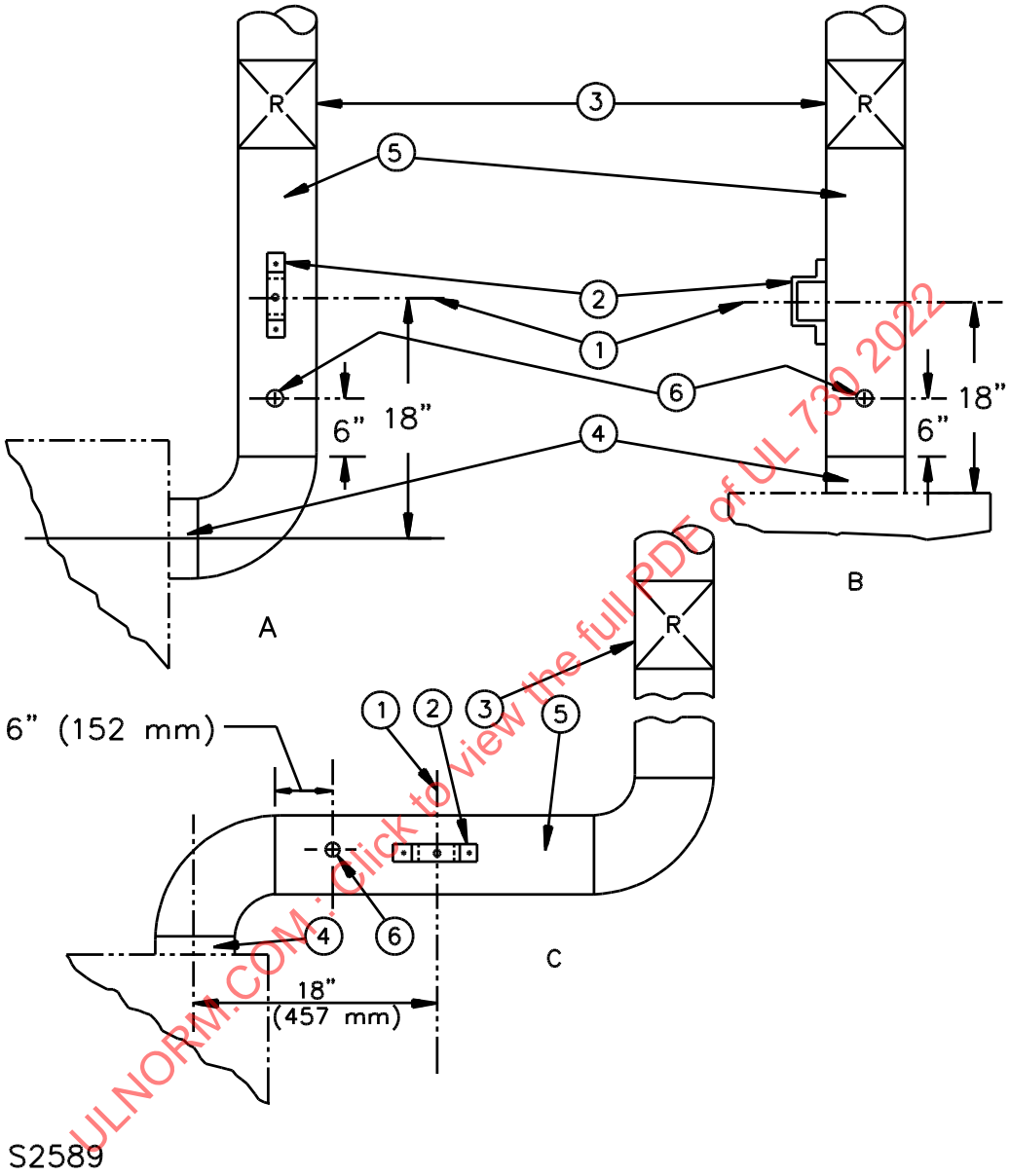


Figure 36.4

Chimney connectors – alcove and closet test



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

1 inch = 25.4 mm

37 Instrumentation

37.1 Draft

37.1.1 Draft is to be measured by a draft gauge which may be read directly to 0.005 inch (0.10 mm) water column and which has an accuracy of ±0.0025 inch (0.050 mm). A gauge is to be checked for zero reading at the beginning and the end of each test.

37.2 Fuel input

37.2.1 The flue 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.

37.3 Power measurement

37.3.1 The total electrical input to a furnace is to be measured in amperes.

37.3.2 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.

37.4 Speed measurement

37.4.1 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 output).

37.5 Temperature measurement

37.5.1 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).

37.5.2 Temperatures of the simulated building structure in contact with any portion of the furnace are to be measured by thermocouples placed at intervals in rows extending around the top, sides, and bottom of the furnace and at other points as deemed necessary. Thermocouples are to be placed on the wall surface at points to the sides and above the furnace and on the surface of the ceiling at suitable intervals to determine surface temperatures. Thermocouples are to be located at points attaining maximum temperatures.

37.5.3 A 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, soldering, or securing the thermocouple to the metal with a screw may be necessary.

37.5.4 Thermocouples are to be secured to wood surfaces by staples over insulated portions of the wire and with the tip held in 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 furnace at points of zero clearance.

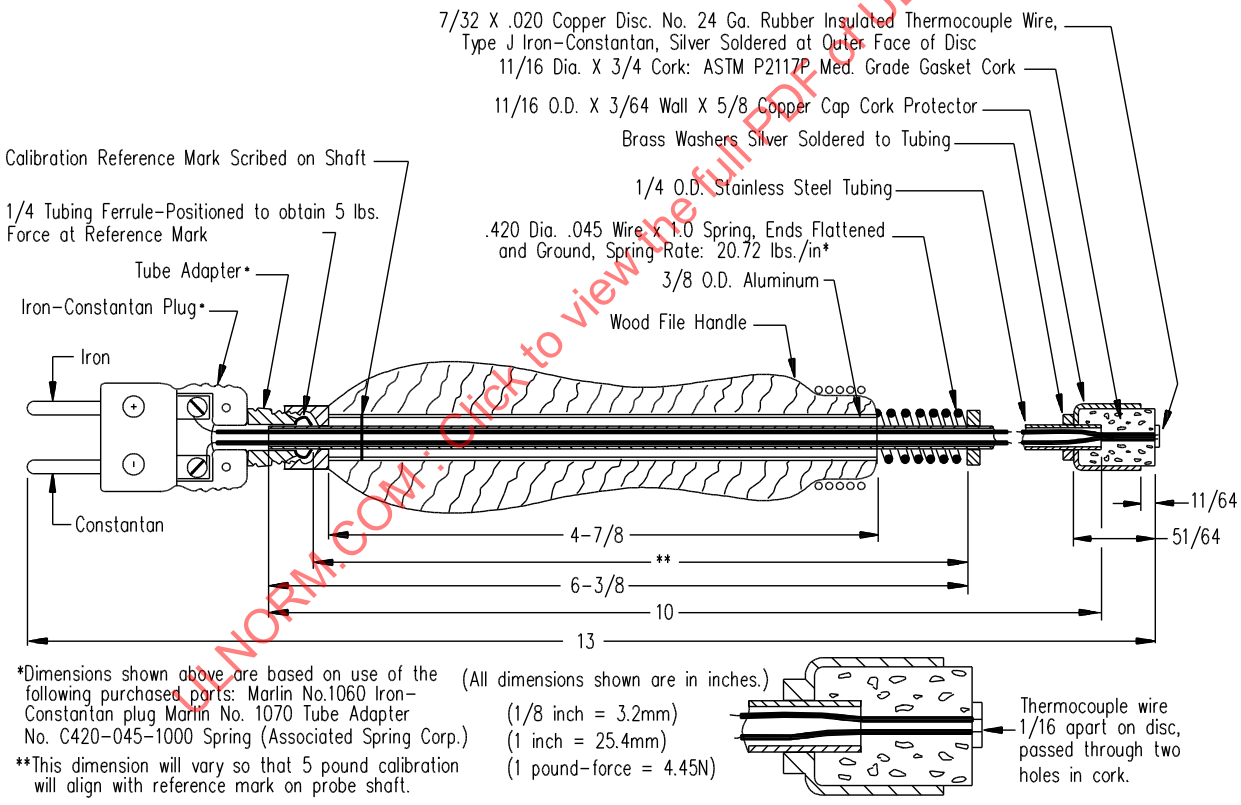
37.5.5 Thermocouples are to be attached to surfaces other than as described above, including parts to be handled by the operator as described in 44.3(d), by being cemented or taped to the surface in a manner to assure complete thermal contact with the surface.

37.5.6 Temperatures of furnace surfaces which can be contacted as described in 44.3(b) are to be determined by use of the probe shown in Figure 37.1. For each measurement the probe is to be at the ambient temperature, and then is to be heated for 15 seconds to approximately the temperature of the surface under consideration. The probe is then to be applied to the surface under consideration with a 5 pound (22 N) force for 10 seconds. The probe is to be moved from the preheat position to the surface as quickly as possible, and is to be applied so that the tip will fully contact the surface. The tip is considered to be the disc and the flat surface of the cork surrounding the disc.

37.5.7 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 37.2, inserted into the chimney connector as shown on Figure 37.3. There is to be no draft control between the furnace and the point where the flue-gas temperature is measured. If a draft control is incorporated in the furnace, it shall be sealed dependably in the position allowing maximum flue-gas temperature during all tests.

Figure 37.1

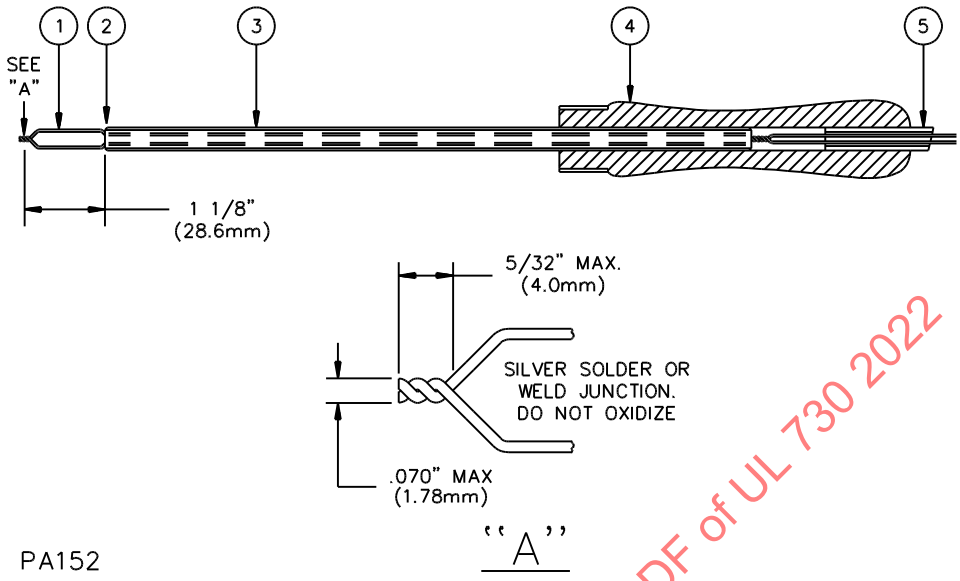
Temperature-measuring probe



PA150

Figure 37.2

Standard thermocouple for flue-gas temperature



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

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

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

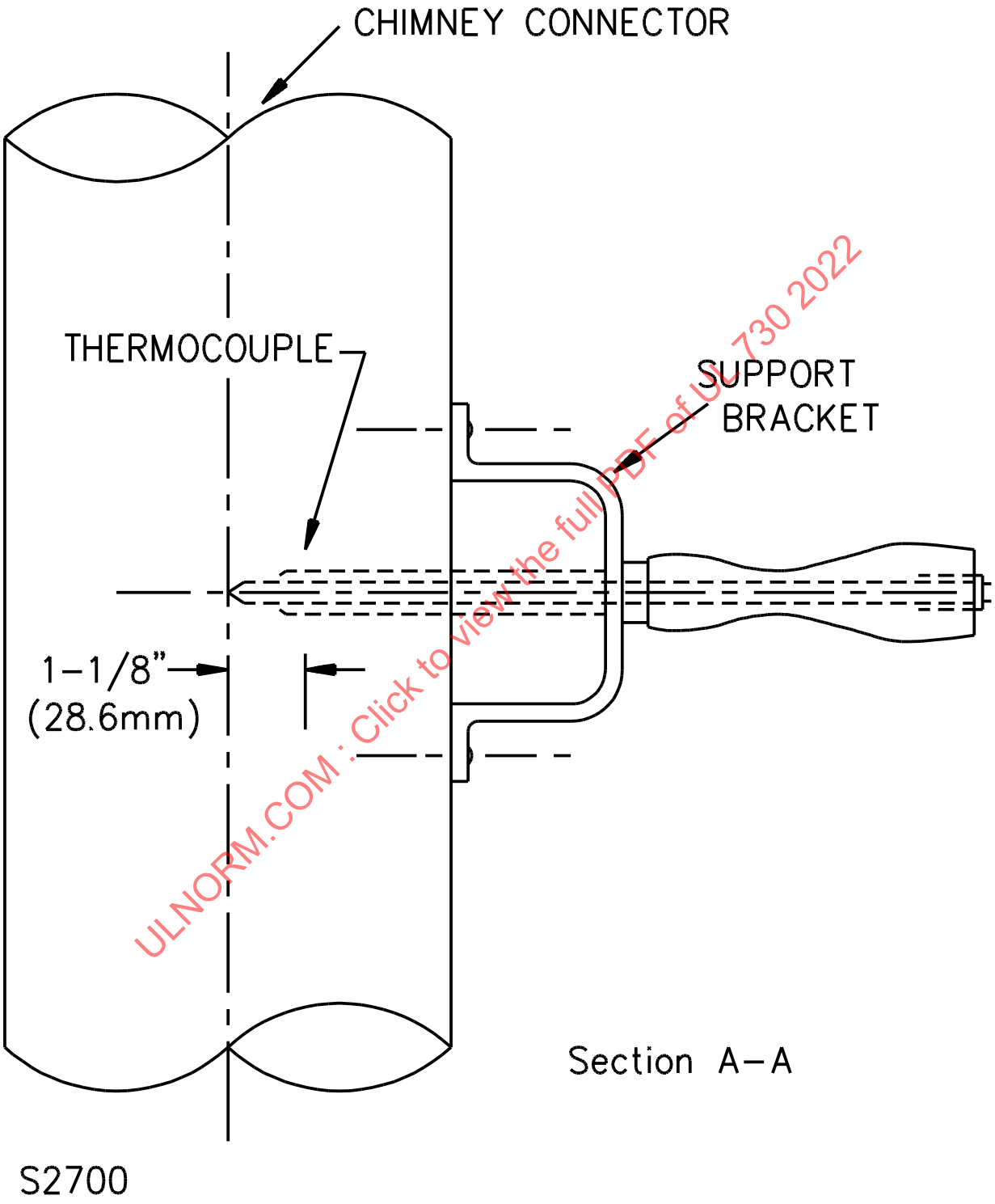
4. 1 – Small wooden handle.

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

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

Figure 37.3

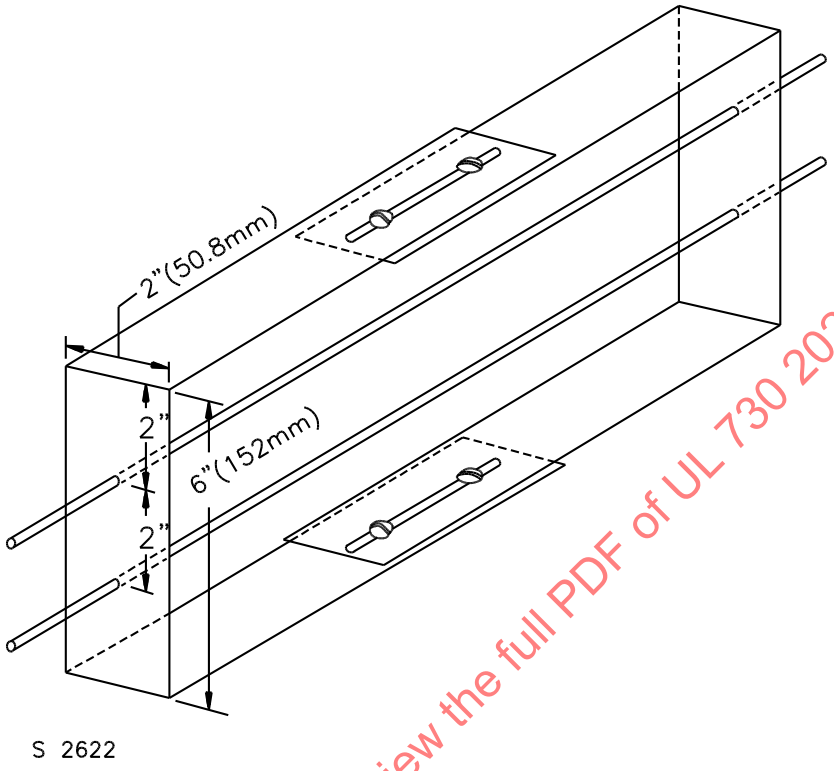
Flue gas thermocouple and support bracket



1 – Thermocouple, 2 – Support bracket

Figure 37.4

Thermocouple shield for outlet-air temperature



37.5.8 The maximum outlet-air temperature is to be determined by exploration with parallel-connected bead-type thermocouples, not heavier than 24 AWG (0.21 mm^2) located 1 inch (25.4 mm) from the outer face of warm air grille or register.

37.5.9 For furnaces having warm-air outlets substantially in a vertical plane, the thermocouples are to be arranged in two horizontal rows located 2 inches (51 mm) apart vertically.

37.5.10 For warm-air outlets not more than 12 inches (305 mm) in width, six thermocouples are to be in each horizontal row. For warm air outlets more than 12 inches (305 mm) in width, one additional thermocouple is to be added to each row for each additional 2 inches (50.8 mm) or fraction thereof of opening width.

37.5.11 The outer thermocouples in each row are to be 1 inch (25.4 mm) inside the boundary of the opening, and the other thermocouples are to be evenly spaced between the outer thermocouples.

37.5.12 The thermocouples are to be supported in a rectangular shield as illustrated in Figure 37.4. The length of the shield is to correspond to the width of the warm-air outlet opening.

37.5.13 The thermocouple assembly is to be moved vertically over the face of the outlet opening to determine the maximum indicated temperature.

37.5.14 For furnaces having warm-air outlets substantially in a vertical plane, the temperature is to be measured using 12 or more parallel connected thermocouples spaced approximately on 2 inch (50.8 mm) centers in a shield similar to that illustrated in Figure 37.4.

37.5.15 The inlet-air temperature is to be measured by thermocouples, not heavier than 24 AWG (0.21 mm^2) suitably shielded from direct radiation and located as specified in 37.5.16 – 37.5.18.

37.5.16 For a built-in style furnace the temperature is to be the average as measured by two thermocouples, each to be placed at a point located 24 inches (610 mm) above the floor of the test structure, 6 inches (152 mm) horizontally from the outer edge of the side wall, and 6 inches horizontally from the inner face of the side wall.

37.5.17 For a heater extending into an alcove, a single thermocouple placed centrally 24 inches (610 mm) opposite the wall furnace towards the alcove opening and 24 inches above the floor of the test enclosure is to be used.

37.5.18 For a furnace extending into a closet, the thermocouple is to be placed in the center of the lower ventilating opening into the closet. If no ventilating openings are employed, the thermocouple is to be placed at a point 6 inches (152 mm) centrally from the exterior of the closet door and 24 inches (610 mm) above the floor of the test structure.

38 Initial Test Conditions

38.1 General

38.1.1 The furnace is to be set up for test in the appropriate enclosure and manner described in Sections 35 and 36.

38.1.2 An air-circulating fan, the capacity of which is intended to be varied only by the installer, such as with a belt-drive or a motor-speed control, is to be tested with the fan speed adjusted so that approximately rated air delivery is obtained. This adjustment is to be maintained during the conduct of all tests described herein.

38.1.3 A furnace equipped with a device intended for manual change or adjustment by the user, such as a motor speed control or a circulating air damper, or the like, the positioning of which could affect the results of the following tests, is to be tested with the adjustable device in the position or positions likely to develop maximum temperatures or to disclose malfunction.

38.1.4 If the results of a furnace test involving the operation of a limit control are likely to be affected by the temperature of the inlet air, the test is to be conducted under conditions which maintain the inlet-air temperature between 15.6°C (60°F) and 26.7°C (80°F).

38.1.5 If a furnace is to be equipped with air filters, they are to be in place.

38.1.6 Unless otherwise specified in the paragraphs describing the tests, furnaces are to be tested at the potentials indicated in Table 38.1.

Table 38.1
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

38.2 Furnace equipped with mechanical atomizing burner

38.2.1 The furnace 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 (1.52 mm) water column.

38.3 Furnace equipped with vaporizing burner

38.3.1 The furnace is to be fired at its rated Btu per hour (W) input, ±2 percent.

38.3.2 No. 1 Fuel oil having a viscosity conforming to Table 38.2 is to be used for firing vaporizing burners.

Table 38.2
Viscosity for no. 1 Fuel oil

Oil viscosity	Maximum	Mean	Minimum
Centistokes at 38°C (100°F)	2.04	1.97	1.90
Centistokes at 25°C (77°F)	2.44	2.34	2.24

38.3.3 The firing rate at high fire is to be equivalent to the rated input of the furnace.

38.3.4 The pilot-fire burning rate is to be a rate equivalent to the pilot-fire burning rate obtained at the maximum allowable setting of the metering device with No. 1 oil plus the valve manufacturer's plus tolerance.

38.3.5 If adjustable oil shutoff controls are provided, they are to be adjusted to the maximum allowed timing for shut-off.

38.3.6 The depth of oil in the burner under a pooled condition is to be the maximum to be allowed in production.

38.3.7 The draft at the flue collar is to be as recommended by the manufacturer, which is to be not less than 0.02 inch (0.51 mm) water column.

39 Combustion Test – Burner and Furnace

39.1 A wall furnace shall be capable of functioning uniformly and reliably without producing excessive smoke when installed and adjusted in accordance with the manufacturer's instructions.

39.2 When the furnace is fired at rated input and such that the stack loss is not more than 25 percent and operated until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established, the smoke in the flue gases is not to exceed that indicated by a number 2 spot as indicated on the Shell-Bacharach Scale with the Model RDC Smokemeter.

40 Operation Tests

40.1 A limit control, when adjusted to its maximum setting allowed by a fixed stop shall prevent a furnace when tested as described herein from delivering air at a temperature in excess of 250°F (121°C). See Limit Control Cutout Test, Section 41.

40.2 A wall furnace fired at rated input shall be capable of continuous operation without the limit control functioning to cause reduction in the input when the furnace is tested as described herein. See Continuity of Operation Test, Section 42.

41 Limit Control Cutout Test

41.1 The limit control is to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting. A thermocouple is to be attached to the limit control sensing element at its midpoint.

41.2 The furnace is to be operated until equilibrium outlet-air temperature has been attained. The circulating air flow is to be gradually restricted (the fuel input may be increased also) until the limit control functions, and at this instant the temperature of the outlet air and the limit-control sensing element temperature (T_{L1}) is to be determined. The outlet-air temperature is to be measured as described in 37.5.8 – 37.5.13. Also, after the limit control functions, its sensing element is not to attain a temperature that will adversely affect the limit-control calibration. See 40.1.

41.3 If the furnace is equipped with an automatic-reset type limit control, the furnace is to be allowed to operate until it recycles on the limit control. The temperature obtained is not to exceed the value specified in 40.1 at the time the limit control functions.

42 Continuity of Operation Test

42.1 The limit control is to be bypassed to permit continued operation during this test, but its sensing element is to remain in its normal location.

42.2 The furnace is to be placed in operation. The air-circulating fan, if its speed is variable, is to be adjusted so that approximately rated air delivery is obtained.

42.3 An adjustable register shutter is to be set in the position allowing maximum air flow. If a furnace is intended for installation with an optional number of warm-air outlets, all except the minimum number of outlets to be always employed are to be closed.

42.4 Operation of the furnace is to be continued until equilibrium outlet-air temperature is obtained. The inlet-air temperature (T_1) and the limit control sensing element temperature (T_{L2}) are to be measured.

42.5 To be in conformance with 40.2, the operation of the furnace is not to be interrupted by any control device included as part of the heater and:

$$T_{L2} \text{ is to be not more than } T_{L1} \text{ minus } 70$$

in which: