UL 729

STANDARD FOR SAFETY

Oil-Fired Floor Furnaces

UL Standard for Safety for Oil-Fired Floor Furnaces, UL 729

Sixth Edition, Dated August 29, 2003

Summary of Topics

This revision of ANSI/UL 729 is being issued to reaffirm approval as an American National Standard. No changes in requirements are involved.

The revisions are substantially in accordance with Proposal(s) on this subject dated September 30, 2016.

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 729

Standard for Oil-Fired Floor Furnaces

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The most recent designation of ANSI/UL 729 as a Reaffirmed American National Standard (ANS) occurred on November 22, 2016. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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 floor furnaces.

1.2 Requirements for the installation and use of oil-burning equipment are included in the Standard for the Installation of Oil-Burning Equipment, ANSI/NFPA 31. Requirements for the installation of oil-burning equipment are also included in codes such as the International Mechanical Code and the Uniform Mechanical Code.

1.2 revised October 1, 2008

1.3 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, or both.

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 excessive 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 in the main burner is 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 furnace, exclusive of legs.

3.8 BURNER – A device for the final conveyance of fuel and air to the combustion zone.

3.9 BURNER, MANUALLY LIGHTED – A burner in which fuel to the main burner is turned on only by hand and ignited under supervision.

3.10 BURNER, MECHANICAL ATOMIZING – A power-operated burner that prepares and delivers the fuel 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 and vertical rotary atomizing, and vertical rotary wall-flame burners.

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

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

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

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

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

3.16 CHIMNEY CONNECTOR – The pipe that connects a solid or liquid fuel-burning appliance to a chimney.

3.17 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 is to be considered as combustible even though flameproofed, fire-retardant treated, or plastered.

3.18 COMBUSTION – The rapid oxidation of fuel accompanied by the production of heat or heat and light.

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

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

3.21 CONSTANT LEVEL VALVE – A device that maintains a constant level of fuel in a reservoir for delivery to the burner.

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

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

3.24 CONTROL, SAFETY – An automatic control, including a relay, switch, or other auxiliary equipment used in conjunction therewith to form a safety control system that is intended to reduce the likelihood of operation of the controlled equipment that may result in a risk of fire or injury to persons.

3.25 CONTROL, PRIMARY SAFETY – An automatic safety control intended to reduce the likelihood of abnormal discharge of fuel at the burner in case of ignition failure or flame failure.

3.26 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.

3.27 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.

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

3.29 DAMPER, MANUALLY OPERATED – An adjustable damper manually set and locked in the position intended to be used.

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

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

3.32 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 that involves a potential of not more than 30 volts rms alternating-current (42.4 volts peak) or direct current and supplied by:

1) A primary battery,

2) A Class 2 transformer, or

3) A combination of transformer and fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer.

A circuit derived from 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.

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

3.34 FLUE COLLAR – That portion of an appliance constructed for attachment of the chimney connector.

3.35 FLUE GASES – Combustion products and excess air.

3.36 FUEL OIL – Any hydrocarbon oil defined by Specifications for Fuel Oils, ANSI/ASTM D396.

3.36 revised October 1, 2008

3.37 FURNACE, FLOOR – A completely self-contained, indirect-fired unit furnace having integral plenums, warm air outlet, and cold air return and intended to be inserted into and suspended from the floor of the space being heated. The furnace takes air for combustion from outside this space and has a means for observing the flame and lighting the appliance from such space.

a) Gravity Type Floor Furnace – A floor furnace depending primarily on circulation of air by gravity. This category also includes floor furnaces equipped with booster-type fans which do not materially restrict circulation of air by gravity flow when such fans are not in operation.

b) Fan Type Floor Furnace – A floor furnace equipped with a fan which provides the primary means for circulation of air.

3.38 HEAT EXCHANGER, DIRECT – A heat exchanger in which heat generated in the combustion chamber of the appliance is transferred directly 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. A direct heat exchanger is a self-contained combustion and heat transfer device.

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

3.40 HEATING SURFACES – A surface that transmits heat directly from flame or flue gases to the medium to be heated.

3.41 INDIRECT FIRED APPLIANCE – An appliance constructed 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.

3.42 LINER – See Radiation Shield – 3.48.

3.43 MAINTENANCE – 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 as maintenance. Some examples of maintenance 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.

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

3.45 OIL-FIRED FLOOR FURNACE – A heating furnace equipped with one or more oil burners, safety controls, electrical equipment, and related equipment, manufactured for assembly as a complete unit.

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

3.47 PRIMARY AIR – The air that is introduced into a burner and mixed with the fuel before it reaches the ignition zone.

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

3.49 RADIATOR – An auxiliary heat transfer surface within the casing, connected between the combustion chamber and the flue collar.

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

3.51 SAFETY CONTROL – See Control, Safety – 3.24.

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

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

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

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

3.56 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 Shutoff 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.

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

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.

3A.1 added October 1, 2008

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard, including the oil burner and its primary safety control as assembled as part of a furnace assembly, 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 furnace shall be intended for installation as a single assembly and shall include all the essential components necessary for its intended function when installed. The furnace may be shipped as two or more subassemblies.

5.2 A floor furnace, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. Except as indicated in 5.3, each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or more subassemblies which must bear a definite relationship to each other for the intended installation or operation of the floor furnace shall be:

a) Arranged and constructed to permit them to be incorporated into the complete assembly, in the correct relationship with each other, without need for alteration or alignment; or

b) Assembled, tested, and shipped from the factory as a single assembly.

5.3 In accordance with 5.2, major subassemblies of a floor furnace are considered 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

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

A wiring harness may be packaged with one of the major subassemblies. Cutting or drilling required for the attachment of a return air plenum, the installation of an optional filter rack, or the provision of a return air opening in the furnace casing is deemed to conform to 5.2. If a return air opening is to be cut in the casing panel by the installer, suitable instructions and a template shall be furnished with the furnace, or the corners of the opening shall be embossed in knockout form.

5.4 A radiation shield or baffle employed to reduce the likelihood of 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 intended operation; or

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

5.5 The construction of a floor furnace shall be such that, for any typical installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to reduce the likelihood of excessive temperatures is not required.

5.6 Parts of a floor furnace which must be removed for installation shall be assembled to the furnace in a manner to permit easy removal, without dismantling factory wiring, and replacement. See 5.2 – 5.5.

5.7 A floor furnace shall be constructed to provide a constant circulation of heated air at all times during intended operation.

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

5.9 A floor furnace having two warm air registers equipped with a shutter shall be such that only one or a fraction of one warm air register may be closed at one time.

5.10 Except for the attachment of a return air duct, there shall be no opening in the casing of a floor furnace for admission of circulating air below the floor level unless applicable performance requirements are met with such an opening closed or open.

5.11 A furnace shall be constructed so that parts requiring attention or manipulation by the user during typical use can be easily operated.

5.12 Adjustable or movable parts should be provided with locking devices to reduce the risk of shifting.

5.13 Any external door providing access into the combustion chamber of a furnace is to fit tightly and be constructed in a manner to resist displacement by a jarring or pressure created during intended use. A door shall be self-closing or arranged so that it must be closed to replace the floor register.

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

5.15 A floor furnace equipped with an antiflooding device shall be constructed so 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 A floor furnace shall be constructed so that parts such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers can be cleaned, without major dismantling of the furnace or removal of parts required by 5.2 to be factory assembled.

6.2 The removal of an access panel, burner, blower, cap, plug, or the like, intended to permit removal and replacement for servicing and the detachment of the chimney connector, is not considered major dismantling with regard to the requirement in 6.1.

6.3 Burners, controls, and safety devices shall be accessible for cleaning, inspection, repair, and replacement when the furnace is installed as recommended by the manufacturer. The arrangement of parts in the assembly that may be removed for maintenance shall be such that their replacement, following removal, will not necessitate their realignment to maintain their intended relationship with other parts of the assembly. Specific tools required for maintenance to be done by the operator shall be provided with the furnace.

7 Moving Parts

7.1 A moving part such as a fan blade, blower wheel, pulley, belt, and the like, that may cause injury to persons shall be enclosed or guarded.

7.2 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 provided as specified in 61.18.

7.3 The distance from an opening in a required guard or enclosure to the moving parts mentioned in 7.1 shall be as specified in Table 7.1, but the minor dimension of the opening shall not exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values specified in the table, the distance from the opening to the moving part shall not be less than that determined by interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 7.1
Dimensions of openings

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

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

7.4 A moving part is not to be considered when evaluating compliance with 36.1 and 7.1 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

8 Disposal of Combustion Products

8.1 A furnace shall be constructed so that the products of combustion are not mixed with the circulating air.

9 Casing

9.1 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:

a) Steel not less than 0.020 inch (0.51 mm) thick if uncoated, or 0.023 inch (0.58 mm) thick if galvanized, or

b) Nonferrous sheet metal not less than 0.029 inch (0.74 mm) thick.

All surfaces shall be protected against corrosion. A finish required for corrosion protection shall not be damaged by heat during any of the tests specified in these requirements.

9.2 A coating provided on sheet metal as corrosion protection shall be equivalent to:

a) Hot-dipped mill galvanized sheet steel conforming with the coating Designation G90 in Table I of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653.

b) Terne sheet having a coating of not less than 8 – 12 pounds (3.6 – 5.4 kg) per double base box, 112 sheets, 20 by 28 inches (508 by 711 mm).

c) Aluminum coated steel suitable as determined by test.

d) Durable coating of outdoor paint, such as one of the organic alkyd resin types.

9.2 revised October 1, 2008

9.3 The casing of a floor furnace shall be constructed to provide access for servicing and cleaning of parts within the enclosure. If these operations cannot be performed readily from the floor level, access doors shall be provided for this purpose. The bottom of a casing shall be provided with a drain opening to reduce the risk of accumulation of liquids.

9.4 A floor furnace shall be constructed to provide control and operation from above the floor level, including the manipulation of any reset devices.

9.5 Access panels that need to be removed for service and accessibility shall be constructed to provide repeated removal and replacement without causing damage or reducing any required insulating value.

9.6 A removable panel through which air is drawn for combustion shall be constructed to reduce the risk of it being attached in a manner that may result in a risk of fire or injury to persons.

9.7 A removable panel shall be so constructed that it cannot be interchanged with other panels on the same furnace if interchange may result in a risk of fire or injury to persons.

9.8 The casing of a forced-air type furnace shall have no uncovered openings communicating with the circulating air compartments unless such openings are intended to be always connected to a return air duct.

9.9 The furnace shall be constructed so that the negative pressure created by an air circulating fan cannot affect the combustion air supply or draw products of combustion into the circulating air.

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

9.11 An access opening to a return air compartment shall be completely covered.

10 Support

10.1 A floor furnace shall incorporate features to provide support when installed as intended.

10.2 A floor furnace shall be supported independently of the register.

10.3 A support provided in accordance with 10.2 may be accomplished by providing substantial flanges at least 3/4 inch (19.1 mm) wide at the top of the furnace casing or reinforced openings in the casing which will accommodate screws for attachment to the floor framing. Reinforced openings are to be located approximately 3-1/2 inches (89 mm) below the top of the casing. The total thickness of metal surrounding the reinforced opening is to be not less than 0.032 inch (0.8 mm). At least twelve such holes, uniformly distributed, are to be provided. Where this method is employed, the necessary wood screws are to be supplied with each furnace. The practice of driving nails through the casing does not meet the intent of this requirement.

11 Radiation Shield

11.1 A radiation shield or liner shall be constructed, formed, and supported to provide for its intended positioning and to reduce the likelihood of distortion or sagging in service. See 12.4 and 12.5. A shield or liner shall be protected against corrosion if its deterioration may cause temperatures in excess of those specified in Table 44.1 when the furnace is tested as specified in Sections 44 – 51. Any finish used to obtain the required resistance to corrosion shall not be damaged by heat when the furnace is tested as specified in Sections 44 – 51.

12 Materials in an Air Handling Compartment

12.1 Materials in a compartment handling conditioned air for circulation shall have a flame spread rating of not more than 25 and a smoke developed rating of not more than 50 when tested as specified in the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723.

Exception: This requirement does not apply to the following:

a) An air filter, drive belt, wire insulation, paint applied for corrosion protection, or tubing of material equivalent to one of the types of wire insulation permitted by this standard.

b) A gasket forming an air or water seal between metal parts.

c) A miscellaneous small part such as a resilient or vibration mount, wire tie, clamp, label, and the like.

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

e) Molded or formed polymeric-material components (not liners) in such quantity that their total exposed surface area within the compartment does not exceed 10 square feet (0.9 m^2). See 12.6.

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

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

12.4 Thermal or acoustic insulating material shall be securely positioned if loosening may reduce or block air flow to cause temperatures in excess of those intended during tests as specified in Sections 44 – 51 or if loosening will result in short-circuiting, grounding, or reduction of electrical spacings below the required values. Leading edges of insulation shall be protected against damage caused by moving air.

12.5 A mechanical fastener for each square foot (0.09 m^2) of exposed surface is considered to securely position insulating liners to comply with 12.3. A mechanical fastener may be a bolt, metal clamp, wire rod, or the equivalent. Butting the edges of insulation against bulkheads may be employed to protect leading edges against damage caused by moving air. For rigid or semirigid sheets of insulating material, fastening is not required to the extent needed for less rigid material nor is protection of leading edges required.

12.6 Polymeric materials exempted by the Exception to 12.1(e) shall have a flame spread rating of not more than 25 or shall comply with the requirements of the Flammability Tests for Materials in Air Handling Compartments, Section 56.

13 Air Filter

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

14 Combustion Chamber

14.1 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 not less than 0.032 inch (0.81 mm) thick.

14.2 A combustion chamber (fire box) lining material shall be durable, secured in place, and accessible for replacement with equivalent material.

15 Radiator

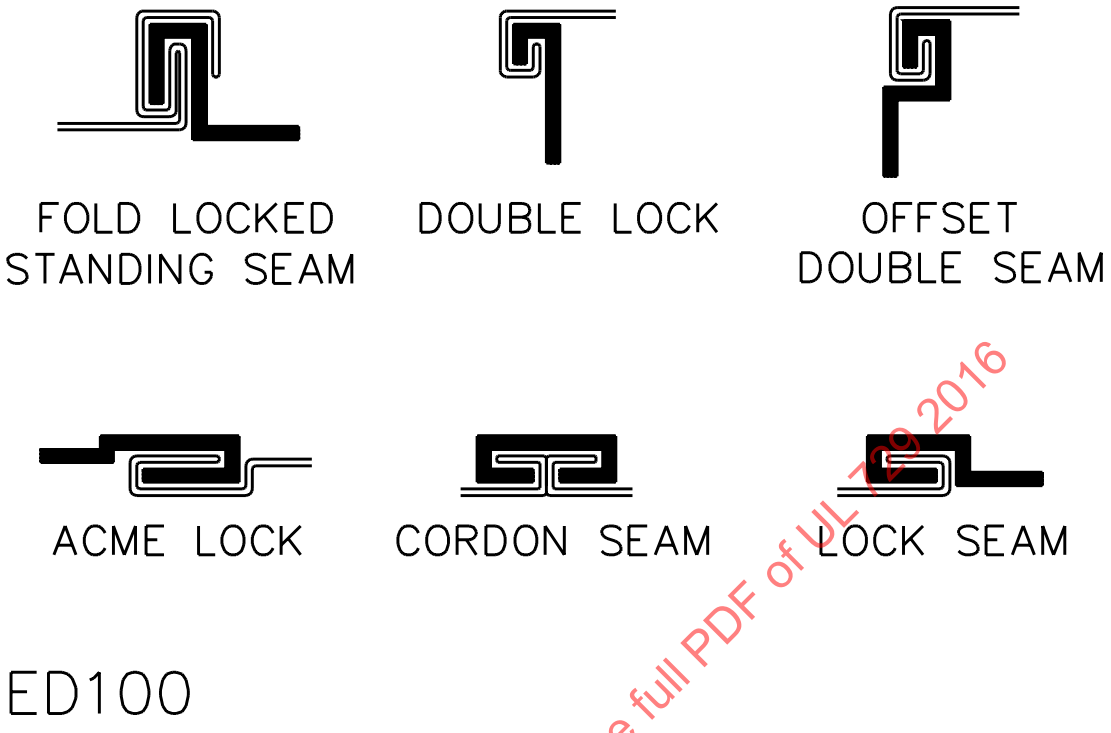
15.1 A radiator shall be made of a material that complies with the requirement specified in 14.1 for a combustion chamber and shall be capable of being cleaned as intended.

16 Heating Surface Joints

16.1 Joints in heating surfaces shall be mechanically secure and tight, for example, welded, lock-seamed, machined and bolted, riveted, or the like. A joint shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

16.2 Examples of some acceptable lock-seams are illustrated in Figure 16.1.

Figure 16.1
Types of acceptable lock-seams



17 Baffles

17.1 A baffle in a flue gas passage or otherwise exposed to combustion products shall be constructed and arranged to remain in its intended position.

17.2 A flue baffle shall be made of material having rigidity, heat and corrosion resistance equivalent to AISI 1010 sheet steel not less than .0.032 inch (0.81 mm) thick unless its deterioration will not cause temperatures in excess of those specified when the furnace is tested as specified in the Temperature Test, Section 44; Maximum Register Temperature Test, Section 45, and Continuous-Operation Temperatures Test, Section 46.

17.3 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall be constructed so that it can be removed and replaced only in its intended position.

18 Flue Collar

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

18.2 A flue collar, flue collector part, or extensions exterior to the air handling compartment shall have rigidity, heat, and corrosion resistance equivalent to sheet steel not less than 0.016 inch (0.41 mm) thick.

18.3 A flue collar or flue collector part within the air handling compartment shall have rigidity, heat, and corrosion resistance equivalent to sheet steel not less than 0.032 inch (0.81 mm) thick.

18.4 The top of the flue collar shall be located not less than 20-1/2 inches (520 mm) below the intended floor level (upper surface of finished floor) to provide the required clearance between the flue pipe and floor joists.

19 Damper and Draft Regulator

19.1 A floor furnace equipped with a natural draft burner shall be provided with an automatic draft regulator.

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

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

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

20 Field Wiring System Connections

20.1 Sheet metal to which a wiring system is to be connected in the field shall not be less than 0.032 inch (0.81 mm) thick if uncoated steel, not less than 0.034 inch (0.864 mm) thick if galvanized steel, and not less than 0.045 inch (1.14 mm) thick if nonferrous.

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

20.3 In an enclosure intended to be supported by rigid conduit, the threaded opening for connection to the conduit shall be provided with at least five full threads.

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

20.5 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing, and shall be located so 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.

20.6 A plate or plug for an unused conduit opening or other hole in the enclosure shall not be less than:

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

b) 0.027 inch (0.69 mm) thick if steel or 0.032 inch (0.81 mm) thick if 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 a plate or plug shall be securely mounted.

CONSTRUCTION – ELECTRICAL

21 Controls

21.1 Application

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

21.1.2 A short circuit or combination of short circuits to ground shall not render a safety control or protective device inoperative. Safety control circuit arrangements other than described in 21.1.1 may be considered if they accomplish the intent of this requirement.

21.1.3 The requirement in 21.1.1 does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

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

21.1.5 A safety control shall be accessible.

21.1.6 A safety control shall be supported in such a manner that the control 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.

21.1.7 Nothing shall be provided for the purpose of rendering any safety control ineffective or to allow firing of the furnace without the protection of each of the required safety controls.

21.1.8 A burner not equipped to provide for automatic restarting shall be constructed 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.

21.2 Limit control

21.2.1 A floor furnace shall be provided with a limit control to reduce the likelihood of temperatures in excess of those specified in Sections 47 – 51.

21.2.2 The maximum setting of a limit control allowed by a fixed stop shall not permit an outlet air temperature more than that indicated in 42.1.

21.2.3 An automatically lighted furnace shall be provided with an automatic-reset type limit control. An auxiliary limit control may be of the manual-reset type.

21.2.4 A furnace equipped with a limit control that throttles the oil supply to produce a pilot fire shall be constructed to furnish air for combustion when the floor register is completely covered.

21.2.5 A limit control that functions to interrupt the delivery of fuel for combustion by opening an electrical circuit shall be arranged to effect the direct opening of that circuit, whether the switching mechanism is integral with or remote from the sensing element.

21.2.6 The requirement specified in 21.2.5 is intended to reduce the likelihood of interposing in the limit control circuit other controls, the malfunction of which may create a condition that the limit control is intended to preclude. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller 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 multi-phase circuit.

21.2.7 A furnace equipped with a vaporizing burner shall be constructed to reduce the likelihood of pooling of the burner upon functioning of the limit control.

21.2.8 The limit control or controls shall be factory installed on the furnace or its location shall be factory predetermined.

21.3 Primary safety control

21.3.1 A furnace shall be equipped with a primary safety control.

22 Field Wiring

22.1 General

22.1.1 A furnace shall have provision for connection of a power supply wiring system in accordance with the National Electrical Code, ANSI/NFPA 70.

22.1.1 revised October 1, 2008

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

22.1.3 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.

22.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall not be less than that specified in Table 22.1. 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).

22.1.4 revised October 1, 2008

22.1.5 A knockout for connection of a field-wiring system to a terminal box or compartment shall accommodate conduit of the trade size specified in Table 22.2.

Table 22.1
Size of junction boxes

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

Table 22.2
Trade size of conduit in inches[a](mm OD)

Wire size		Number of wires									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)

[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.

22.1.6 Wiring exterior to a furnace between the burner assembly and a limit control, a primary safety control, or a motor controller that can be done readily with Type T wire enclosed in conduit or with metal-clad cable in accordance with these requirements need not be furnished by the manufacturer as part of the furnace if instructions for installing such wiring are furnished with each furnace. See 23.1.4.

22.1.7 A terminal 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 servicing of the furnace. This requirement does not apply to separate limit controls and stack-mounted primary safety controls, where permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

22.1.8 A terminal box or enclosure in which field-installed conductors are to be connected as indicated in 22.1.6, 22.1.7, and 22.1.9 shall be located so 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 Type T wire in Table 44.1 when the furnace is tested as specified in Sections 44 and 46 – 51.

22.1.9 Except as indicated in 23.1.4, wiring to be connected in the field between the furnace and devices not attached to the furnace or between separate devices that are field-installed and located shall comply with these requirements if done with Type T wire enclosed in conduit or with metal-clad cable.

22.2 Leads and terminals

22.2.1 Wiring terminals, or leads 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, corresponding to the marked rating of the assembly.

Exception: A lead may be less than 6 inches (152 mm) long if it is evident that the use of a longer lead might result in damage to the lead insulation.

22.2.1 revised October 1, 2008

22.2.2 A lead 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 if such stress may cause the lead to separate from its termination or result in damage to the lead from sharp edges. See Strain Relief Test, Section 57.

22.2.3 A terminal or lead intended to be connected to the grounded conductor of the supply circuit shall not be electrically connected to a single-pole manual switching device which has an off position or to a single-pole overcurrent (not inherent overheating) protective device.

22.2.4 Field-wiring terminals shall be secured to their supporting surfaces by means other than friction between surfaces so that they cannot turn or shift in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by:

a) Two screws or rivets;

b) Square shoulders or mortices;

c) A dowel pin, lug, or offset;

d) A connecting strap or clip fitted into an adjacent part; or

e) Some other equivalent method.

22.2.5 A conductor provided for connection of a grounded conductor shall be 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. No other leads, other than grounded conductors, shall be so identified. A terminal for connection of a grounded conductor shall be of or plated with metal 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.

22.2.5 revised October 1, 2008

22.2.6 At terminals, stranded conductors shall be restrained from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by using a pressure-terminal connector, soldering lug, crimped eyelet, soldering all strands of the wire together, or equivalent means. An open slot-type connector shall not be used unless it is constructed to reduce the likelihood of disconnection resulting from loosening of the clamping means.

22.2.7 The shank of a terminal connector 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 insulation on the shanks shall be not less than 0.028 inch (0.71 mm) thick.

22.2.8 A lead provided for a spliced connection to an external high-voltage circuit shall not be connected to a wire binding screw or pressure-terminal connector located in the same compartment as the splice and shall not be visible to the installer, unless:

a) The screw or connector is rendered unusable for field-wiring connections or

b) The lead is insulated at the unconnected end.

22.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors, secured in place as specified in 22.2.4, 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.

22.2.9 revised October 1, 2008

22.2.10 A wire binding screw at a high-voltage wiring terminal for field connection shall not be smaller than No. 10.

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

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

22.2.10 revised October 1, 2008

22.2.11 A terminal plate for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG (2.1 mm^2). There shall not be less than two full threads in the metal.

22.2.11 revised October 1, 2008

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

22.2.13 A wire binding screw shall thread into metal.

23 Internal Wiring

23.1 General

23.1.1 The wiring of high-voltage and safety-control circuits shall conform with the requirements in 23.1.2 – 23.3.2.

23.1.2 Insulated conductors having ampacity, voltage, and temperature ratings consistent with their use shall be provided. A conductor, other than an integral part of a component, shall not be smaller than 18 AWG (0.82 mm^2).

23.1.2 revised October 1, 2008

23.1.3 Except as indicated in 22.1.6, the wiring for all furnace circuits shall be provided by the manufacturer as part of the furnace. If the furnace is not assembled and wired at the factory, such wiring shall be provided as a harness with each furnace and shall 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.

23.1.4 If insulated conductors rated for use at temperatures higher than 60°C (140°F) are required for compliance with these requirements, the devices to be connected by such wiring shall be factory located on the equipment.

Exception: The requirement does not apply to a primary safety control to be field-installed on the chimney connector.

23.2 Methods

23.2.1 Electrical wiring to a part that must be moved for intended 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 a part shall terminate in eyelets or connectors. If the wiring to a part that functions also as an access plate or cover, such as 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 stress the wiring or its connections.

23.2.2 Except as noted in 23.2.15 and 23.2.16, conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable.

23.2.3 Some wiring materials acceptable for use if enclosed as specified in 23.2.2 are given in Group A of Table 23.1.

Table 23.1
Typical wiring materials

Table 23.1 revised October 1, 2008

Group	Type of wire, cord, cable	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	RF-2, FF-2, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, T, THW, XHHW, MTW, THW-MTW, THWN, TW or thermoplastic appliance wiring material, with insulation thicknesses shown at the right corresponding to wire size indicated	10 and smaller	5.3	2/64	0.8
		8	8.4	3/64	1.2
		6	13.3	4/64	1.6
		4	21.2	4/64	1.6
		3	26.7	4/64	1.6
		2	33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	54.0	5/64	2.0
		2/0	67.0	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.2	5/64	2.0
B	SO, ST, SJO, SJT, or appliance wiring material having thermo-plastic or neoprene insulation, with insulation thicknesses shown at right corresponding to the wire sizes indicated	18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.4	6/64	2.4
		6	13.3	8/64	3.2
Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm^2), are considered equivalent to the wiring material referenced in Group B, when the conductors are covered with 1/32 inch (0.8 mm) thickness thermoplastic insulating tubing of a type acceptable for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, flammability, and the like.				

23.2.4 Flexible metal conduit shall not be smaller than 3/8 inch electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads.

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

23.2.6 A splice and connection 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 a risk of fire or injury to persons.

23.2.7 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 may not be maintained.

23.2.8 A splicing device, such as a fixture-type splicing connector, pressure wire connector, or the like, may be employed if it has insulation acceptable for the voltage to which it is subjected. In determining if splice insulation consisting of coated fabric, thermoplastic, or other type of tubing meets the intent of this requirement, consideration is to be given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge does not meet the intent of this requirement.

23.2.9 A splice is to be enclosed by installation in a junction box, control box, or other compartment in which high-voltage wiring materials as specified in Group A of Table 23.1 may be employed.

23.2.10 A splice shall be located, enclosed, and supported so that it is not subject to damage, flexing, motion, or vibration.

23.2.11 A splice in an enclosed machinery compartment is to be secured to a fixed member in the compartment so that it is not subject to movement or damage during servicing.

23.2.12 A conductor shall be protected from abrasion at all points where conduit or metal-clad cable terminates. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided and the connector or clamp shall be constructed so that the insulating bushing or its equivalent will be visible for inspection.

23.2.13 The construction of a wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and will maintain electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges that may cause damage to the insulation on wires.

23.2.14 All wiring shall be supported and routed to reduce the likelihood of damage from sharp edges or moving parts.

23.2.15 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 met:

a) It is not practical to do the wiring in accordance with 23.2.2.

b) The cord is not required to be bent, twisted, or otherwise displaced during 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.

23.2.16 A cord or appliance wiring material specified in Group B of Table 23.1 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 except for a drain opening as required by 9.3, 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) Suitable strain relief is provided at the terminations of cords and wiring material.

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

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

e) If flammable material other than electrical insulation is located within the compartment, the wiring is separated from such material and the material has the characteristics described in 23.2.17. An air filter may be employed within the enclosure.

23.2.17 With reference to 23.2.16(e), 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 Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

23.2.18 A cord and other wiring material that complies with 23.2.16 shall be supported so that it will not be damaged, such as by closely following surfaces. Strain relief, if required, shall be provided.

23.2.19 A hole in a wall or partition through which insulated wires or cords pass shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires or cords may bear so that the insulation will not be abraded. A bushing shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

23.2.20 A fiber bushing shall:

a) Not be less than 3/64 inch (1.2 mm) thick;

b) Be located so that it will not be exposed to moisture; and

c) Not be employed where it will be subjected to a temperature higher than 90°C (194°F) under normal operating conditions.

23.2.21 Provision for an unbushed opening in sheet metal usually requires rolling and/or extrusion of the metal around the opening or the insertion of a grommet conforming to 23.2.19.

23.3 Short circuit protection

23.3.1 Except as indicated in 23.3.2, conductors of motor circuits having two or more motors, one or more of which have thermal or overcurrent protection, wired for connection to one supply line, shall withstand the Short-Circuit Test, Section 53, without creating a risk of fire or electric shock.

23.3.2 Conductors that comply with the following are considered acceptable without test:

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

b) Conductors that are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.22 m) long if the appliance will be protected by a 60 ampere fuse or smaller. This applies to any of the wiring materials specified in this standard, including those enclosed in raceways; or

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

23.3.2 revised October 1, 2008

24 Separation of Circuits

24.1 Unless provided with insulation for the highest voltage involved, insulated conductors of different internal wiring circuits shall be separated by barriers or 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.

24.2 Segregation of insulated conductors as specified in 24.1 may be accomplished by clamping, routing, or equivalent means that maintains permanent separation from insulated or uninsulated live parts of a different circuit.

24.3 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, the short-circuiting of which may result in the risk of fire, electric shock, or injury to persons, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that Type T, RF-2, or equivalent conductors are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

24.3 revised October 1, 2008

24.4 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts of the 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.

24.5 If the number of openings in the enclosure does not exceed the minimum required for the intended wiring of the furnace and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 24.3, that the conductors entering an opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility is to be investigated of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit.

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

24.7 A metal barrier shall have a thickness not less than that specified in Table 29.1 or 29.2, whichever applies, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) thick and shall be thicker if its deformation may defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

24.8 Openings in a barrier for the passage of conductors shall not be 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 that will need to pass through the barrier. The closure for any other opening shall have a smooth surface wherever an insulated wire may contact 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.

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25 Bonding for Grounding

25.1 An exposed or accessible dead metal part that may become energized and that may be contacted by the user or by service personnel during service operations that are likely to be performed when the equipment is energized, shall be electrically connected to the point of connection of an equipment ground.

25.2 Except as indicated in 25.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like shall be bonded for grounding if they may be contacted by the user or serviceman.

25.3 Metal parts, as described below, need not be grounded.

a) Adhesive attached metal-foil markings, screws, handles, 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 a magnet frame and armature, small assembly screws, and the like, that are separated from wiring and uninsulated live parts.

c) A panel or cover that does not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover.

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

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

25.5 A splice shall not be employed in a wire conductor used for bonding.

25.6 Metal-to-metal hinge bearing members meet the intent of employing a means for bonding a door for grounding.

25.7 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.

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

25.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 58.1 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 that are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

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

25.11 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. The size of the conductor or strap shall be as specified in Table 25.1 unless a smaller size conductor or strap is found to be acceptable when subjected to the Bonding Conductor Test, Section 58.

Table 25.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

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

25.13 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.

25.14 A terminal for connection of an equipment-grounding conductor shall be located in the field-wiring compartment and shall be acceptable for connection of a conductor of the size required by the National Electrical Code, NFPA 70.

25.14 revised October 1, 2008

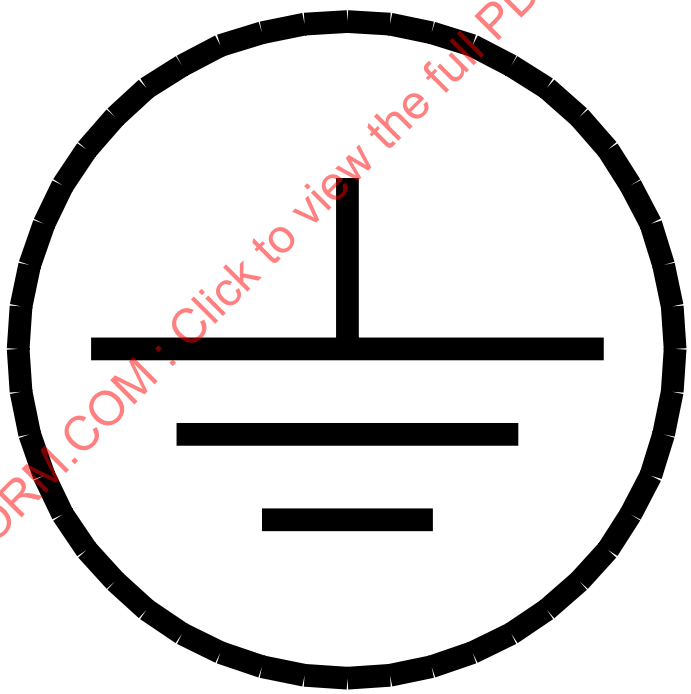
25.15 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector shall not be used for the terminal for the field-installed grounding conductor.

25.16 The terminal for the connection of the equipment grounding conductor shall be a green not readily removable terminal screw with a hexagonal head, a green, hexagonal, not readily removable terminal nut, or a green pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the words ″GREEN″, ″GROUND″; the letters ″G″, ″GR″; a grounding symbol such as Figure 25.1; or otherwise identified by a distinctive green color. When the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be similarly marked.

25.16 revised October 1, 2008

Figure 25.1
Grounding symbol

Figure 25.1 added October 1, 2008



25.17 If a pressure terminal 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) A marking shall be additionally provided indicating EQUIPMENT GROUND;

b) The conductor shall be identified by a green color; or

c) Both.

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

26 Servicing and Adjustment

26.1 Service functions that may have to be performed with the equipment energized include:

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

b) Resetting a control trip mechanism;

c) Operating a manual switch; or

d) Adjusting an air-flow damper.

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

26.2 An adjustable or resettable electrical control or manual-switching device 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 intended direction of access if uninsulated high-voltage live parts or moving parts that may cause injury to persons are:

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

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

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

26.4 A component in a low-voltage circuit shall comply with the requirements in 26.3 in its relation to uninsulated live parts in a high-voltage circuit and to moving parts that may cause a risk of injury to persons.

27 Electrical Components

27.1 Electrical components and wiring shall be arranged to reduce the likelihood of oil or water dripping or running on them during usage or from a connection required to be uncoupled for servicing the furnace.

27.2 An attachment plug or a separable connector shall not be used in a circuit if the breaking or making of the circuit by the device may result in a risk of fire, electric shock, or injury to persons.

28 Mounting of Electrical Components

28.1 A switch, fuseholder, lampholder, or similar component shall be mounted securely and shall be restrained from turning.

Exception No. 1: A switch need not be restrained from turning 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 is unlikely to loosen as a result of operation of the switch.

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.

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be restrained from turning if rotation cannot reduce spacings below the required values.

28.2 The means for restraining turning is to consist of more than friction between surfaces. A toothed lock washer that provides both spring take-up and an interference lock meets the intent of employing a means for restraining a small stem-mounted switch or other device having a single-hole mounting means from turning.

28.3 An uninsulated live part shall be secured to the base or mounting surface so that it will be restrained from turning or shifting in position if such motion may result in a reduction of spacings below the required values.

28.4 Control equipment located within the plenum or return air compartment of a furnace shall be constructed, enclosed, or protected, so that dense smoke will not be generated or flame emitted under any conditions that may occur in service.

29 Electrical Enclosures

29.1 General

29.1.1 The thickness of sheet metal for the individual enclosure of electrical components shall be as specified in Table 29.1 or 29.2.

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

a) Mechanical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

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

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

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

29.1.4 A terminal housing of a motor, 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.

29.1.4 revised October 1, 2008

29.1.5 A steel enclosure shall be protected against corrosion by painting, plating, or other equivalent means.

29.1.6 Sheet metal to which a wiring system is to be connected in the field shall not be less than 0.032 inch (0.81 mm) thick, if uncoated steel, not less than 0.034 inch (0.86 mm) thick, if galvanized steel, and not less than 0.045 inch (1.14 mm) thick, if nonferrous.

29.1.7 If the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of metal thinner than specified in Table 29.1 or 29.2 may be employed.

29.1.8 If insulating material other than electrical insulation is provided within the enclosure, consideration is to be given to the burning characteristics and combustibility of the material, and the proximity of an ignition source.

29.1.9 All intended mounting positions of the furnace are to be considered when determining compliance with the requirements in 29.1.7.

29.1.10 A junction box that is formed in part by another part such as a fan scroll or a motor casing shall 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 the entrance of a flat feeler gauge, 5/64 by 1/2 inch (2.0 by 12.7 mm) wide.

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

29.1.11 The criteria for determining compliance of an opening in an electrical enclosure are given in Section 36, Accessibility of Uninsulated Live Parts, Film-Coated Parts, and Moving Parts.

Table 29.1
Minimum thickness of sheet metal for enclosures, carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.3)	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	(1.35)	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	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	(15)		(15)	
25.0	(63.5)	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	(2.03)	0.084	(2.13)
35.0	(88.9)	47.0	(119.4)	54.0	(137.2)	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	(2.82)
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)

Table 29.1 Continued on Next Page

Table 29.1 Continued

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

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that 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 that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

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

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

3) An enclosure surface loosely attached to a frame, such as with spring clips.

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

[c] For a panel that is not supported along one side, such as a panel of a box, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

Table 29.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(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	(21.6)	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	(34.3)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.3)	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	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.5)	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)	

Table 29.2 Continued on Next Page

Table 29.2 Continued

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

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that 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 that is as rigid as one built with a frame of angles or channels. Construction considered to be without a supporting frame includes:

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

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

3) An enclosure surface loosely attached to a frame, such as with spring clips.

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

[c] For a panel that is not supported along one side, such as a panel of a box, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

29.2 Doors and covers

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

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

29.2.3 The assembly shall be arranged so that an overcurrent-protective device, such as a fuse, the intended function of which requires renewal, can be replaced or a manual-reset device can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device. See 29.2.7.

29.2.4 A required protective device shall be inaccessible from outside the furnace without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually reset motor protector, the reset button of a manually reset pressure switch, and similar parts may project outside the appliance enclosure.

29.2.5 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.

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

29.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the intended 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 29.2.8.

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

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

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

c) Fuses in low-voltage circuits.

29.2.9 A hinged cover, if required, shall not depend solely upon screws or other means requiring the use of tools to hold it closed, but shall be provided with a catch or spring latch.

29.2.10 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 to open meets the intent for holding the door in place as required in 29.2.9.

29.2.11 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 that provides equivalent protection, such as a fuse enclosure within an outer enclosure or a combination of flange and rabbet, is acceptable.

29.2.12 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.

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

30 Motors and Motor Overload Protection

30.1 A motor shall be protected by an integral thermal- or overload-protective device, or a combination thereof.

30.2 An overload-protective device specified in 30.1 is one that complies with the requirements in the National Electrical Code, ANSI/NFPA 70, as follows:

a) A separate overload device that is responsive to motor current. This device shall be rated or selected to trip at not more than the following percent of the motor full-load current rating:

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

Motors with a marked temperature rise not over 40°C (72°F) – 125 percent

All other motors – 115 percent

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

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

Motors with a marked service factor not less than 1.15 – 140 percent

Motors with a marked temperature rise not over 40°C (72°F) – 140 percent

All other motors – 130 percent

30.2 revised October 1, 2008

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

30.4 A separate overload device, except when included as part of a magnetic motor controller, shall be assembled as part of the equipment, and 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 result in the risk of fire, electric shock, or injury to persons.

30.5 A motor, such as a direct-drive fan motor, that is not normally subjected to overloads, and that is determined to be protected against overheating due to locked-rotor current by a thermal- or overload-protective device meets the intent of the requirement if it is determined that the motor will not overheat under actual conditions of use.

30.6 Impedance protection may be employed in a motor that is determined to be protected against overheating due to locked-rotor current, if the motor does not overheat under actual conditions of use.

30.7 Impedance protection shall not be employed if the motor is installed in a compartment handling air for circulation to the conditioned space.

30.8 A fuse shall not be used for motor overload protection unless the motor is protected by the largest size fuse that can be inserted in the fuseholder.

30.9 A motor shall not exceed the temperature rise specified in Table 44.1 when tested as described in Sections 44 and 46 – 51.

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

30.11 Interruption of the circuit to a motor by the overload- or thermal-protective device shall not result in operation of the equipment or discharge of fuel that results in a risk of fire, electric shock, or injury to persons. 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.

30.12 An automatic-reset protective device shall not be used if the automatic reclosing of the circuit to the motor by the device may result in a risk of fire, electric shock, or injury to persons.

30.13 The enclosure of a motor shall have no openings that will permit a drop of liquid or a particle falling vertically onto the motor to enter the motor.

30.14 Compliance with the requirement in 30.13 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor installed in the furnace.

30.15 A motor having openings in the enclosure or frame shall be installed or shielded to reduce the likelihood of particles falling out of the motor onto combustible material located within or under the assembly.

30.16 The requirement in 30.15 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 type of motor:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor of a permanent split-capacitor motor short-circuited; or

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

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

30.17 The barrier specified in 30.16 shall:

a) Be horizontal;

b) Be located as illustrated in Figure 30.1; and

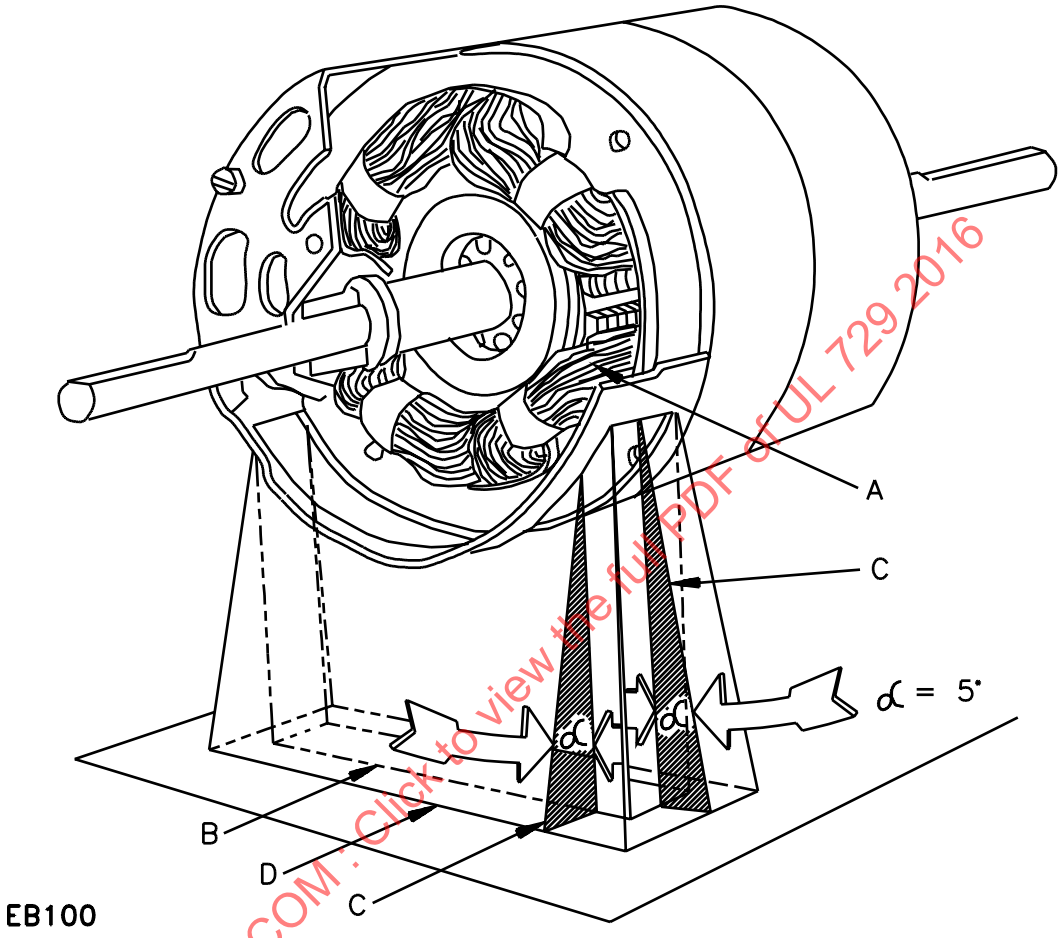
c) Have an area not less than that described in Figure 30.1.

Openings for drainage, ventilation, or the like, may be employed in the barrier, if such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

30.18 An overload-protective device or thermal-protective device for a motor shall comply with the requirements in the Short-Circuit Test, Section 53.

Figure 30.1
Location and extent of barrier

LOCATION AND EXTENT OF BARRIER



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

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

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

1) Tangent to the motor winding;

2) 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.

31 Switches and Controllers

31.1 A controller or controllers shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

Exception: A controller is not required for an assembly with more than one motor if the marked maximum fuse size does not exceed 20 amperes at 125 volts or less, or 15 amperes at 126 to 600 volts, and having not more than 6 amperes full-load current for each motor.

31.2 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 61.9 if the same controller contacts handle a remote motor or motors in addition to the motor or motors in the unit containing the controller.

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

31.4 A controller that may be required 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.

31.5 A controller that is cycled by the operation of an automatic-reset overload device shall be one that has been investigated and found to withstand an endurance test under locked-rotor conditions without breakdown. The endurance test is to be of a duration equivalent to that required for the overload device and at an equivalent rate.

31.6 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.

31.7 A motor controller shall be arranged so that it will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

32 Capacitors

32.1 A capacitor as a part of a capacitor motor and a capacitor connected across-the-line, such as a capacitor for radio-interference elimination, shall be housed within an enclosure or container so that mechanical damage to the plates will not occur, and flame or molten material will not be emitted as a result of breakdown of the capacitor. The construction shall comply with one of the following:

a) The capacitor container shall be of sheet steel not less than 0.020 inch (0.51 mm) thick or shall be constructed to provide equivalent protection; or

b) A capacitor having a sheet-steel container thinner than 0.020 inch (0.51 mm) or of other material shall be mounted in an enclosure that houses other parts of the appliance and that is acceptable for the enclosure of live parts.

32.2 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts in accordance with Table 34.1.

32.3 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 53.

32.4 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 53.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component or components.

33 Electrical Insulating Material

33.1 A material used for the sole support, separation, or both of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

33.2 Ordinary vulcanized fiber may be used for the insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts if shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock. Plastic materials may be used for the sole support of uninsulated live parts, if found to have mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric strength, and other properties as needed for the application.

34 Spacings – High-Voltage Circuits

34.1 Except as noted in 34.2 – 34.5, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than the values specified in Table 34.1.

Table 34.1
Minimum spacings

Ratings		Minimum spacings[a,b]					
		Through air		Over surface		To enclosure[c]	
Volt-amperes	Volts	Inch	(mm)	Inch	(mm)	Inch	(mm)
0 – 2000	0 – 300[d]	1/8[e]	3.2	1/4	6.4	1/4	6.4
More than 2000	0 – 150	1/8[e]	3.2	1/4	6.4	1/2	12.7
	151 – 300	1/4	6.4	3/8	9.5	1/2	12.7
	301 – 600	3/8	9.5	1/2[c]	12.7	1/2	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 not be less than 0.028 inch (0.71 mm) thick, except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.

[b] 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.

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

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

[e] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and grounded metal, shall not be less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be 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.

34.2 The through-air and over-surface spacings in Table 34.1 at an individual component part are to be evaluated on the basis of the total volt-ampere consumption of the load or loads that the component controls. However, the spacing from the component to the enclosure shall be evaluated on the basis of the total load on all components in the enclosure. For example, the through-air and over-surface spacings at a component that controls only a motor are evaluated on the basis of the volt-amperes of the motor. A component that controls loads in addition to the motor is similarly evaluated on the basis of the sum of the volt-amperes of the loads so controlled; except that a component that independently controls separate loads is evaluated on the basis of the volt-ampere of the larger load. The volt-ampere values for the loads referred to are to be determined by the measured input.

34.3 The spacing requirements in Table 34.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component that is evaluated on the basis of the requirements for the component. However, the spacing resulting from the installation of a component, including the spacing to dead metal or enclosures, are to be those specified in the table.

34.4 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 in 34.1 – 34.3 and shall be evaluated on the basis of the highest voltage involved.

34.5 For a circuit not exceeding 300 volts, the over-surface spacings for glass-insulated terminals of the motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in Table 34.1; and may be 1/4 inch (6.4 mm) where 3/8 inch (9.5 mm) is specified.

35 Spacings – Low-Voltage Circuits

35.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload-protective device, or other protective device, where a short or grounded circuit may result in a risk of fire or electric shock shall comply with the requirements in 35.2 – 35.5.

35.2 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 not be less than 1/8 inch (3.2 mm). See 34.4.

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

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

35.5 The spacings in low-voltage circuits that do not contain a device such as those indicated in 35.1 are not specified.

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

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

36.2 The requirement in 36.1 does not apply to mechanical service functions that are not performed with the equipment energized.

36.3 Accessibility and protection to reduce the risk of electric shock and injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 36.1.

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

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

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

e) An extractor-type fuseholder and snap switch mounted through the control assembly enclosure is located so that there is unimpeded access to the component through the access opening in the outer cabinet and so that it is not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless the live parts are guarded.

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

a) Coils of a controller;

b) Coils of a relay or solenoid;

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

d) An insulated terminal or splice; and

e) Insulated wire.

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

a) For an opening that has a minor dimension (see 36.9) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 36.2.

b) For an opening that has a minor dimension of 1 inch (25.4 mm) or more, such a part or wire shall be spaced from the opening as specified in Table 36.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 36.6.

Figure 36.1
Accessibility and protection

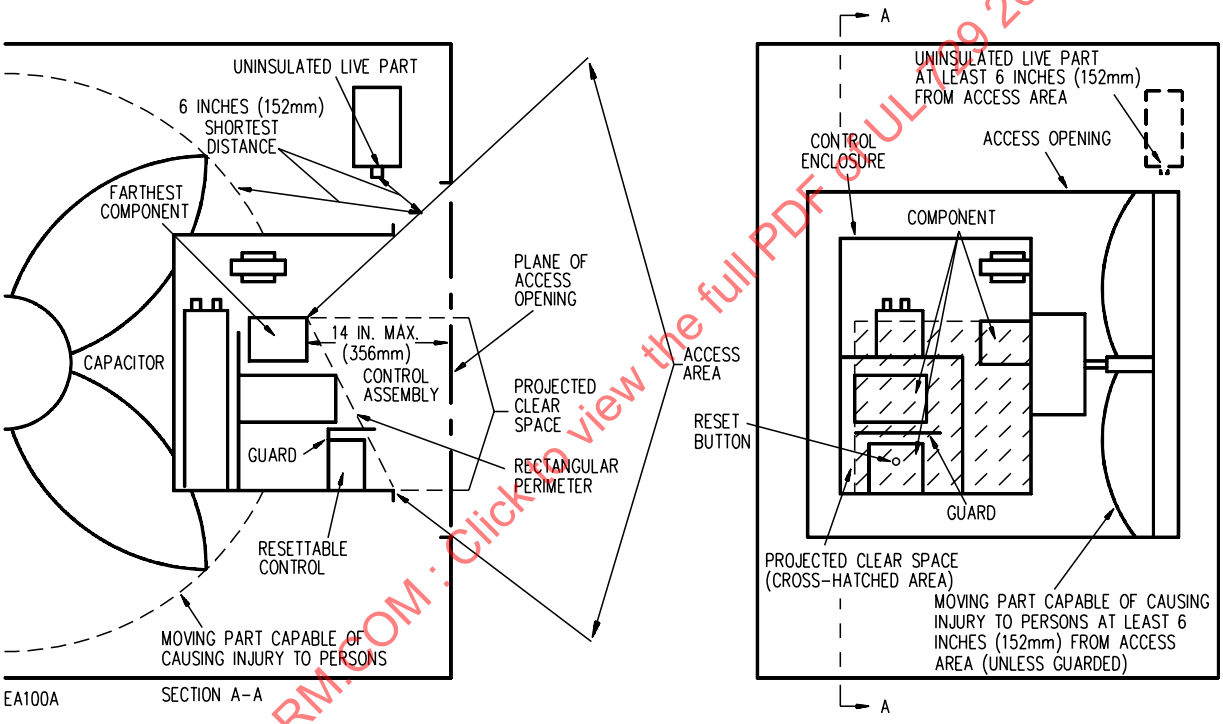


Figure 36.2
Articulate probe with web stop

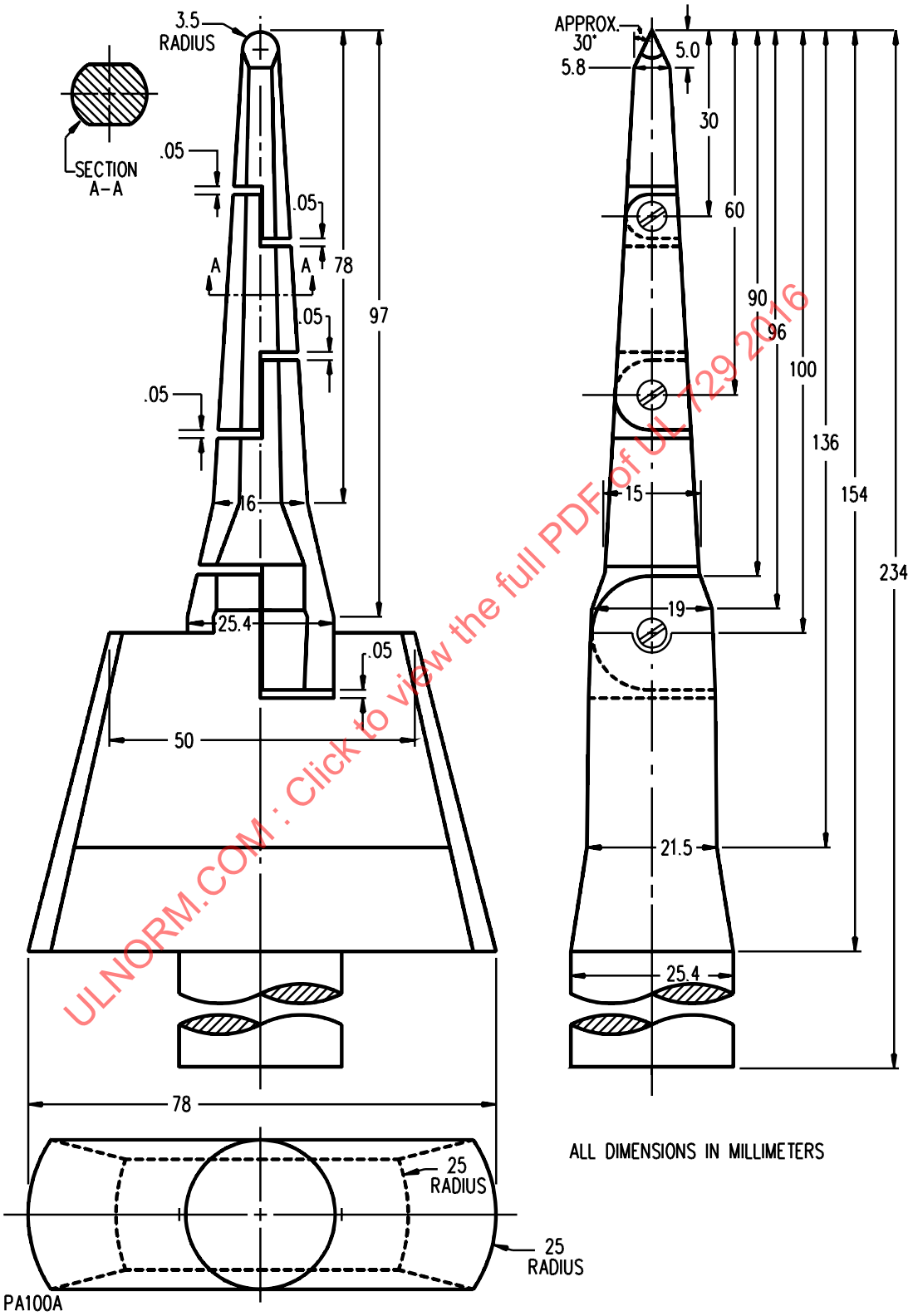


Table 36.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening		Minimum distance from opening to part,	
inches	(mm)[b]	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 36.9.
[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 dimensions 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).

36.6 With respect to a part or wire as mentioned in 36.5, in an integral enclosure of a motor as mentioned in the exception to 36.5:

a) An opening that has a minor dimension (see 36.9) less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 36.3;

2) In a directly accessible motor (see 36.10), an uninsulated live part cannot be contacted by the probe illustrated in Figure 36.4; and

3) In an indirectly accessible motor (see 36.10), an uninsulated live part cannot be contacted by the probe illustrated in Figure 36.5.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 36.1.

Figure 36.3
Probe for film-coated wire

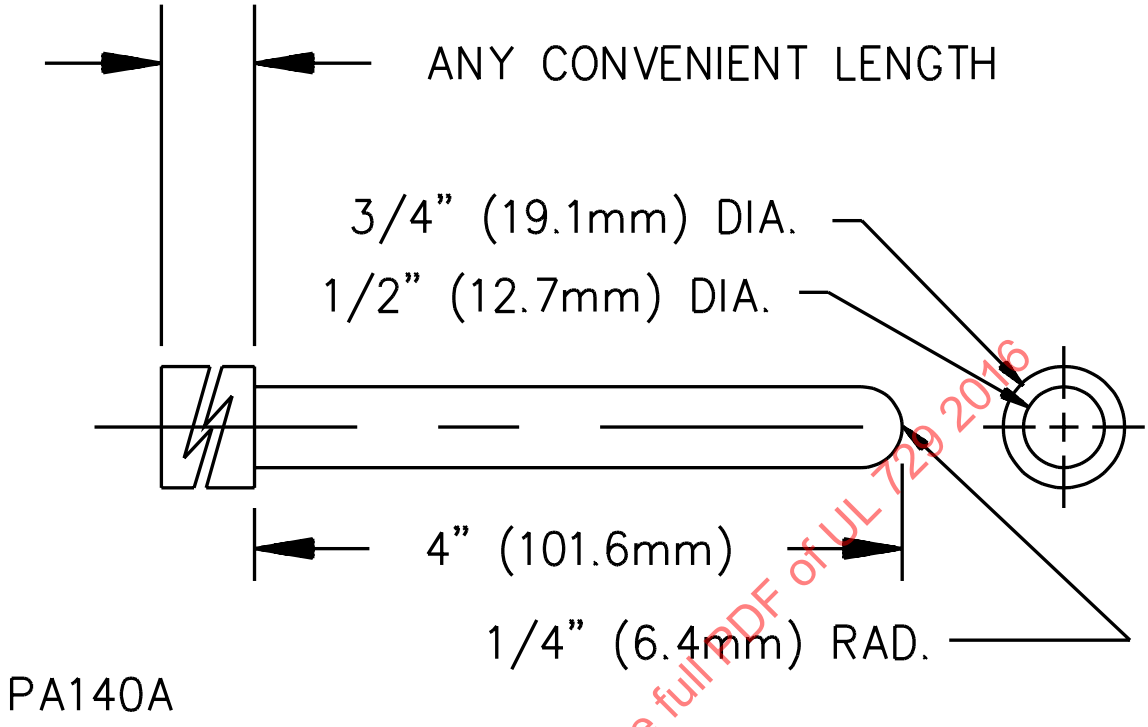


Figure 36.4
IEC articulate probe

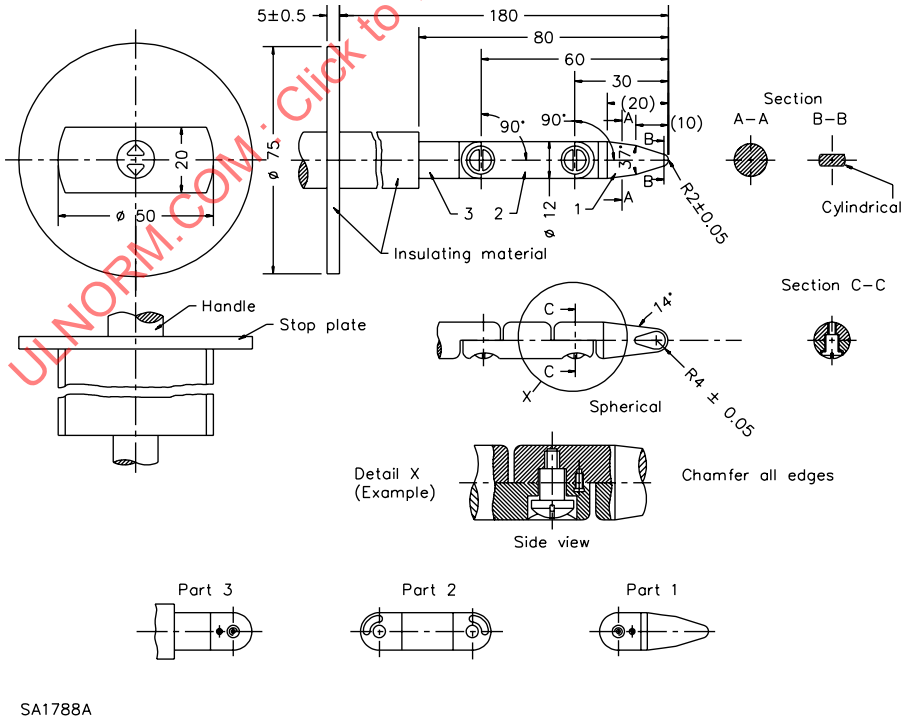
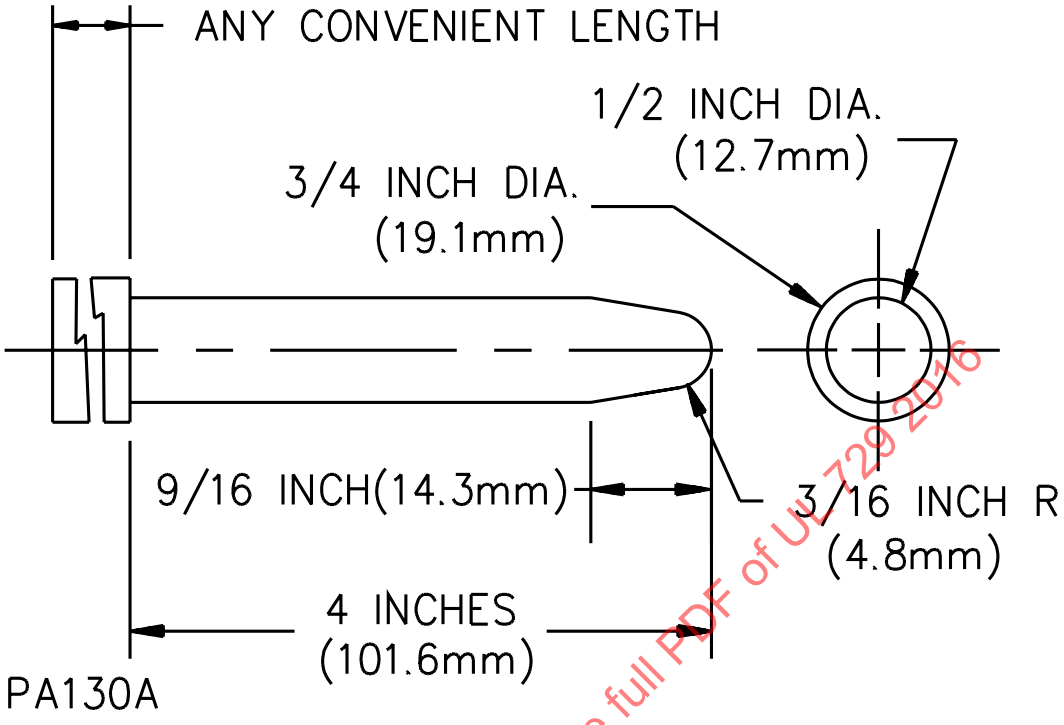


Figure 36.5
Probe for uninsulated live metal parts



36.7 The probes mentioned in 36.5 and 36.6 and illustrated in Figures 36.2 – 36.5 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 Figures 36.2 and 36.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

36.8 The probes mentioned in 36.7 and 36.9 shall be used as measuring instruments to evaluate the accessibility provided by an opening, and not as instruments to evaluate the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

36.9 With reference to the requirements in 36.5 and 36.6, 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.

36.10 With reference to the requirements in 36.6, 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:

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

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

36.11 During the examination of a product to determine whether it complies with the requirements in 36.5 or 36.6, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

36.12 With reference to the requirements in 36.5 and 36.6, insulated brush caps are not required to be additionally enclosed.

PERFORMANCE

37 General

37.1 A floor furnace shall comply with the applicable test requirements in Sections 37– 57. A furnace of a type not specifically described in this standard shall be tested in accordance with the intent of these requirements. If there are any indications during the tests that a furnace will not continue to comply with the requirements during intended use, supplementary tests may be necessary to determine the acceptability of the furnace.

38 Test Installation

38.1 Enclosure

38.1.1 A floor furnace provided with a floor register only is to be installed in a test platform as illustrated in Figure 38.1, and a floor furnace provided with a single or dual wall register is to be installed in a test platform as illustrated in Figure 38.2.

38.1.2 The floor of the test platform is to extend at least 18 inches (457 mm) beyond all sides of the register of the furnace when installed for test. The floor of the test platform is to be made of nominal 1-inch (25.4 mm) softwood flooring covered with one thickness of building paper superimposed by nominal 1-inch tongue-and-groove oak flooring finished with clear varnish. The test platform is to be elevated to provide a clearance of at least 6 inches (152 mm) between the bottom of the furnace and the floor of the test room. The hole in the test platform to receive the furnace is to be sized in accordance with the installation instructions furnished with the furnace.

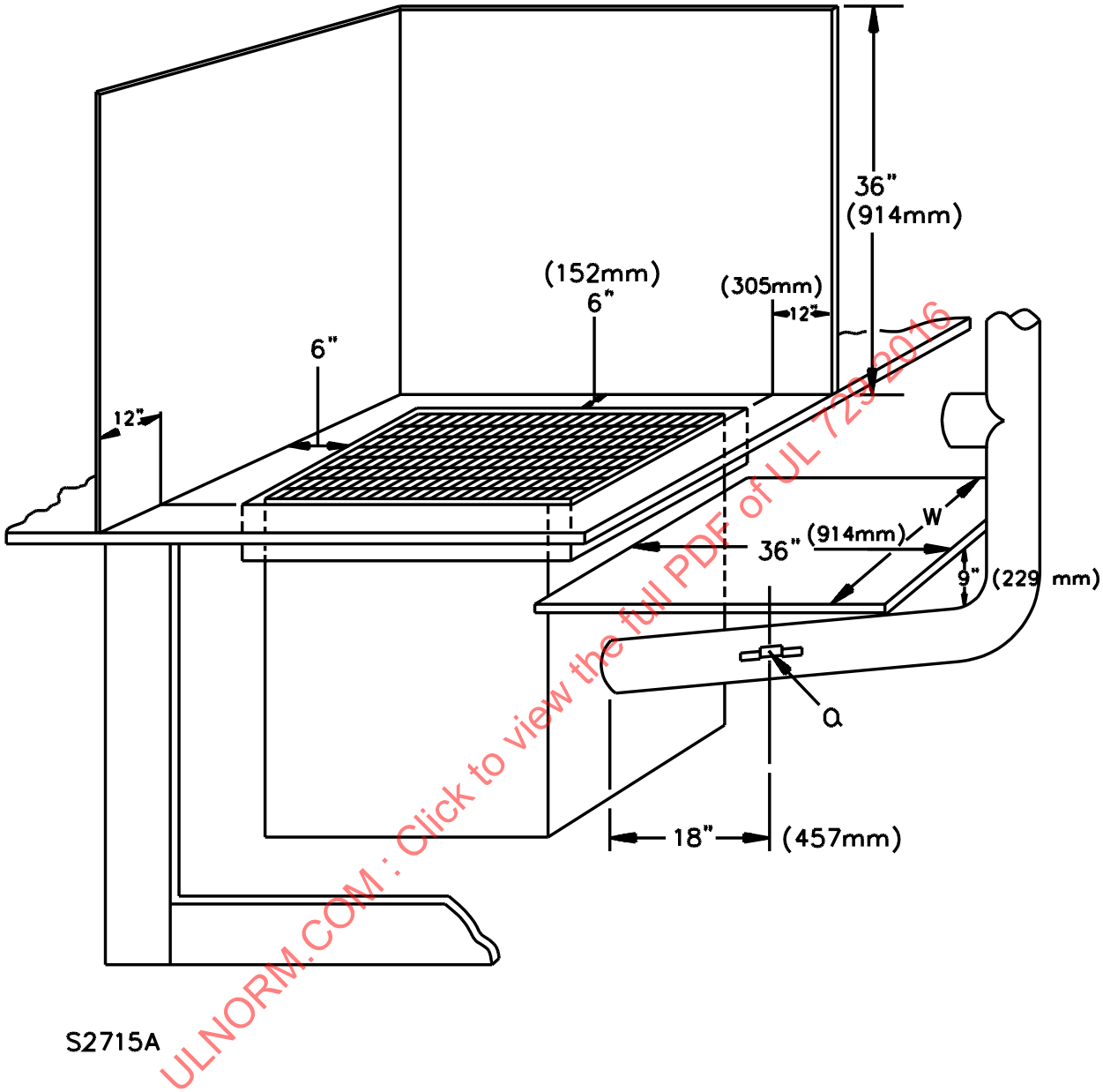
38.1.3 Four nominal 2- by 12-inch (50.8 by 304.8 mm) boards are to be placed with the sides in close contact with the sides of the floor furnace and with the top edges butting against the underside of the test platform.

38.1.4 For tests on a floor-register type floor furnace, two walls, 36 inches (914 mm) high and fitted together to form a corner, are to be placed on the test platform so that each wall is 6 inches (152 mm) from adjacent sides of the register. Each wall is to extend from the corner to a point at least 12 inches (305 mm) beyond the far end of the register side adjacent to that wall. The walls are to be made of 1-inch (25.4 mm) nominal thickness boards with all joints sealed, or of plywood at least 3/4 inch (19.1 mm) thick.

38.1.5 For tests on a wall-register type floor furnace, a single wall enclosing the sides and top of the wall register is to be placed on the test platform. The edges of this wall in contact with the top and sides of the wall register are to be made of softwood boards having a nominal thickness of 2 inches (50.8 mm). The total width of these edges is to be equivalent to the maximum thickness of the wall in which the register is intended to be installed. The wall is to extend at least 36 inches (914 mm) above the top and beyond one side of the wall register and 6 inches (152 mm) beyond the other side. A second wall of the same height is to be placed at right angles against the edge of the first wall which is 6 inches (152 mm) from the side of the register. The surfaces of both walls are to be made of 1 inch (25.4 mm) nominal thickness

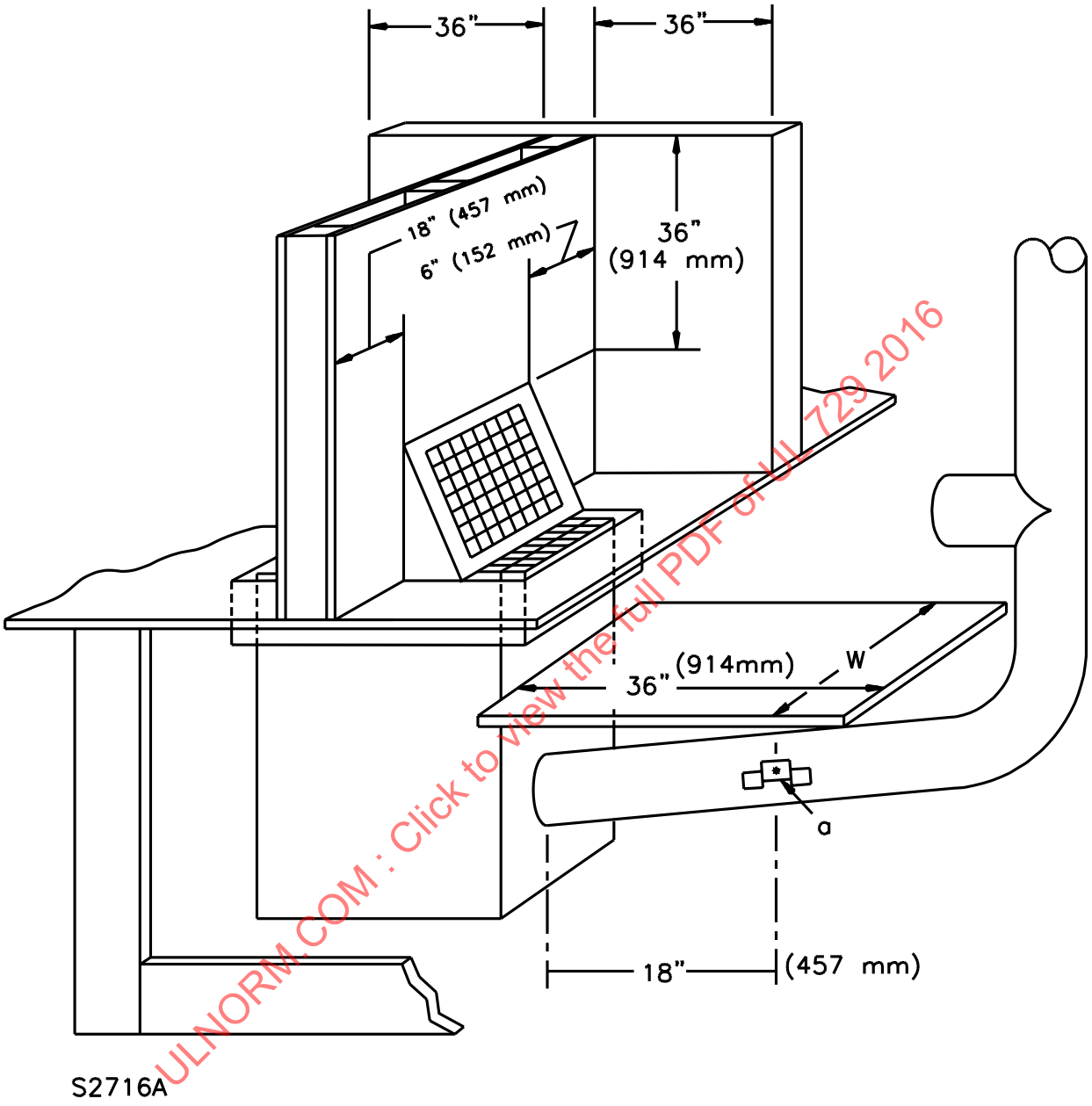
softwood boards with all joints sealed or of plywood at least 3/4 inch (19.1 mm) thick. If the wall register has a single outlet, the back side of the register is to be completely covered by boards having a nominal thickness of 2 inches (50.8 mm) and in close contact with the back side.

Figure 38.1
Test platform – floor register furnace



[a] Support bracket for flue gas thermocouple

Figure 38.2
Test platform – wall register furnace



[a] Support bracket for flue gas thermocouple

38.2 Chimney connector

38.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe more than 0.023 inch (0.58 mm) thick is to be used.

38.2.2 The chimney connector is to extend beyond the edge of the platform and then vertically as illustrated in Figures 38.1 and 38.2. The horizontal run length is to extend a minimum of 45 inches (1143 mm) and have an upward slope of 1/4 inch per foot (21 mm/m).

38.2.3 A simulated ceiling section a minimum length of 36 inches (914 mm) and a minimum width equivalent to the diameter of the flue pipe plus 24 inches (610 mm) is to be placed symmetrically above the horizontal flue pipe. The minimum distance between the top of the horizontal pipe and the lower surface of the ceiling and the minimum distance from the vertical pipe to the edge of the ceiling is to be 9 inches (229 mm). The ceiling is to be made of 1-inch (25.4 mm) nominal thickness lumber or minimum 3/4 inch (19.1 mm) thick plywood.

38.2.4 A draft regulator is to be provided for test purposes and is to be located in the vertical flue pipe approximately 36 inches (914 mm) above the bottom of the vertical flue pipe.

38.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as illustrated in Figures 38.1 or 38.2.

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

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

39 Instrumentation

39.1 Draft measurement

39.1.1 Draft is to be measured by a draft gauge that can be read directly to 0.005 inch (0.13 mm) water column and that has an accuracy of ±0.0025 inch (±0.050 mm). The gauge is to be checked for zero reading at the beginning and at the end of each test.

39.2 Fuel input measurement

39.2.1 The fuel-input rate to a burner during a test is to be determined by a scale accurate to 0.01 pound-mass (5 g) or a burette capable of the same resultant accuracy.

39.3 Power measurement

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

39.3.2 The ammeter 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.

39.4 Speed measurement

39.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or of the mechanism driven by it. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is to be used for measuring speed of a motor under 1/8 horsepower (93 W output).

39.5 Temperature measurement

39.5.1 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 larger than 24 AWG (0.21 mm^2).

39.5.1 revised October 1, 2008

39.5.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Temperatures are to be determined on all wood surfaces in contact with the furnace casing or register, on the surfaces of walls adjacent to the register, and on the ceiling surface exposed to radiation from the horizontal flue pipe. All such wall and ceiling surfaces are to be finished a flat black. Thermocouples are to be attached to other materials and parts such as those mentioned in Table 44.1.

39.5.3 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material the temperature of which is being measured. Intended thermal contact will usually result from securely taping or cementing the thermocouple in place. If a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

39.5.4 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with the tip held in thermal contact with the surface by pressure-sensitive tape. For zero clearance, the thermocouples are to be applied to surfaces of the furnace at points of zero clearance.

39.5.5 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 39.1. The thermocouple is to be inserted into the chimney connector as illustrated in Figure 39.2. 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 securely sealed in the position allowing maximum draft during all tests.

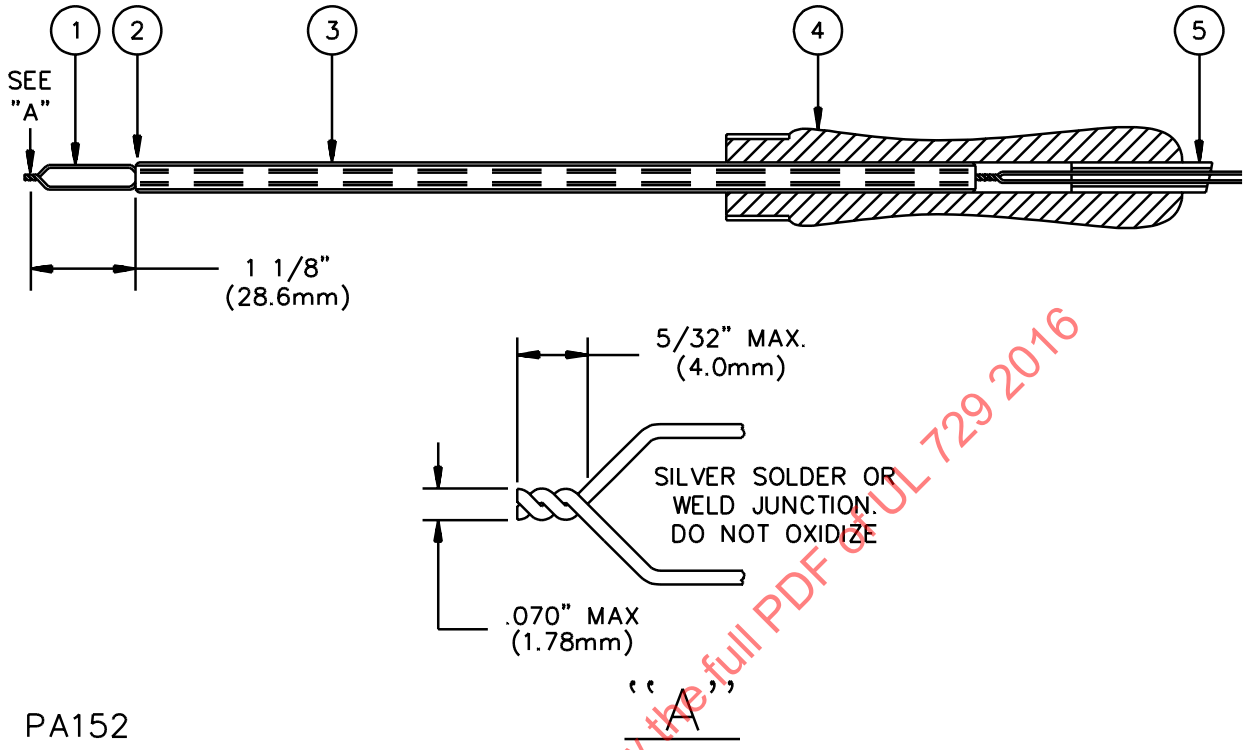
39.5.6 The inlet-air temperature is to be measured by a thermocouple placed 6 inches (152 mm) from the outer edge of the register adjacent to the cold air return and 1 inch (25.4 mm) above the register level.

39.5.7 The maximum outlet air temperature is to be determined by exploration with four parallel-connected bead-type thermocouples of not larger than 24 AWG (0.21 mm^2) located 1 inch (25.4 mm) above the warm air register and 1/2 inch (12.7 mm) from the center of a shield. See Figure 39.3. The shield is to be formed from sheet steel a minimum 0.02 inch (0.51 mm) thick and is to consist of an outer collar 2 inches (50.8 mm) high and 6 inches (152 mm) in diameter enclosing a square inner collar of the same height, its diagonal being 6 inches. The square is to be attached to the round collar at its corners only. The overall height of the assembly is to be 3 inches (76.2 mm).

39.5.7 revised October 1, 2008

Figure 39.1
Standard thermocouple for flue-gas temperature

Figure 39.1 revised October 1, 2008



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 the equivalent, 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 39.2
Flue-gas thermocouple and support bracket

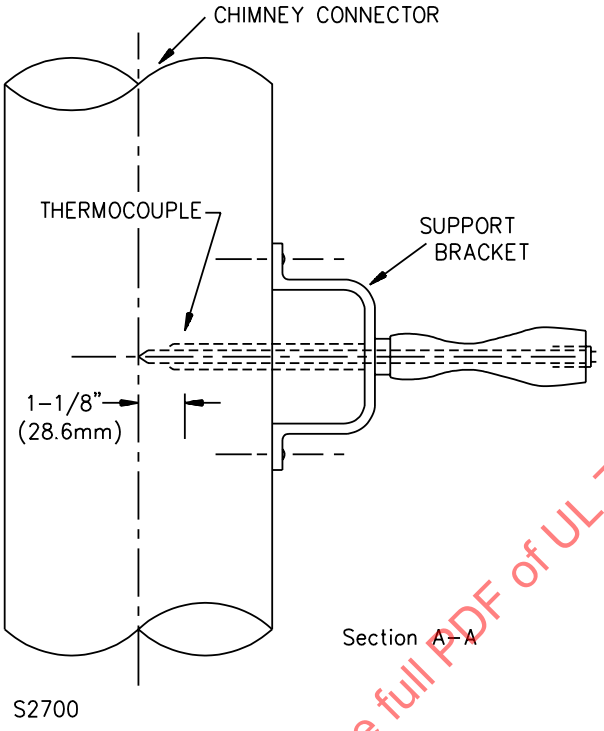
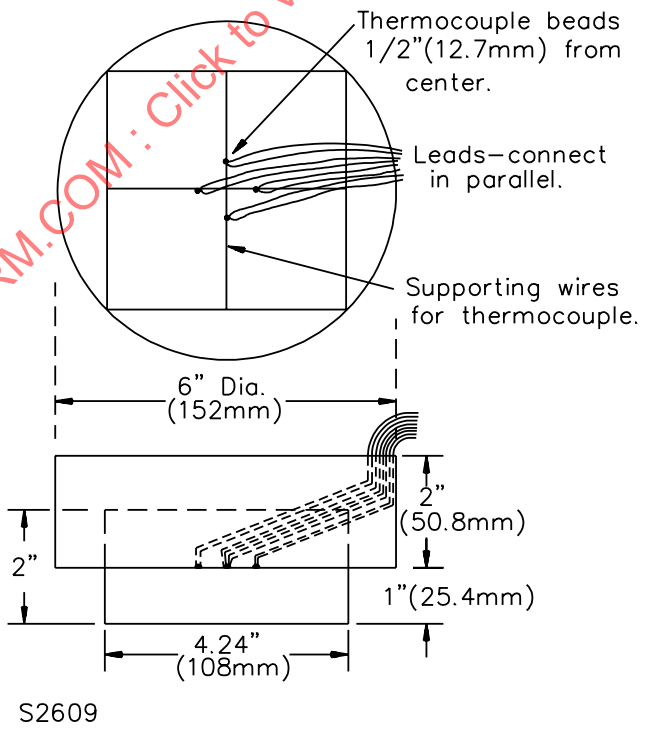


Figure 39.3
Thermocouple shield for outlet-air temperature



40 Initial Test Conditions

40.1 General

40.1.1 The furnace is to be set up for test in the appropriate enclosure and manner described in Test Installation, Section 38.

40.1.2 A furnace equipped with 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 to obtain rated air flow. This adjustment is to be maintained during all of the tests described in this standard.

40.1.3 A furnace equipped with a user adjustable device intended for manual change of an air-circulating fan (such as a motor speed control, 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.

40.1.4 If the results of a test, which involves the operation of a limit control, are likely to be affected by the temperature of the inlet air, the test is to be conducted with the inlet-air temperature between 15.6 and 26.7°C (60 and 80°F).

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

40.1.6 Unless otherwise specified, furnaces are to be tested at the potential specified in Table 40.1.

Table 40.1
Test voltages

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

40.2 Furnace equipped with mechanical atomizing burner

40.2.1 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.

40.3 Furnace equipped with vaporizing burner

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

40.3.2 No. 1 fuel oil having a viscosity as specified in Table 40.2 is to be used for firing vaporizing burners.

Table 40.2
Oil viscosity of No. 1 fuel oil

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

40.3.3 The high fire burning rate is to be adjusted to deliver the rated high-fire input of the furnace.

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

40.3.5 If an adjustable oil-shutoff control is provided, it is to be adjusted to the maximum allowed timing for shutoff.

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

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

41 Combustion Test – Burner and Furnace

41.1 When a floor furnace is operating at steady-state conditions as specified in 41.2, the smoke in the flue gases shall not exceed that indicated by a number 2 spot on the Shell-Bacharach Scale with the Model RDC Smokemeter.

41.2 The furnace is to be installed and adjusted in accordance with the manufacturer's instructions. The furnace is then to be fired at rated input and such that the stack loss is not more than 25 percent and operated until steady-state conditions of draft, fuel-input rate, and flue-gas temperature have been established.

42 Limit Control Cutout Test

42.1 A floor furnace shall be operated as described in 42.2 and 42.3 until the limit control functions. The outlet air temperature shall not exceed 121°C (250°F).

42.2 The limit control is to be adjusted to the maximum:

a) Setting allowed by its fixed stop; and

b) Indicated differential setting.

A thermocouple is to be attached to the limit control sensing element at its midpoint.

42.3 The furnace is to be operated until outlet-air temperature has stabilized. The circulating air flow is to be gradually restricted (the fuel input may be increased also) until the limit control functions. At this instant, the temperature of the outlet air and the limit control sensing element (T_{L1}) is to be determined. The outlet air temperature is not to exceed 121°C (250°F). After the limit control has functioned, its sensing element shall not attain a temperature that will adversely affect the limit control calibration.

43 Continuity of Operation Test

43.1 A floor 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 in 43.2 – 43.5.

43.2 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. The furnace is to be placed in operation. An air-circulating fan, if its speed is variable, is to be adjusted to obtain rated air flow.

43.3 The furnace is to be operated until outlet-air temperature has stabilized. The temperature of the inlet-air (T_1) and the limit control sensing element (T_{L2}) is to be measured.

43.4 To comply with 43.1, the operation of the furnace is not to be interrupted by any control included as part of the furnace and:

$$T_{L2} \leq T_{L1} + T_1 - 60$$

where:

T_1 = Inlet-air temperature in this test, in degrees F

T_{L1} = Limit control sensing element temperature in the Limit Control Cutout Test, in degrees F

T_{L2} = Limit control sensing element temperature in this test, in degrees F

60 = Assumed maximum inlet-air temperature that would demand continuous operation of the furnace at high-fire input, in degrees F

43.5 During the test, the total furnace electrical input and the electrical input of each component are to be measured.

Exception: The electrical input measurement of a component having a pilot duty rating only is not required.

44 Temperature Tests

44.1 A furnace shall be tested in accordance with Sections 46 – 52. No part shall attain a temperature that will:

a) Damage required corrosion protection;

b) Adversely affect operation of safety controls;

c) Reduce the value of required thermal or electrical insulation; or

d) Cause creeping, distortion, sagging, or similar damage if such damage to the material or part may increase the risk of fire, electric shock, or injury to persons.

The temperature rises at specific points shall not exceed those specified in Table 44.1 unless otherwise indicated.

Table 44.1
Maximum temperature rises

Device or material	Column 1 Degrees		Column 2 Degrees	
	C	F	C	F
A. Motor[a,b]				
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).				
a. In open motors –				
Thermocouple or resistance method	75	135	115	208
b. In totally enclosed motors –				
Thermocouple or resistance method	80	144	115	208
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
a. In open motors –				
Thermocouple method	65	117	115	208
Resistance method	75	135	115	208
b. In totally enclosed motors –				
Thermocouple method	70	126	115	208
Resistance method	80	144	115	208
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors).				
a. In open motors –				
Thermocouple or resistance method	95	171	140	252
b. In totally enclosed motors –				

Table 44.1 Continued on Next Page

Table 44.1 Continued

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
Thermocouple or resistance method	100	180	140	252
4. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
a. In open motors –				
Thermocouple method	85	153	140	252
Resistance method	95	171	140	252
b. In totally enclosed motors –				
Thermocouple method	90	162	140	252
Resistance method	100	180	140	252
B. Components				
1. Capacitors				
Electrolytic type[c]	40	72		
Other types[d]	65	117	(Not specified)	
2. Field wiring	35	63	60	108
3. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated windings –				
Thermocouple method	65	117	115	208
b. Class 130 insulated windings –	85	153	140	252
Thermocouple method				
4. Sealing compounds	40°C (72°F) less than its melting point			
5. Transformer enclosures[b] –				
a. Class 2 transformer	60	108	85	153
b. Power and ignition transformers	65	117	90	162
C. Insulated Conductors				
1. Appliance wiring material				
75°C rating	50	90	65	117
80°C rating	55	99	70	126
90°C rating	65	117	80	144
105°C rating	80	144	95	171
200°C rating	175	315	200	360
250°C rating	225	405	250	450
2. Flexible cord – Types SO, ST, SJO, SJT	35	63	60	108
3. GTO cable	35	63	60	108
4. Wire, Code				
Types RF, FF, RUW	35	63	60	108
Types RH, RFH, FFH, RHW, THW, THWN	50	90	75	135
Types T, TF, TFF, TW	35	63	60	108
Type TA	65	117	90	162
5. Other types of insulated wires	See note[e]			
D. Electrical Insulation – General[f]				
1. Class C electrical insulation material	Not specified			
2. Class (180) electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	117	90	162
4. Phenolic composition used as electrical insulation or as parts where failure will result in a hazardous condition shock	125	225	150	270

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