UL 391

STANDARD FOR SAFETY

Solid-Fuel and Combination-Fuel Central and Supplementary Furnaces

UL Standard for Safety for Solid-Fuel and Combination-Fuel Central and Supplementary Furnaces, UL 391

Fifth Edition, Dated September 10, 2010

Summary of Topics

This revision of ANSI/UL 391 dated August 28, 2019 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated June 28, 2019.

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Standard for Solid-Fuel and Combination-Fuel Central and Supplementary Furnaces

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The most recent designation of ANSI/UL 391 as a Reaffirmed American National Standard (ANS) occurred on August 19, 2019. 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 manually fueled, solid-fuel-fired central furnaces. Included are supplementary central furnaces intended for interconnection with forced-air central furnaces utilizing other fuels, and combination oil-fired and solid-fuel-fired, forced-air central furnaces.

1.2 The furnaces are intended to burn solid fuels, such as wood, coal, or any other biomass fuel, as specified by the manufacturer.

1.3 The furnaces are intended for connection to chimneys for residential and building heating appliances in compliance with the Standard for Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances, NFPA 211, and intended for installation in compliance with the Standard for Installation of Warm Air Heating and Air Conditioning Systems, NFPA 90B; and the National Electrical Code, ANSI/NFPA 70; and applicable mechanical codes such as the BOCA National Mechanical Code, the Standard Mechanical Code, and the Uniform Mechanical Code.

1.4 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 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.2 A component need not comply with a specific requirement that:

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

b) Is superseded by a requirement in this standard.

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

2.4 Specific components are recognized as being 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 for which they have been recognized.

3 Units of Measurement

3.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

4 Undated References

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

5 Glossary

5.1 For the purpose of this standard the following definitions apply.

5.2 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary air, secondary air, or both. It may be either manually or automatically operated.

5.3 APPLIANCE FLUE – The passages within the product that conduct the products of combustion (flue gases) through the product.

5.4 BURNER, OIL – A power-operated burner that prepares and delivers the oil and all or part of the air by mechanical process in controllable quantities for combustion.

5.5 CHIMNEY CONNECTOR – The pipe that connects a fuel-burning product to a chimney.

5.6 COMBUSTIBLE MATERIAL, COMBUSTIBLE PRODUCTS, NONCOMBUSTIBLE – These terms, as used in this standard, are defined in the Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances, NFPA 211.

5.7 CONTROL, LIMIT – An automatic control responsive to changes in pressure or temperature and intended to limit the operation of the controlled equipment.

5.8 CONTROL, PRIMARY SAFETY – The automatic control relied upon to reduce the risk of discharge of oil at the burner in case of loss of ignition or loss of flame.

5.9 CONTROL, SAFETY – Any automatic control, such as a relay or switch, used in conjunction with other auxiliary equipment to form a safety control system that is relied upon to reduce the risk of fire, electric shock, or injury to persons.

5.10 CONTROL, SAFETY COMBUSTION – A primary control directly responsive to flame properties. Senses the presence of flame and causes fuel to be shut off in event of loss of flame.

5.11 CONTROL, THERMOSTATIC DAMPER – An automatic control responsive to changes in temperature. Usually acts through direct mechanical linkage to reduce or increase the supply of air needed for combustion, thereby regulating the combustion rate and limiting the operation of the product when the product is burning solid fuel.

5.12 CONVENIENCE RECEPTACLE – A contact device provided with permanently connected electrical conductors intended for quick and easy connection to a plug attached to a flexible electric cord.

5.13 DAMPER – A valve or plate that regulates draft or flow of flue gases or inlet combustion air. May be either manually or automatically operated.

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

5.15 ELECTRICAL CIRCUITS:

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

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak or direct current) and supplied by a NEC Class 2 transformer, or by a battery, or by a battery and fixed impedance, or by a transformer and fixed impedance each of which, as a unit, is either in compliance with requirements for a Class 2 transformer or is otherwise limited to a maximum output of 100 volt-amperes. A circuit derived by connecting resistance in series with a high-voltage circuit as a means of limiting the voltage and current is not considered a low-voltage circuit.

c) Isolated Limited Secondary Circuit – A circuit of limited energy output derived from a isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and open-circuit secondary voltage rating not exceeding 1000 volts.

5.16 FLOOR PROTECTOR (STOVE MAT) – The noncombustible material applied to the floor area underneath, in front of, and at the sides of the fuel charging area and underneath the chimney connector area of the product.

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

5.18 FURNACE, CENTRAL – A self-contained indirect-fired product supplying heated air through ducts to the space to be heated. Air is circulated either by means of a power-driven fan (a forced-air furnace) or by means of natural convection (a gravity furnace).

5.19 FURNACE, COMBINATION OIL-FIRED AND SOLID-FUEL-FIRED CENTRAL – A central furnace burning fuel oil and solid fuel either separately or simultaneously. The furnace makes use of either separate or common combustion chambers and flues for burning the two fuels.

5.20 FURNACE, SUPPLEMENTARY CENTRAL – A solid-fuel-burning product intended to be interconnected with a gas- or oil-fired forced-air central furnace by means of a common warm-air supply plenum in accordance with the manufacturer's instructions.

5.21 GRATE – A metal frame provided by the manufacturer for supporting the fuel within a furnace.

5.22 HEARTH – The floor area within the fire chamber of a furnace.

5.23 INDIRECT-FIRED VENTED PRODUCT – A product in which the products of combustion and the medium being heated (circulating air, for example) are segregated by the walls of the fire chamber and flues; it is provided with a flue collar to accommodate a chimney connector for conveying the products of combustion to the outdoors.

5.24 RADIATION SHIELD – A separate panel or separate panels interposed between heating surfaces and adjacent objects for the purpose of reducing heat transmission by radiation.

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

5.26 SERVICING – The periodic tasks usually performed to operate and maintain a product, such as air, fuel, and pressure adjustments, cleaning of flues and chimney, lubrication, and resetting of controls. Repair and replacement of parts other than those expected to be renewed periodically, such as replacement of air filters, is not considered to be servicing. Some examples of servicing are:

a) Cleaning or replacing nozzles;

b) Setting ignition electrodes;

c) Cleaning or replacing strainer or filter elements;

d) Resetting safety control; and

e) Replacing igniter cable.

CONSTRUCTION

6 General

6.1 A furnace shall be factory built as a complete assembly and shall include all the components necessary for its intended installation and operation. A furnace may be shipped as two or more major subassemblies.

6.2 Major subassemblies of a furnace are considered to be:

a) The burner;

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

c) The blower assembly, including its base, filters, and casing; and

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

A wiring harness may be packaged with one of the major subassemblies.

6.3 A furnace shall be arranged in major subassemblies, if the furnace is not assembled by the manufacturer as a unit. Each subassembly shall be capable of assembly into the final assembly without the installer altering, cutting, drilling (except as indicated in 6.4), threading, welding, or performing similar tasks. If the intended installation and operation of the furnace so requires, two or more subassemblies shall either:

a) Be arranged and constructed so that they can be incorporated into the complete assembly only in the intended manner; or

b) Be assembled, tested, and shipped from the factory as one element.

6.4 Cutting or drilling complies with the requirements of 6.3 if it is needed for either:

a) The attachment of a return or supply plenum or an optional filter rack; or

b) The provision of a return-air opening in the furnace casing. If a return-air opening is to be cut in the casing panel by the installer, either the necessary instructions and template shall be furnished with the furnace, or the corners of the opening shall be embossed in knockout form.

6.5 A radiation shield or baffle relied upon to reduce the risk of temperatures in excess of those intended shall:

a) Be assembled as part of the furnace;

b) Be part of a subassembly that must be attached to the furnace for its intended operation; or

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

6.6 Alteration or removal of a baffle, insulation, or radiation shield needed to reduce the risk of excessive temperatures shall not be required for any intended furnace installation.

6.7 The construction of a furnace shall permit the user to operate those parts requiring the user's attention or adjustment in anticipated usage.

6.8 An adjustable or movable part shall be provided with a locking device to secure it against unintended shifting.

6.9 A screw or bolt used to attach a part that may be detached for care or servicing of the product shall hold its position upon the application of the torque specified in Table 6.1 after removal and replacement of the part.

Table 6.1
Torque requirements for screws or bolts

American standard screw size		Torque		I.S.O. screw size	Torque	
No.	mm	Lb-inch	N·m	mm	N·m	Lb-inch
–	–	–	–	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
Inch	**mm**	**Lb-inch**	**N·m**	**mm**	**N·m**	**Lb-inch**
1/4	6.4	100	11.3	6	8.7	77
–	–	–	–	7	15.0	133
5/16	7.9	200	22.6	8	23.5	208
–	–	–	–	9	33.6	297
3/8	9.5	350	39.6	10	45.2	400
7/16	11.1	575	65.0	12	81.0	715
1/2	12.7	850	96.0	14	128.0	1130
9/16	14.3	1200	136.0	–	–	–
5/8	15.9	1600	181.0	16	185.0	1640

6.10 Any external door providing access to the combustion chamber of a furnace and intended for installation with a clearance of less than 24 inches (610 mm) from the face of the door or 48 inches (1220 mm) above the door shall be self-closing.

6.11 A furnace intended for installation in the cooled-air path, downstream from a cooling coil, shall comply with (a) – (d):

a) All interior surfaces of the heat exchanger, combustion chamber (including its bottom), radiators, and flues shall resist corrosion by moisture.

b) The firebox liner shall resist deterioration from wetting by condensation.

c) Condensation shall not drip on burner parts or other parts vulnerable to corrosion if corrosion of any of the parts may cause a risk of fire, electric shock, or injury to persons.

d) The heat exchanger and appliance flue shall not contain traps or pockets in which condensation may collect.

6.12 An oil burner shall be secured so that it will not twist, slide, or drop out of position.

6.13 A grate shall be used in a furnace intended to burn coal.

6.14 When a user's hand is withdrawn from a separable door handle (if provided) that is intended to be used either during solid-fuel loading and ash removal or with products requiring manual operation, the handle shall not remain in a position that allows temperatures on the handle to rise above those specified in Table 57.1.

6.15 Provision shall be made for storing a separable handle on the furnace. When the handle is stored in its intended position, its temperature shall not exceed the appropriate temperature specified in Table 57.1.

6.16 Fuel-loading and ash-removal doors shall not warp or misalign when the furnace is subjected to the tests specified in the Performance section of this standard if air leaking into the combustion chamber because of the warping or misalignment can result in a risk of overfiring or fire outside the furnace.

6.17 Fuel-loading and ash-removal doors shall close by gravity or shall be provided with a latch. Combination oil-fired and solid-fuel-fired furnace doors shall not open during delayed oil ignition unless it can be determined that particles of burning solid fuel cannot be expelled through the door opening by the force of the delayed oil ignition. See Delayed Oil Ignition Test, Section 60.

6.18 A combination oil-fired and solid-fuel-fired central furnace shall be provided with an interlock relied upon to reduce the risk of firing of the oil burner with either or both the solid-fuel loading door or the ash-removal door open, if this operation can result in the risk of fire, explosion, or injury to persons.

7 Accessibility for Servicing

7.1 A furnace shall be provided with means of access for cleaning of parts, such as internal heating surfaces in contact with combustion products, oil-inlet pipes, and oil strainers, without major dismantling of the furnace or removal of parts required to be factory-assembled.

7.2 With reference to the requirements of 7.1, the removal of access panels, burners, blowers, caps, plugs, and the like, permitting removal and replacement of parts for servicing, and the detachment of the chimney connector are not considered major dismantling.

7.3 All burners, controls, and safety devices shall be accessible for cleaning, inspection, repair, and replacement when the furnace is installed as intended by the manufacturer. Parts in the assembly removable for servicing shall be arranged so that their restoration, following removal, will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special facilities required for servicing to be performed by the operator shall accompany the furnace as supplied by the user.

8 Protection of Users and Service Personnel

8.1 An uninsulated, high-voltage live part or a moving part that creates a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the risk of unintended contact by personnel performing service functions that may have to be performed while the equipment is energized.

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

a) Adjusting the setting of temperature controls that do or do not have marked dial settings;

b) Resetting a control trip mechanism;

c) Operating manual switches; and

d) Adjusting air-flow dampers.

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

8.3 The requirements of 8.1 are not applicable to mechanical service functions not anticipated to be performed while the equipment is energized. Such functions include adjusting or replacing belts and cleaning and replacing strainers and oil filters.

8.4 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated high-voltage 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 involving a risk of injury to persons are:

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

b) Are not located within 6 inches (150 mm) of the mechanism, whether the parts are positioned on any side of the mechanism or whether they are behind it, unless they are guarded.

8.5 The location and mounting of an electrical control component relative to other components and grounded metal parts shall not subject service personnel to risk of electric shock from adjacent uninsulated live parts or the risk of injury from adjacent moving parts if components need to be reached while it is energized.

Exception: This requirement does not apply when service personnel make voltage measurements using jacks or terminals specifically intended for the purpose.

8.6 Accessibility to each compartment and protection of persons from the risk of electric shock and contact with moving parts that can cause injury may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each compartment through an access cover or panel in the outer cabinet and through the cover of the control assembly enclosure described in (a) – (e). See Figure 8.1.

a) The components shall be 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 (355 mm) from the plane of the access opening.

b) Uninsulated live parts that lie outside the control assembly's projected clear space (except for live parts within a control panel) or unguarded moving parts that create a risk of injury to persons shall be located not closer than 6 inches (150 mm) to 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 that can surround the outside edge of the components or control enclosure, when such an enclosure is 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) shall be free of obstructions, including wiring.

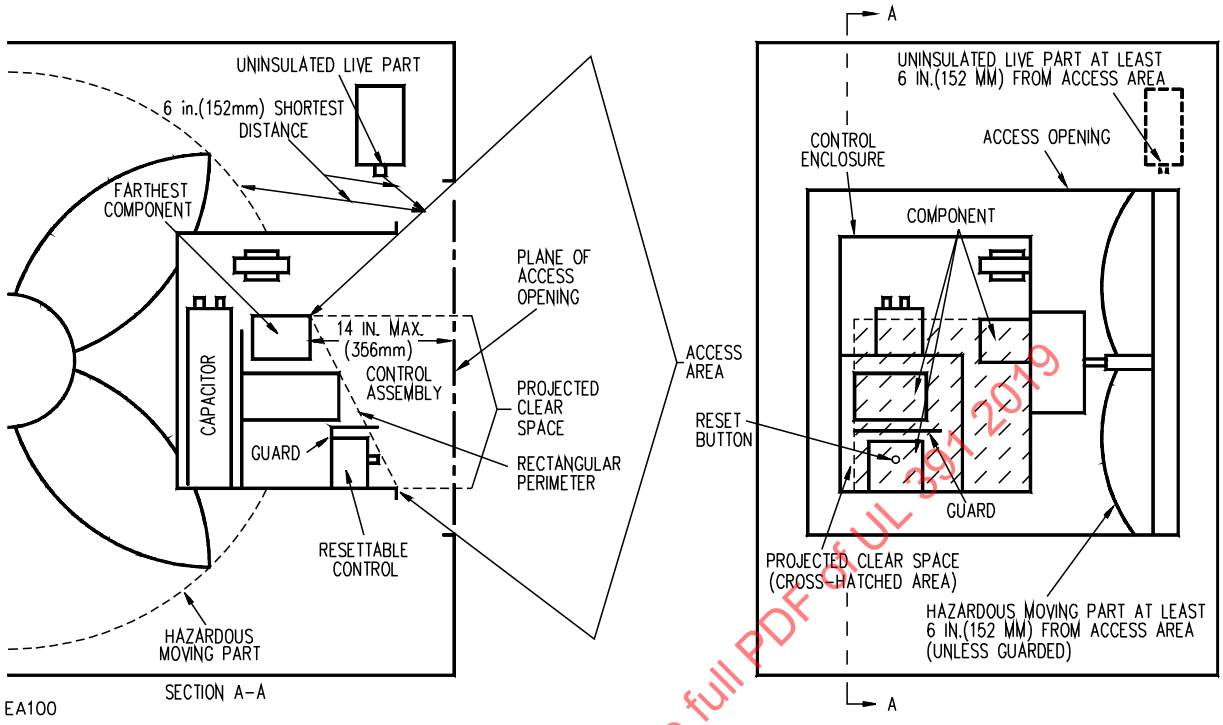
d) Access to the components in the control assembly shall not be impeded in the direction of access by other components or by wiring in this assembly.

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

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

2) The components are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless these parts are guarded. See 40.4.

Figure 8.1
Accessibility and protection



8.7 A component in a low-voltage circuit shall comply with the requirements of 8.5 in its relation to uninsulated live parts in a high-voltage circuit and to moving parts that can cause a risk of injury to persons.

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

a) Coils of controllers, relays, and solenoids;

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

c) Enclosed motor windings;

d) Insulated terminals and splices; and

e) Insulated wire.

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

8.10 The distance from an opening in the guard or enclosure specified in 8.9 to the moving part shall be as specified in Table 8.1, but the minor dimension of the opening shall not exceed 3 inches (76 mm). For an opening having a minor dimension intermediate between two of the values indicated in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is to be determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 8.1
Dimensions of openings in enclosure

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	(368.0)
Over 2	(over 50.8)	30	(762.0)

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

8.11 A moving part is not to be considered when compliance with the requirements of 8.1 and 8.9 is determined, if the part is unlikely to be contacted through the opening because of intervening fixed components, including baffles.

8.12 An interlocking device that disconnects the drive motor from its source of power when a door or panel is opened or removed to provide access to moving parts complies with the requirement of 8.9.

8.13 A moving part, as specified in 8.9, driven by a motor that is started or restarted by an automatic cycling device such as a fan control or thermal protector, shall be guarded if it is exposed when air filters are changed or anticipated adjustments are made.

Exception: This requirement does not apply if the access door or panel requires the use of a tool for opening or removal or if an interlock device of the type specified in 8.12 is provided.

8.14 The scroll of a centrifugal blower is a suitable guard for the blower wheel.

9 Base

9.1 The base of a furnace shall be constructed of metal or of other nonflammable material providing strength and durability equivalent to that of metal.

10 Casings

10.1 An outer casing or jacket shall be made of steel or material of equivalent strength, reinforced or formed if necessary to reduce the risk of damage from handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) if the steel is uncoated, or 0.023 inch (0.58 mm) if galvanized. Casings may also be of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

10.2 Access panels that may be removed for servicing or for other reasons shall permit repeated removal and replacement without damage and without impairment of any required insulating property.

10.3 A removable panel through which air is drawn for combustion shall be constructed so that it cannot be attached in a manner that may affect the intended performance of the furnace.

10.4 A removable panel shall be constructed so that it will not be interchangeable with other panels on the same furnace if interchange may impair the intended operation of the furnace.

10.5 The casing of a furnace for installation on combustible flooring material shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor. However, an opening intended to be permanently connected to a circulating-air distribution duct meets the intent of the requirement.

10.6 The casing of a forced-air-type furnace shall have no uncovered opening communicating with the circulating air compartments unless:

a) Such an opening is intended to be permanently connected to a circulating air distribution duct; or

b) The opening is automatically closed by a shutter or cover when the circulating-air fan or blower is operated, and the automatic closing latches the shutter or cover in the closed position and requires manual opening.

10.7 The furnace shall be constructed so that the operation of an air-circulating fan will not affect the combustion air supply or draw products of combustion into the circulating air.

10.8 A connection between the heat exchanger and the casing enclosing circulating air shall be constructed so that combustion products will not leak into the circulating air.

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

10.10 A furnace shall provide for the attachment of warm-air outlet ducts and cold-air return ducts.

11 Radiation Shields or Liners

11.1 A radiation shield or liner shall be constructed, formed, and supported so that it will be installed as intended and will resist distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration can cause excessive temperature when the furnace is tested in accordance with the requirements in the Performance section of this Standard. Any finish applied to obtain the required resistance to corrosion shall not be damaged by heat when the furnace is tested under these requirements.

12 Materials in Air-Handling Compartments

12.1 A material in a compartment handling air for circulation through a duct system shall comply with the requirements of the Surface Burning Test, Section 66. This requirement does not apply to the following:

a) An air filter, drive belt, wire insulation, or paint applied for corrosion protection.

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

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

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

e) A molded or formed component made of polymeric materials having a total surface area in the compartment of not more than 10 square feet (0.93 m^2). See 12.2. However, thermal or acoustic insulating liners are not exempted from the requirements of 12.1.

12.2 Polymeric materials not subject to the requirements of 12.1 shall have a flame-spread rating not greater than 25. Otherwise, they shall comply with the requirements of the Polymeric Materials Tests, Section 67.

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 secured in position if:

a) Loosening may reduce or block air flow to cause temperatures or pressures in excess of those specified in the temperature tests;

b) Loosening will result in reduction of electrical spacings below the required values; or

c) Loosening will result in electrical short-circuiting or grounding. Leading edges of insulation shall be shielded against damage from the effects of the velocity of the moving air.

12.5 With reference to 12.4, the use of one mechanical fastener for each square foot (0.9 m^2) of exposed surface is suitable for positioning insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Butting the edges of insulation against bulkhead shall shield leading edges against damage from effects of the velocity of moving air. A rigid or semirigid sheet of insulating material does not require fastening to the extent needed for less rigid material or shielding of leading edges.

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

13 Air Filters

13.1 An air filter supplied as a part of the furnace shall be accessible for inspection or replacement without the use of special tools and without need to dismantle the furnace.

14 Combustion Chambers

14.1 A combustion chamber and flueway within the air-handling compartment shall be constructed of cast iron, sheet steel, or equivalent material. Sheet steel shall have strength, rigidity, durability, resistance to corrosion, and other physical properties, equivalent to those of sheet steel having a minimum thickness of 0.042 inch (1.07 mm).

14.2 Combustion-chamber (firebox) lining material shall be secured in place and shall be accessible for replacement with material equivalent to the original.

15 Radiators

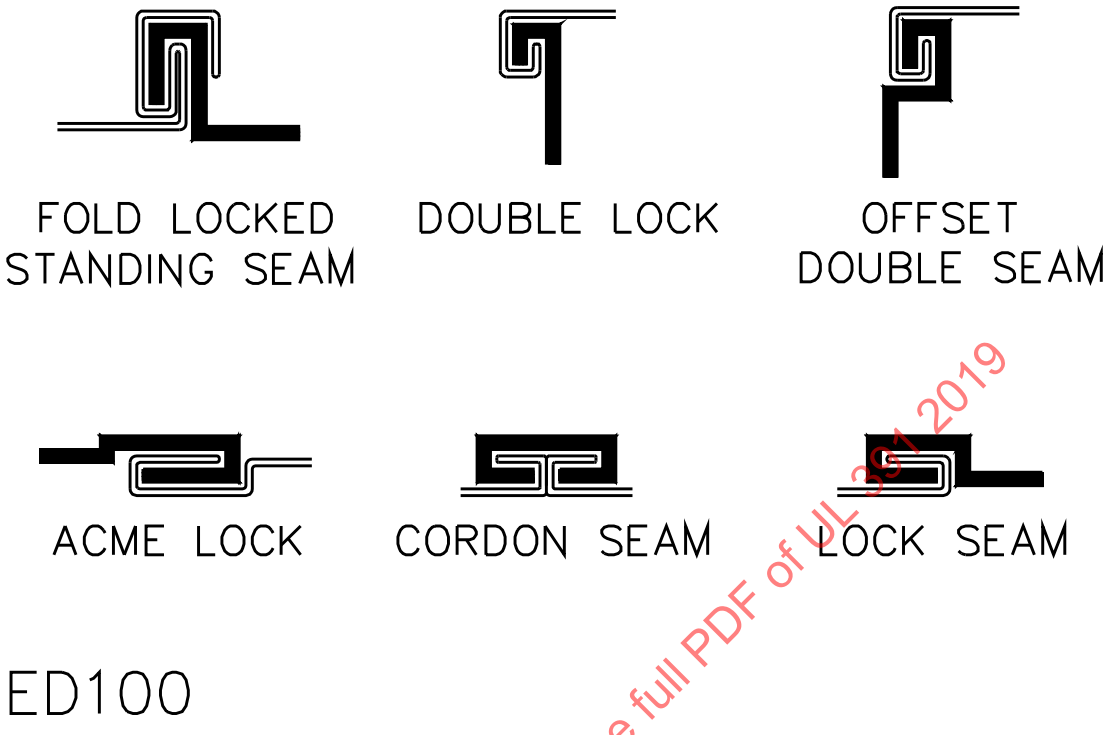
15.1 A radiator shall be made of material not lighter than that specified in 14.1 for a combustion chamber and shall be accessible for cleaning.

16 Heating Surface Joints

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

16.2 Examples of lock-seams that meet the intent of this requirement are illustrated by Figure 16.1.

Figure 16.1
Lock-seams



17 Baffles

17.1 A baffle positioned in a flue-gas passage or otherwise exposed to combustion products shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to the resistance of hot-rolled sheet steel having a minimum thickness of 0.042 inch (1.07 mm), unless deterioration of the material will not cause temperatures in excess of those specified in Table 57.1 when the furnace is tested in compliance with the performance requirements.

17.2 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall facilitate its removal and subsequent replacement only in its intended position.

18 Flue Collars

18.1 A flue collar shall provide for the attachment of the chimney connector.

18.2 A flue collar, flue collector part, or an extension outside the air handling compartment shall have rigidity, heat, and corrosion-resistance at least equivalent to those of sheet steel having a thickness of not less than 0.016 inch (0.41 mm).

18.3 A flue collar or a flue collector part within the air handling compartment shall have rigidity, heat, and corrosion resistance at least equivalent to those of sheet steel having a thickness of not less than 0.042 inch (1.07 mm).

19 Disposal of Combustion Products

19.1 The construction of a furnace shall not allow the products of combustion to mix with the circulating air.

20 Dampers, Shutters and Draft Regulators

20.1 A combustion-air damper or shutter for control of solid-fuel combustion shall have a maximum opening stop and shall shut off or reduce the supply of combustion air in the event that the linkage malfunctions, if temperatures higher than intended would otherwise be developed when the furnace is tested under the requirements of this standard.

20.2 An adjustable damper for oil combustion shall be equipped with minimum and maximum operating stops. The minimum operating stop shall be located to permit a sufficient air supply for complete oil combustion at minimum-rated burner input.

20.3 A furnace intended to be equipped with a barometric draft regulator shall not require the regulator to be installed in a false ceiling, in a different room, or in any position that will permit a difference in pressure between the air in the vicinity of the regulator inlet and the air in the vicinity of the combustion-air inlet.

21 Electrical Enclosures

21.1 General

21.1.1 An uninsulated, live, high-voltage part shall be enclosed or guarded to reduce the risk of contact by persons during intended use of the equipment. This requirement applies also to any part located in a compartment into which access is required for service operations, such as resetting controls, replacing filters, lubricating, and cleaning.

21.1.2 Among the factors to be taken into consideration when evaluating an enclosure are its:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability;

e) Resistance to corrosion; and

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

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

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

21.1.4 The 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.

21.1.5 A steel enclosure shall be protected from corrosion by painting, plating, or equivalent means.

21.1.6 The thickness of sheet metal serving as the individual enclosures of electrical components shall be as indicated in Tables 21.1 and 21.2.

21.1.7 Where the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 21.1 or 21.2, whichever applies, may be employed.

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

21.1.9 All intended mounting positions of the unit are to be considered when determining compliance with the requirement of 21.1.3.

21.1.10 A junction box, a portion of which is formed by another part, such as a fan scroll or a motor casing, shall fit in such a way that:

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

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

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness, inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Metal coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	(MSG)		(GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
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)				
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)				
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)				
18.0	(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)				
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)				
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)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
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)				
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)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

[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) 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, for example, with spring clips.

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

[c] For a panel which is not supported along one side, for example, 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 21.2
Minimum thickness of sheet metal for enclosures-aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches (mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023
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
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
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
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
14.0	(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
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
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
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
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)

[a]A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal 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) 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, for example, with spring clips.

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

[c] For a panel which is not supported along one side, for example, 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.

21.1.11 The criteria for evaluating an opening in an electrical enclosure are given in Section 22, Accessibility of Uninsulated Live Parts, Film-Coated Wire and Moving Parts.

21.1.12 When compliance with the requirements of 21.1.11 is determined, any part of the enclosure (including air filters) that can be removed without the use of tools is to be removed.

21.1.13 A mounting screw and nut shall be constructed or located so that sharp edges will not damage wiring. A screw shall have a flat or blunt end. The end of the screw shall have no burrs, fins, or sharp edges that might abrade wire insulation and shall not project more than 3/16 inch (4.8 mm) into a wireway.

21.2 Doors and covers

21.2.1 A cover or access panel of an enclosure for uninsulated high-voltage parts shall be provided with means for securing it in place.

21.2.2 A hinged or pivoted panel or cover shall be positioned or arranged so that it is not subject to falling or swinging from an open position due to gravity or vibration if either movement of the cover or exposure of moving parts or uninsulated live parts within the enclosure results in a risk of injury to persons.

21.2.3 The assembly shall be arranged to permit replacement of a fuse or other overcurrent protective device, the protective functioning of which requires renewal, and to permit manual-reset devices to be reset without removing parts other than a service cover, a service panel, or a cover or door enclosing the device. See 21.2.6.

21.2.4 A required protective device shall be inaccessible from outside the product unless a door or cover is opened.

Exception: The operating handle of a circuit breaker, the reset button of a manually resettable limit control, and similar parts may project outside the product enclosure.

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

21.2.6 A fuseholder shall be constructed, installed, or shielded so that uninsulated high-voltage live parts within 4 inches (100 mm) of the fuseholder will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or equivalent material employed for this purpose shall be not less than 0.028 inch (0.71 mm).

Exception: The screw shell of a plug fuseholder, a cartridge fuse clip, or a wiring terminal to a fuseholder need not comply with this requirement.

21.2.7 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 the cover must be opened in connection with the intended operation of the protective device. Resetting a manual-reset overload-protective device is an example of such an operation. Exceptions to this requirement are specified in 21.2.8.

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

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

b) Supplementary-type fuses of 2 amperes or less intended for small auxiliary resistance heaters with a maximum rating of 100 watts;

c) Extractor-type fuses with their own enclosures; or

d) Fuses in low-voltage circuits.

21.2.9 A hinged cover shall not be held closed solely by screws or other similar means requiring the use of tools but shall be provided with a catch or spring latch.

21.2.10 A spring latch, a magnetic latch, a dumpee, or any other mechanical arrangement that will hold the door in place and requires manipulation to open the door meets the intent of the requirement in 21.2.9.

21.2.11 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; otherwise, it 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 and shall overlap the edges of the box by not less than 1/2 inch (12.7 mm). A construction that affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, meets the intent of this requirement.

21.2.12 If a strip is used to provide a rabbet or an angle strip is fastened to the edges of a door, it shall be secured at not less than two points not more than 1-1/2 inches (38 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (150 mm) apart.

21.2.13 Sheet-metal screws threading directly into metal shall not be used to attach a cover, door, or other part removed to install field wiring or to operate the equipment. A sheet-metal screw may thread into a sheet-metal nut that is permanently mounted and protected against corrosion, and a machine screw or self-tapping machine screw may thread directly into a sheet-metal wall.

21.3 Field wiring system connections

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

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

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

21.3.4 A knockout in a sheet-metal enclosure shall be secured but shall be capable of being removed without deformation of the enclosure. See Knockout Security Test, Section 64.

21.3.5 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 less than those required between uninsulated live parts and the bushing.

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

a) 0.014 inch (0.36 mm) if of steel or 0.019 inch (0.48 mm) if of nonferrous metal where the hole has a maximum dimension of 1/4 inch (6.4 mm); and

b) 0.027 inch (0.69 mm) if of steel or 0.032 inch (0.81 mm) if of nonferrous metal where the hole has a maximum dimension of 1-3/8 inch (35 mm).

Either a closure for a larger hole shall have a thickness equal to that required for the enclosure of the device (see Tables 21.1 and 21.2), or a standard knockout seal shall be used. Such a plate or plug shall be mechanically secured.

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

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

a) For an opening that has a minor dimension (see 22.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 22.1.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 22.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 22.2.

Figure 22.1
Probe for uninsulated live parts

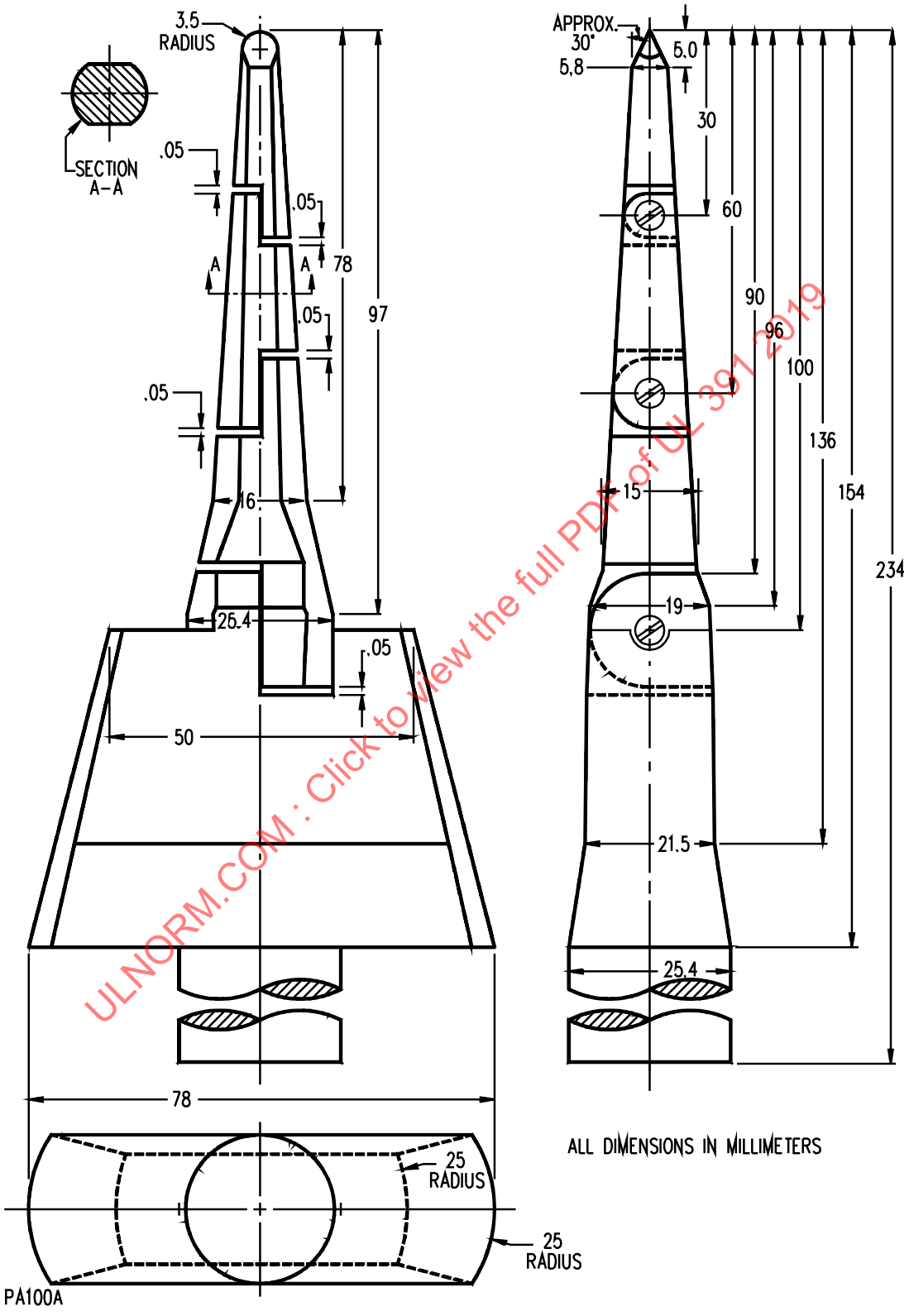


Table 22.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

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

[a] See 22.5.
[b] Between 3/4 inch and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch applies to a motor only.
[d] More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

22.2 With respect to a part or wire as mentioned in 22.1, in an integral enclosure of a motor as mentioned in the exception to 22.1:

a) An opening that has a minor dimension (see 22.5) less than 3/4 inch (19.1 mm) meets the intent of the requirement if:

1) A moving part cannot be contacted by the probe illustrated in Figure 22.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 22.3;

3) In a directly accessible motor (see 22.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 22.4; and

4) In an indirectly accessible motor (see 22.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 22.2.

b) An opening that has a minor dimension of 3/4 inch or more meets the intent of the requirement if a part or wire is spaced from the opening as specified in Table 22.1.

Figure 22.2
Probe for moving parts and uninsulated live parts

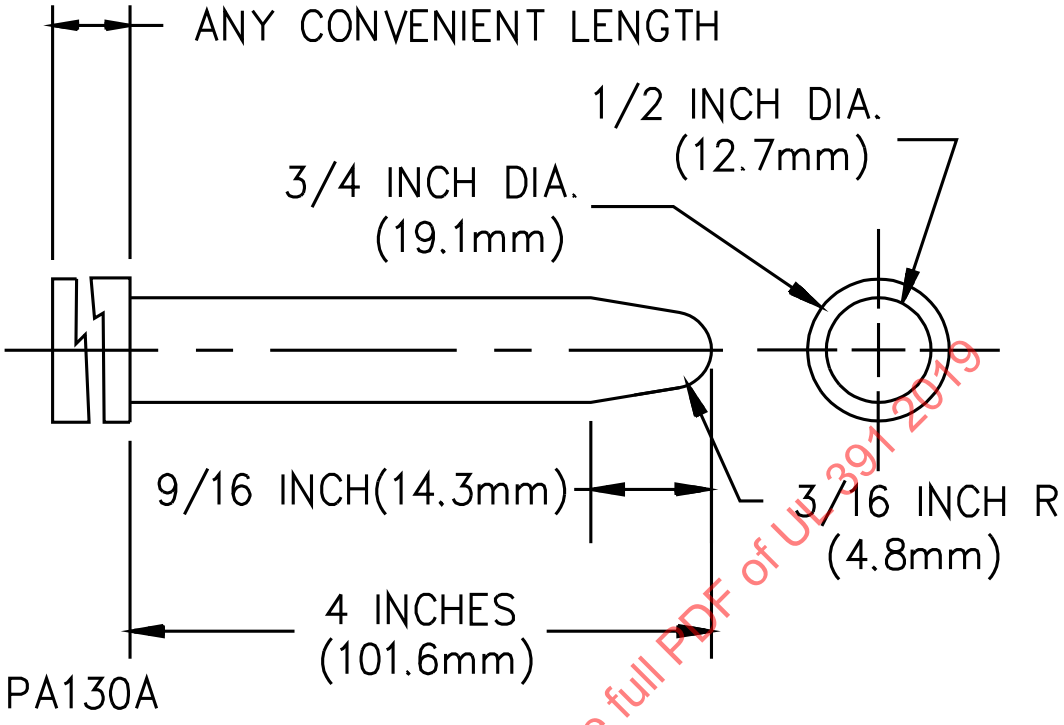


Figure 22.3
Probe for film coated wire

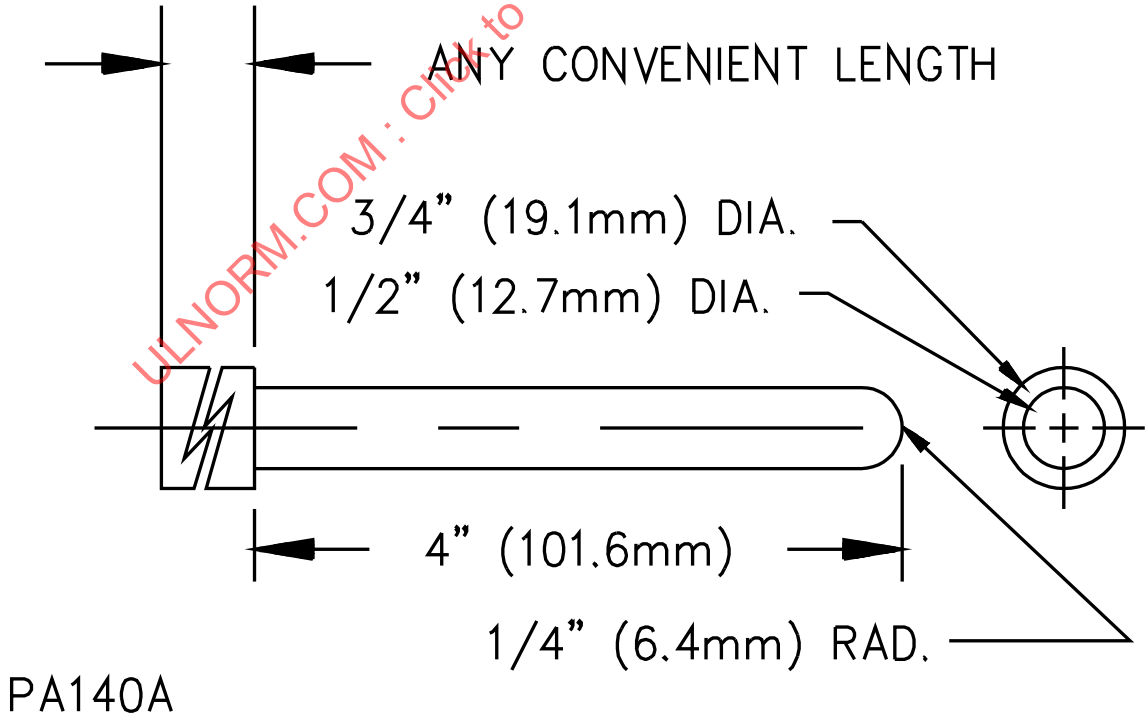
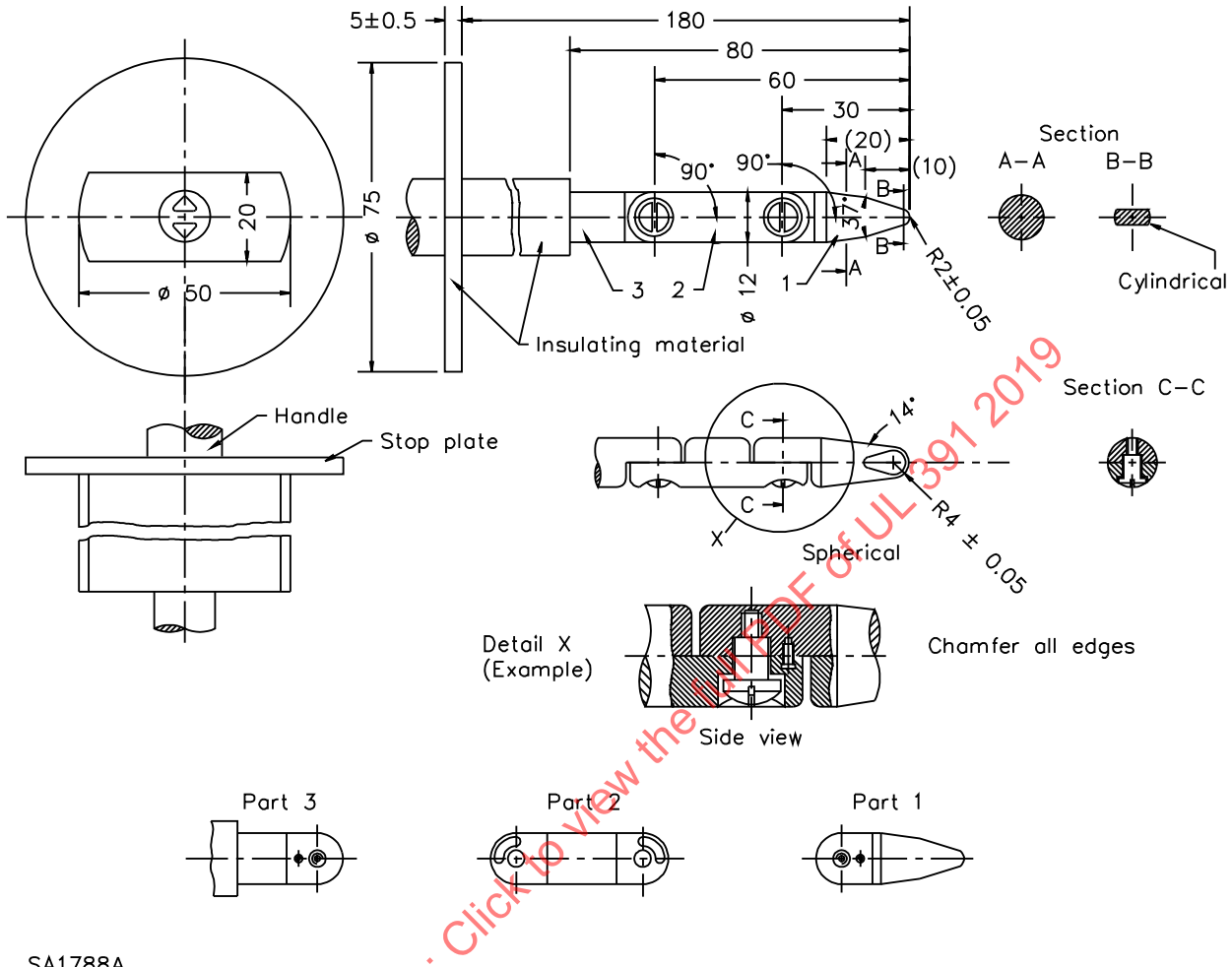


Figure 22.4
IEC articulate probe



22.3 The probes mentioned in 22.1 and 22.2 and illustrated in Figures 22.1 – 22.4 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 22.1 and 22.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

22.4 The probes mentioned in 22.3 and 22.5 shall be used as measuring instruments to determine the accessibility provided by an opening, and not as instruments to determine the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

22.5 With reference to the requirements in 22.1 and 22.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

22.6 With reference to the requirements in 22.2, an indirectly accessible motor is a motor:

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

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

22.7 With reference to the requirements in 22.2, a directly accessible motor is a motor:

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

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

22.8 During the examination of a product to determine whether it complies with the requirements in 22.1 or 22.2, a part of the enclosure that may be removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

22.9 With reference to the requirements in 22.1 and 22.2, insulated brush caps are not required to be additionally enclosed.

FIELD WIRING

23 General

23.1 Provision shall be made for connection of power supply wiring systems that comply with the requirements of the National Electrical Code, ANSI/NFPA 70.

23.2 Provision shall be made for the connection of wiring enclosed in conduit or metal-clad cable, in accordance with these requirements, for all exterior wiring between the furnace and field-installed devices located on the furnace or remote from it. These devices include fan and limit controls, a damper motor, an oil burner, the blower compartment and a remote thermostat or motor controller.

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

23.4 The connections shall be accessible without need to remove parts other than either a service cover, a service panel, or the cover of the junction box or compartment in which the connections are made. A component intended for this use may serve as a cover.

23.5 The size of a junction box in which field-wiring connections are made by splicing shall be not less than that specified in Table 23.1. A conductor passing through the box is considered as a single conductor, and each conductor terminating in the box is also considered as a single conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 23.1
Size of junction boxes

Size of conductor		Free space within box for each conductor,	
AWG	(mm^2)	cubic inches	(cm^3)
16 or smaller	(1.3 or less)	1.5	(24.6)
14	(2.1)	2.0	(32.8)
12	(3.3)	2.25	(36.9)
10	(5.3)	2.5	(41.0)
8	(8.4)	3.0	(49.2)

23.6 A knockout in a junction box or compartment for field-wiring connections shall accommodate conduit of the trade size specified in Table 23.2.

Table 23.2
Trade size of conduit in inches (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)
8	(8.4)	3/4	(26.7)	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)
6	(13.3)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)
4	(21.2)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)
3	(26.7)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	1-1/2	(48.3)
2	(33.6)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)
1	(42.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)	2	(60.3)

NOTES –

1 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.

2 Trade size per the American National Standard for Electrical Rigid Steel Conduit, ANSI C80.1.

23.7 Except as indicated in 25.4, wiring for the connections specified in 23.2 need not be furnished by the manufacturer as part of the furnace if accurate instructions for installing this wiring are furnished with the furnace and if each junction box or compartment in which the connections are to be made is marked, when applicable, in accordance with the requirements in 72.9.

23.8 A junction box or compartment included as part of the assembly and in which a branch circuit supplying power to the furnace is to be connected shall not need to be moved to service the unit. This requirement does not apply to separate limit controls to which metal-clad cable or flexible metallic conduit is to be directly attached.

23.9 If a junction box or compartment is intended to contain field-wiring connections, including power-supply connections, it shall be located so that the temperature of the field-wired conductors within the box or compartment and of surfaces of the box or compartment that are likely to be in contact with the conductors will not exceed the temperature specified for Type T wire in Table 57.1, when the furnace is tested in accordance with the requirements specified in the Performance section.

Exception: If the junction box or compartment is marked in accordance with 72.9, the temperatures on the conductors or surfaces shall not exceed 75 or 90°C (167 or 194°F), as applicable.

24 Leads and Terminals

24.1 Wiring terminals or leads not less than 6 inches (150 mm) long shall be provided for connection of field-wiring conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70, and corresponding to the marked rating of the assembly.

24.2 A lead may be less than 6 inches (150 mm) long if the use of a longer lead may result in damage to the lead insulation.

24.3 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 that may cause the lead to separate from its termination or result in damage to the lead from sharp edges. See the Lead Stress Test, Section 65.

24.4 A grounded terminal or lead shall not be electrically connected to a single-pole manual switching device that has an ″off″ position or to a single-pole overcurrent (not inherent overheating) protective device.

24.5 At terminals, stranded conductors shall not contact other uninsulated live parts or dead metal parts. This may be accomplished by use of pressure-terminal connectors or soldering lugs or crimped eyelets, by the soldering together of all strands of the wire, or by equivalent means. Open slot-type connectors shall not be used unless they are intended to reduce the risk of disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be shielded by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. Insulation on the shanks shall be not less than 0.028 inch (0.71 mm) thick.

24.6 A field-wiring terminal shall be secured to its supporting surfaces by methods other than friction between surfaces so that it will not turn or shift in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some equivalent method.

24.7 Conductors intended for connection to a grounded neutral line shall be finished a white or gray color. All other current-carrying conductors shall be finished in colors other than white, gray, or green. A terminal for connection of a grounded conductor shall be identified by a white metallic-plated coating and shall be readily distinguishable from other terminals; otherwise, it shall be identified on an attached wiring diagram or in some equivalent manner.

24.8 A lead provided for spliced connections to an external high-voltage circuit shall not be connected to a wire-binding screw or a pressure terminal connector that is located in the same compartment as the splice or is visible to the installer, unless the screw or connector is rendered unusable for field-wiring connections or unless the lead is insulated at the unconnected end.

24.9 A terminal part by which field wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with 24.5. However, when a 10 AWG (5.3 mm^2) or smaller wire is used, a part to which wiring connections are made may consist of a clamp or wire binding screw with cupped washer, a terminal plate having upturned lugs, or the equivalent, to hold the wire in position.

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

24.11 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. In either case there shall be not less than two full threads in the metal.

24.12 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.

24.13 A wire-binding screw shall thread into metal.

INTERNAL WIRING

25 General

25.1 The wiring of both high-voltage and safety-control circuits shall comply with the requirements of 25.2 – 25.4.

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

25.3 Except as indicated in 23.7, the wiring for all furnace circuits shall be furnished by the manufacturer as part of the furnace. If the furnace is not assembled and wired at the factory, the wiring shall be furnished as a harness with each furnace and be arranged to facilitate attachment when the furnace is assembled. In this case, a pictorial diagram showing the exact arrangement of the wiring shall be included with each furnace.

25.4 If an insulated conductor rated for use at temperatures in excess of 90°C (194°F) is required, the wiring shall be furnished as part of the assembly. Any device to be connected by such wiring shall be factory-located on the equipment. Also see 23.7 and 72.9.

26 Methods

26.1 Electrical wiring to a part that must be moved for maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. A conductor to be disconnected from a terminal of such a part shall terminate in an eyelet or connector. If the wiring is not detachable from a part that functions as an access plate or cover (for example, a hinged oil-ignition transformer that closes the access to the nozzle assembly), the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any resulting movement of the part shall not unduly twist, bend, or pull the wiring.

26.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 26.12 and 26.13. Group A of Table 26.1 includes some wiring materials identified for use where conductors are enclosed as required. Flexible metal conduit shall be not smaller than nominal 3/8-inch (9.5-mm) electrical trade size, in accordance with the American National Standard for Electrical Rigid Steel Conduit, ANSI C80.1. This does not apply to parts of components, such as conduit, that shield flame-sensor leads considered under other standards.

Table 26.1
Typical wiring materials

Group	Type of wire, cord, cable	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	RF-2, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RUH, RUW, T, THW, XHHW, MTW, TWH-MTW, THWN, TW or thermoplastic appliance wiring material, with insulation thickness shown at the right corresponding to wire sizes 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	(67.4)	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 materials having thermoplastic or neoprene insulation with insulation thickness 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	(8.3)	6.64	(2.4)
		6	(13.3)	8/64	(3.2)

NOTE – Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm^2), are considered equivalent to the wiring material referenced in Group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type recognized for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, and flammability.

26.3 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.4 m) and within 12 inches (300 mm) on each side of a junction box.

Exception: Where flexibility is necessary, lengths not exceeding 36 inches (0.9 m) need not be secured within 12 inches of a junction box.

26.4 All splices and connections shall be mechanically secure and electrically bonded. A soldered connection shall be made mechanically secure before soldering if breaking or loosening of the connection can result in the risk of fire or electric shock.

26.5 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 cannot be maintained.

26.6 A splicing device, such as a fixture-type splicing connector or pressure wire connector, may be employed if it has insulation rated for the voltage to which it will be subjected. Thermoplastic tape wrapped over a sharp edge does not meet the intent of the requirement.

26.7 A splice shall be located, enclosed, and supported so that it is not subject to damage as the result of flexing, motion, or vibration.

26.8 With reference to 26.7, a splice is considered to be enclosed when installed in a junction box, control box, or other enclosed compartment in which high-voltage wiring materials, as specified in Group A of Table 26.1, are employed. A splice in an enclosed machinery compartment shall be secured to a fixed member in the compartment so that it is not subject to movement or damage during servicing.

26.9 At all points where conduit or metal tubing terminates, a conductor shall be shielded from abrasion. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided between the conductors and the armor and the connector or clamp so that the insulating bushing or its equivalent will be visible for inspection.

26.10 The interconnection of sections and fittings shall provide a rigid mechanical assembly and continuity of electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges that might increase the risk of damage to the insulation on wires.

26.11 All wiring shall be supported and routed to reduce the risk of damage inflicted by sharp edges or moving parts.

26.12 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 use Type SO or ST cord, provided that:

a) It is not practical to do the wiring in accordance with 26.2;

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

c) The length of cord outside the assembly is not more than 4 inches (100 mm) and strain relief is provided.

26.13 Cords or appliance wiring material as specified in Group B of Table 26.1 may be employed within a furnace casing, provided that the construction complies with all of the following:

a) The furnace casing includes a bottom surface and there are no openings in this surface.

Exception No. 1: There may be openings if 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.

Exception No. 2: The casing may have an open bottom if all sides extend to the floor level and installation is intended to be only on noncombustible flooring.

b) An opening in other than the bottom of the casing does not permit entrance of a rod having a diameter of 1/2 inch (13 mm), and an opening for an item such as pipe or conduit is not more than 1/2 inch larger in diameter than the object that will be installed through the opening.

c) An opening is not closer than 6 inches (150 mm) to the wiring.

Exception No. 1: An opening may be closer than 6 inches to the wiring if a metallic barrier or baffle is placed between the wiring and the opening.

Exception No. 2: A louvered opening may be closer than 6 inches to the wiring if it serves to protect the wiring from mechanical damage from outside the compartment, and if it is formed so as to assist in confining an electrical disturbance within the compartment. Louvers shall be of a drawn metal shaped to completely obscure the wiring within the compartment from a horizontal view taken outside the compartment. The openings shall be located so that an object falling vertically cannot enter the compartment through a louvered opening.

d) Flammable material, other than electrical insulation, located within the casing or compartment is separated from cords and appliance wiring material. An air filter may be employed within the enclosure.

26.14 With reference to 26.13(d), polymeric materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. Other nonmetallic materials shall have equivalent characteristics.

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26.15 Cords and other wiring material complying with the requirements of 26.12 and 26.13 shall be arranged so that they will not be damaged (for example, by closely following surfaces) and they shall be supported.

26.16 With reference to 26.13, an opening that is intended to be permanently connected to an air duct is considered to be closed.

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

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

26.19 An opening in sheet metal meets the intent of the requirement if the metal surrounding the opening is rolled, extruded, or both. Otherwise, insertion of a grommet complying with requirements of 26.17 is required.

27 Short-Circuit Protection

27.1 Except as indicated in 27.2, conductors of motor circuits having two or more motors, one or more of which is thermal or overcurrent protected, shall withstand the conditions of a short-circuit test without creating risk of fire or electric shock when the motors are wired for connection to one supply line. See Short-Circuit Test, Section 68.

27.2 A conductor that complies with the requirements of (a) – (c) meets the intent of the requirement without test:

a) A conductor that has not less than one-third the ampacity of the required branch-circuit conductor;

b) A conductor that is 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) long, provided that the product will be protected by a 60-ampere or smaller fuse (this applies to any of the wiring materials specified in this standard, including those enclosed in raceways); or

c) A conductor that serves as a jumper lead between controls, provided that the length of a lead does not exceed 3 inches (76 mm) or that the conductor is located in a control panel.

27.3 Factory wiring of a low-voltage safety circuit may use SP-2 cord having neoprene insulation, SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or power-limited Class 3 circuit cable, if such wiring is located in a cavity or compartment of an appliance and is shielded to reduce the risk of damage to the insulation.

28 Separation of Circuits

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

28.2 An insulated conductor may be segregated by clamping, routing, or equivalent means that provides permanent separation from insulated or uninsulated live parts of a different circuit.

28.3 A field-installed conductor of any circuit shall be either separated by barriers or segregated from:

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

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting can result in the risk of fire, electric shock, or injury to persons.

However, a construction in which field-installed conductors can make contact with wiring terminals meets the intent of the requirement, 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.

28.4 Field-installed conductors may be segregated from each other and from uninsulated live parts connected to different circuits by arranging the location of the openings provided 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. However:

a) If the number of openings in the enclosure does not exceed the minimum required for intended wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 28.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) If more than the minimum number of openings are provided, consideration is to be given to the possibility that a conductor will enter at a point not opposite the terminal to which it is intended to be connected. In this situation the possibility that conductor will contact an insulated conductor or uninsulated live part connected to a different circuit is also to be considered.

28.5 To determine compliance with the requirements of 28.3, the product is to be wired as it would be in service. Slack is to be left in each conductor within the enclosure, and no more than anticipated precaution is to be exercised in stowing this slack into the wiring compartment.

28.6 A barrier used to provide separation between the wiring of different circuits or between operating parts and field-installed conductors shall be of metal or insulating material and shall be held in place.

28.7 A metal barrier shall be at least as thick as required by Tables 21.1 and 21.2, 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 of greater thickness if its deformation may be accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

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

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

29 Bonding for Grounding

29.1 An equipment-grounding terminal or lead shall be provided for connection of the equipment grounding conductor and shall be located inside the enclosure provided for field power-supply connections.

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

29.3 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.

29.4 Exposed or accessible noncurrent-carrying metal parts that may become energized and that may be contacted by the user or by service personnel during service operations performed while the equipment is energized shall be electrically connected to the point of connection of field wiring leading to the equipment grounding terminal or lead and to the metal surrounding the knockout, hole or bushing provided for field connection of conduit.

29.5 Except as permitted in 29.6, an uninsulated metal part of a cabinet, an electrical enclosure, a motor frame, a motor-frame mounting bracket, a controller mounting bracket, a capacitor or other electrical component, interconnecting tubing or a piping valve shall be bonded for grounding if it may be contacted by the user or service personnel.

29.6 A metal part, as described below, need not be grounded:

a) Any adhesive-attached metal-foil-marking, screw, handle, or part that is located on the outside of an enclosure or cabinet and is isolated from electrical components or wiring by grounded metal parts.

b) Any isolated metal part, such as a magnet frame or armature, and any small assembly screw that is separated from wiring and uninsulated live parts.

c) Any 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.

29.7 A component, such as a switch, that may be separated from its intended grounding means for purposes of testing or adjustment while the equipment is energized shall be provided with a grounding conductor not requiring removal for such service.

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

29.9 A metal-to-metal hinge bearing member is considered to be means for bonding a door for grounding, provided that a multiple bearing-pin-type (piano-type) hinge is employed.

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

a) Be located within the confines of an outer enclosure or frame that acts as a barrier against mechanical damage; and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding, unless the bonding conductor would not ordinarily be omitted after removal and replacement of the fastener.

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

29.12 A connection that depends upon the clamping action exerted by rubber or similar materials meets the intent of the requirement if it complies with the requirements of 29.17 under any degree of compression permitted by a variable clamping device and if, after exposure to the effects of oil, grease, moisture, and thermal degradation that are likely to occur in service, the connection performs as intended. A clamping device shall be arranged for reassembly in its intended position following disassembly or removal for maintenance purposes.

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

29.14 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 29.15, the size of the conductor or strap shall be in accordance with Table 29.1.

Table 29.1
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.

29.15 A bonding conductor connected 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.

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

29.17 If a bonding connection cannot be determined to comply with the requirements specified in 29.11 – 29.13 or if a bonding conductor is smaller than required in 29.14 – 29.16, the connection or conductor shall not open when subjected to:

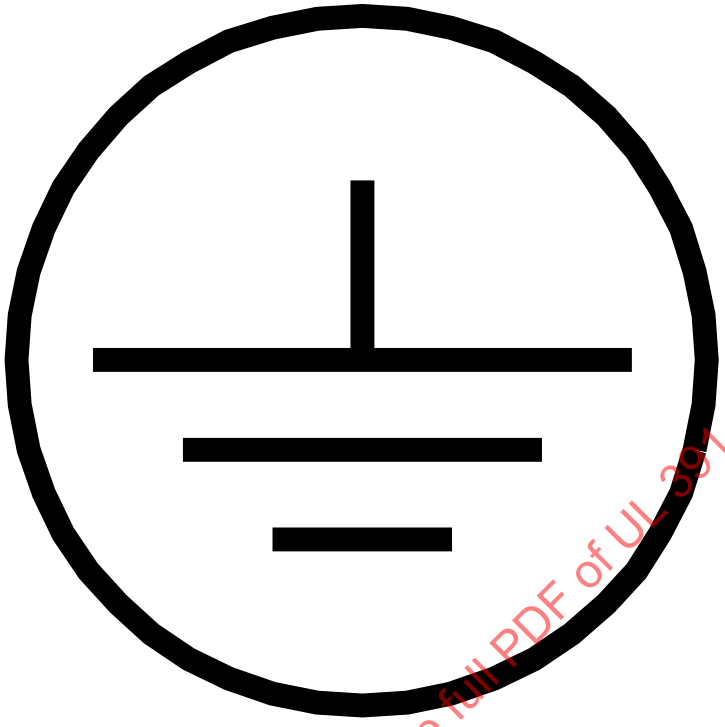
a) The Bonding Conductor Test, Section 63; and

b) The Short-Circuit Test, Section 68.

29.18 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked,″G,″ ″GR,″ ″GROUND,″ ″GROUNDING,″ by the symbol illustrated in Figure 29.1 or the like, or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be located so that it does not need to be removed during servicing. Upturned lugs, or the equivalent, shall be provided at a wire-binding screw to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors involving the neutral of a grounded supply, a marking shall be additionally provided indicating ″EQUIPMENT GROUND,″ identifying the connector by a green color, or making both of these indications.

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

Figure 29.1
Grounding symbol (IEC publication 417, symbol no. 5019)



ELECTRICAL COMPONENTS

30 General

30.1 Electrical equipment and wiring shall be arranged so that, when the product is in use or when uncoupling of a connection is required for servicing, the equipment and wiring will not be contacted by water or oil.

30.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may create risk of fire or electric shock during operation of the equipment.

31 Mounting of Electrical Components

31.1 A switch, fuseholder, lampholder, receptacle, or similar electrical component shall be mounted to secure it from turning, except as noted in 31.2 and 31.3.

31.2 A switch need not be secured against 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; by contrast, 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 not subject to loosening as the result of operation of the switch;

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

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

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

31.4 The means used to secure an electrical component against turning shall 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 the requirement as the means to prevent turning of a small stem-mounted switch or other device having a single-hole mounting means.

31.5 An uninsulated live part shall be secured to the base or mounting surface so that it will not turn or shift in position if such motion may result in a reduction of spacings below the acceptable values specified in Spacings, Sections 38 and 39.

31.6 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.

32 Electrical Insulating Material

32.1 Material for the mounting of current-carrying parts shall be of moisture-resistant material, such as porcelain, phenolic composition, or cold-molded composition.

32.2 Vulcanized fiber may be used for the insulating bushings, washers, separators, and barriers but may not be used as the sole support for uninsulated live parts of other than low-voltage circuits.

33 Capacitors

33.1 A motor-starting or -running capacitor shall be housed within an enclosure or container that will shield the plates against mechanical damage and that will block the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 33.2 and 33.3, the container shall be of metal providing strength and shielding not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

33.2 The individual container of a capacitor may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the furnace. Such a box or case shall comply with the requirement for the enclosure of current-carrying parts.

33.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts in accordance with the requirements of Table 38.1.

33.4 A capacitor employing a dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable requirements of Performance, Sections 40 – 68, including fault overcurrent conditions based on the circuit in which it is used. See 33.5 and Short Circuit Test, Section 68.

33.5 If the available fault current is limited by other components in the circuit (for example, a motor start winding), the capacitor is to be tested using a fault current that may be less than the value specified in Table 68.1 but may not be less than the current established by dividing the circuit voltage by the impedance of the other components.

34 Receptacles

34.1 A 15- or 20-ampere 125 volt attachment-plug receptacles intended for general use as a convenience receptacle in the equipment shall be of the grounding type, and shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

34.2 Unless attachment-plug receptacles intended for general use are provided with a dedicated supply source, over-current protection shall be provided as part of the appliance as required by Article 210 of the National Electrical Code, NFPA 70.

34.3 An attachment-plug receptacle intended for general use shall be of the grounding type. The grounding contact of the receptacle shall be bonded to the point of connection of the equipment-grounding conductor to the appliance. See Section 63, Bonding Conductor Test.

34.4 General use attachment-plug receptacles on equipment intended to be used outdoors or in wet or damp locations shall be provided with a Class A ground-fault circuit interrupter (GFCI) with open neutral protection. The convenience receptacle shall be located so that it does not become wet during normal operation.

34.5 All nominal 120 Volt receptacles provided on equipment intended to be installed outdoors or in a wet location shall have a weathereproof cover enclosure that is marked for use in wet locations.

34.6 A receptacle that is intended to be employed for servicing the unit, shall be powered from the line side of the equipment main disconnect, except as noted in 34.8. A receptacle powered from the line side of the equipment disconnect shall be marked in accordance with 71.1(k).

34.7 A receptacle powered from the line side of the equipment disconnect shall have an enclosure and cover separate from servicable electrical components and live metal parts controlled by the equipment main disconnect.

34.8 When a receptacle is powered from a separate branch circuit, it shall be located in a separate enclosure and marked in accordance with 71.1(l).

35 Motors and Motor (Overload) Protection

35.1 A motor shall be protected by an integral thermal protector or by overload protective devices or by a combination of these.

35.2 An overload protective device specified in 35.1 is one that complies with the requirements of the National Electrical Code, ANSI/NFPA 70, as follows:

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

125 percent – For a motor with a marked service factor of not less than 1.15

125 percent – For a motor with a marked temperature rise of not more than 40°C (72°F)

115 percent – For any other motor

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

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

140 percent – For a motor with a marked service factor of not less than 1.15

140 percent – For a motor with a marked temperature rise of not more than 40°C (72°F)

130 percent – For any other motor

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

UL 1004-3 will replace Part III of UL 2111 effective September 15, 2014

35.4 A separate overload device, except when included as part of a magnetic motor controller, shall be assembled as part of the equipment and shall be identifiable as such after assembly to the equipment. This protection shall not include means for manually interrupting the motor circuit if the interruption can increase the risk of fire, electric shock, or injury to persons.

35.5 Except as indicated in 35.6, 3-phase motors shall be provided with overcurrent protection as follows:

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

b) Thermal protectors, combinations of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies so investigated shall be marked as specified in 72.6.

35.6 If the assembly is of such a construction that it is not intended to be installed in isolated, inaccessible, or unattended locations, then two acceptably rated overcurrent devices, or equivalent thermal protection, may be employed, provided that the furnace is marked as specified in 72.13.

35.7 ″Unattended″ as used in 35.6 is defined as lacking the presence of a person capable of exercising responsible control of the motor under consideration. This person need not be an electrician. Also, he need not be in sight of the motor at all times but must be available for opening the motor circuit in the event of motor overheating.

35.8 A direct-drive fan motor or other such motor that is not intended to be subjected to overloads and that is protected by a thermal or overcurrent protective device against overheating caused by locked-rotor current meets the intent of the requirement provided that the motor will not overheat when operated under the severest anticipated conditions of use.

35.9 Impedance protection may be used in a motor to reduce the risk of overheating caused by locked-rotor current if the motor will not overheat during the performance tests of this standard. However, impedance protection does not meet the intent of the requirement for protection in a situation where a motor is installed in a compartment handling air for circulation to the conditioned space.

35.10 A fuse shall not be used as a motor overload protective device unless the largest fuse that can be inserted in the fuseholder provides the required protection for the motor.

35.11 In no case shall interruption of the circuit to a motor by the overcurrent or overtemperature protective device result in operation of the equipment that creates risk of fire, electric shock, or injury to persons or discharge of fuel. If a burner depends upon the operating of 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.

35.12 An automatic-reset protective device shall not be used if the automatic reclosing of the circuit to the motor by the device can result in operation of the equipment that increases the risk of fire, electric shock, or injury to persons.

35.13 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.

35.14 Compliance with the requirement of 35.13 may be provided by the motor frame or another enclosure, structure, shield, or a combination of two or more such items. Compliance is to be determined while the motor is integrated into the assembly.

35.15 A motor having openings in the enclosure or frame shall be installed or shielded so that particles cannot fall out of the motor onto flammable material located within or under the assembly.

35.16 The requirement of 35.15 necessitates the use of a barrier of nonflammable material under an open-type motor unless:

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

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

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) and that is relied upon to prevent the temperature of the motor windings from becoming more than:

1) 125°C (257°F) under the maximum load below which the motor will run without causing the protector to cycle; and

2) 150°C (302°F) with the rotor of the motor locked; or

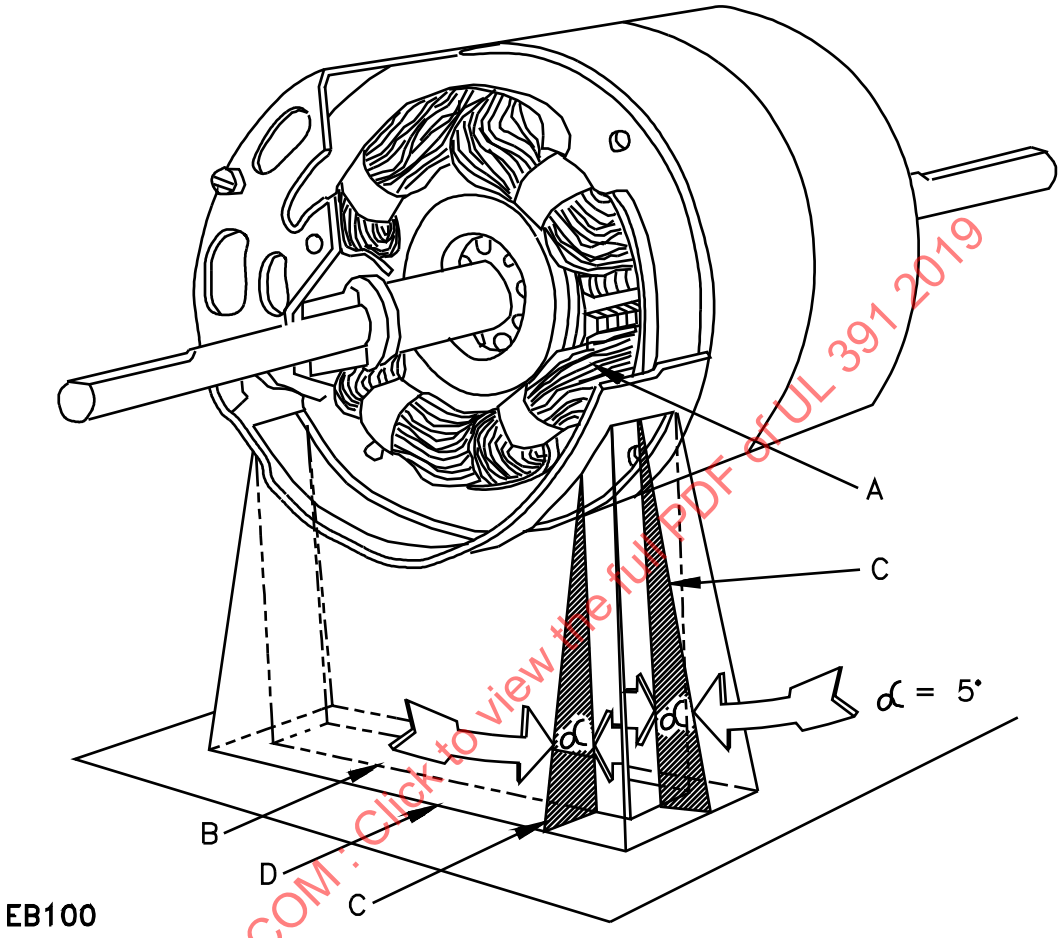
d) The motor complies with the requirements for impedance-protected motors, and the motor winding does not exceed a temperature greater than 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

35.17 The barrier specified in 35.16 shall be horizontal, shall be located as indicated in Figure 35.1, and shall have an area not less than that described in Figure 35.1. There may be openings for drainage and ventilation in the barrier provided that the openings do not permit molten metal, burning insulation, or the like, to fall on flammable materials.

35.18 An overcurrent protective device or a thermal protective device for motors shall comply with the requirements of the Short-Circuit Test, Section 68.

Figure 35.1
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.

36 Safety Controls and Circuits

36.1 General

36.1.1 A safety control circuit shall be 2-wire, one side grounded, and have a nominal rating of 120 volts. A safety control or protective device shall interrupt the ungrounded conductor.

36.1.2 The control circuit shall not allow short circuits to ground to impair the operation of a safety control or protective device. A safety-control-circuit arrangement other than that described in 36.1.1 shall be evaluated to determine if it accomplishes the intent of the requirement.

36.1.3 The requirement of 36.1.1 does not apply to a circuit within a safety control or to the extension of such a circuit to a separate element of the control, such as a flame-sensing device.

36.1.4 A control circuit shall be arranged so that it may be connected to a power-supply branch circuit that can be protected against overcurrent at not more than the value appropriate for the rating of any control included in the circuit in accordance with the National Electrical Code, ANSI/NFPA 70.

36.1.5 All safety controls shall be accessible.

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

36.1.7 A furnace shall have no provision for rendering a safety control ineffective, nor shall the furnace be capable of being fired without the supervision of each of the required safety controls.

36.2 Fan, limit, and thermostatic damper controls

36.2.1 A furnace equipped with an oil burner shall be provided with an automatic-reset limit control that is relied upon to prevent temperatures from rising above the permitted maximum values. The need for a limit control on furnaces firing solid fuel to limit the temperatures for the outlet air and for parts of the furnace is to be determined by the Air Flow Restriction and Disruption Tests, Section 59.

36.2.2 If a furnace is equipped with a limit or thermostatic damper control relied upon to prevent excessive temperatures, the maximum setting permitted by the fixed stop on a limit or thermostatic damper control shall permit an outlet-air temperature of not more than that specified in 56.1.1.

36.2.3 A safety limit control or thermostatic damper control that functions to interrupt or reduce the delivery of fuel or air for combustion by opening an electrical circuit shall be arranged to directly open that circuit, whether the switching mechanism is integral with or remote from the sensing element. No other control that might malfunction to render the limit control ineffective shall be interposed between the limit control and the electrical circuit it governs.

Exception: 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 either:

1) A multiphase circuit; or

2) A single-phase circuit carrying a load greater than the capacity of available limit controls.

36.2.4 A thermostatic damper control relied upon to limit maximum temperatures shall comply with the Standard for Limit Controls, UL 353.

36.2.5 If a combustion-air damper or shutter or fan motor must be operated and controlled by means of a limit or thermostatic damper control to limit maximum temperatures, the entire operating mechanism, including the damper or shutter, crank arms, chains, connecting rods, and associated linkages, shall be located and guarded to reduce risk of tampering or physical damage. Electrical circuits shall be arranged to directly open the damper or fan-motor circuit.

36.2.6 A forced-air or a supplementary central furnace shall be provided with a fan control to start the fan or blower when air in the warm-air supply plenum reaches a temperature not higher than 93°C (200°F), even though a regulating thermostat may have been satisfied.

36.3 Supplementary central furnace controls

36.3.1 A supplementary furnace intended for installation in a parallel-air-flow arrangement with a central furnace shall be equipped with fan controls and dampers or other means to block reverse air flow in the central and supplementary furnaces or to block recirculation of any portion of the circulating air during separate or simultaneous operation of any fan or blower in the two-furnace system.

36.3.2 A supplementary furnace intended for installation in a series-air-flow arrangement with a central furnace shall be equipped with the following controls:

a) An operating control that cycles the gas or oil burner of the central furnace on and off so that the air-temperature rise through the two furnaces will not exceed 72°C (130°F) when the supplementary furnace is firing.

b) An automatic-reset limit control with the maximum set-point stop fixed for operation at a warm-air supply temperature greater than the set point of the operating control referenced in (a) above. Operation of the limit control shall shut off the gas or oil burner of the central furnace when the supply-air temperature is not higher than the temperature specified in 56.1.1.

36.4 Primary safety control

36.4.1 A combination oil-fired and solid-fuel-fired furnace that incorporates a common combustion chamber or flue for firing the two fuels shall be equipped with a primary safety control for the oil burner. To reduce the risk of hot coals or embers remaining in the combustion chamber from previous firing with solid fuel resulting in delayed ignition of the oil burner and to limit the amount of fuel that may be thus ignited, the safety control shall have a nominal trial-for-ignition period not exceeding:

a) 15 seconds for inputs of 20 gallons (76 L) per hour and less.

b) 4 seconds for inputs over 20 gallons per hour.

37 Switches and Controllers

37.1 Except as permitted in 37.2, a controller for regulating the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

37.2 A controller is not required for an assembly having 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 – 600 volts, and the full-load current of any motor does not exceed 6 amperes.

37.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 72.4 if the same controller contacts handle remote motors in addition to handling motors in the unit containing the controller.

37.4 A controller or switch shall be rated for the load that it controls.

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

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

37.7 If the controller is cycled by the operation of an automatic-reset overload device, it shall function as intended when subjected to an endurance test under locked-rotor conditions. The endurance test is to be of a duration equivalent to that required for the overload device and is to be manually cycled at a rate equivalent to that provided by automatic cycling of the overload device.

37.8 The locked-rotor load of a motor is to be based on:

a) Six times the full-load current rating of the motor, in the case of an alternating current motor; and

b) Ten times the full-load current rating, in the case of a direct current motor.

37.9 Two or more motors, each having individual running overcurrent protection, may be connected to the same power supply if:

a) The marked maximum overcurrent-protective-device rating of the furnace does not exceed the maximum size for protecting the motor of the smallest rating; and

b) A protective device of the marked size will not open under the most severe conditions of intended use that can be encountered.

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

SPACINGS

38 High-Voltage Circuits

38.1 Except as noted in 38.2 – 38.4, spacings between uninsulated live parts of opposite polarity or between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 38.1.

Table 38.1
Minimum spacings

Ratings		Minimum spacings[a,b]					
Volt-amperes	Volts	Through air		Over surface		To enclosure[c]	
		Inch	(mm)	Inch	(mm)	Inch	(mm)
0 – 2000	0 – 300[d]	1/8[e]	(3.2)	1/4[f]	(6.4)	1/4	(6.4)
More than 2000	0 – 150	1/8[e]	(3.2)	1/4[f]	(6.4)	1/2	(12.7)
	151 – 300	1/4	(6.4)	3/8[g]	(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 (0.7 mm) in thickness, except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness may be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a less 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.

[f] The over surface spacing for a glass-insulated motor terminal may be 1/8 inch (3.2 mm).

[g] The over surface spacing for a glass-insulated motor terminal may be 1/4 inch (6.4 mm).

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

38.3 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 Table 38.1 and are to be evaluated on the basis of the highest voltage involved.

38.4 The spacing requirements in Table 38.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component that is evaluated on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component (this includes clearances to dead metal or enclosures) shall be as specified in Table 38.1.

39 Low-Voltage Circuits

39.1 Where operation of the product in a short- or grounded-circuit may result in risk of fire, electric shock or injury to persons, spacings for low-voltage electrical components that are installed in a circuit that includes a motor-overload protective device, or other protective device, shall comply with the requirements of 39.2 – 39.5.

39.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be greater than or equal to 1/8 inch (3.2 mm). See 38.3.

39.3 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 device is installed shall be greater than or equal to 1/4 inch (6.4 mm).

39.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part (other than the enclosure) that may be grounded when the device is installed shall be greater than or equal to 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be maintained in intended use of the product.

39.5 The spacings in low-voltage circuits that do not contain devices such as those indicated in 39.2 are not specified.

PERFORMANCE

40 General

40.1 A furnace shall comply with the applicable requirements when tested as described herein. A furnace of a type not described specifically herein is to be tested in accordance with the intent of these requirements.

40.2 A supplementary furnace intended for installation in conjunction with a gas- or oil-fired central furnace is to be tested in conjunction with one or more representative central furnaces. A representative furnace is considered to be one whose operation is most likely to be affected by the installation of the supplementary furnace when factors such as temperature rise, air delivery, and continuity of operation are examined.

40.3 A furnace is to be tested for installation on noncombustible floors and in a position providing clearances to combustible walls and ceilings as specified in Table 40.1. At the option of the manufacturer, a furnace may be tested for installation on combustible floors.

Table 40.1
Standard clearances

Minimum clearance, inches (mm)				
A	B	C	D	E
Above	Front	Connector	Rear	Sides
18 (460)	48 (1220)	18 (460)	18 (460)	18 (460)

40.4 At the option of the manufacturer a furnace may be tested with clearances other than those specified in Table 40.1. However, clearances from a chimney connector shall be greater than or equal to 18 inches (460 mm).

40.5 Use of the clearances specified in Table 40.1 assumes that the furnace is being installed in a room that is large compared to the size of the furnace. All clearances designated in Table 40.1 or designated by the manufacturer under an option are to be given in integral inches for testing purposes.

TEST INSTALLATION FOR CENTRAL FURNACES

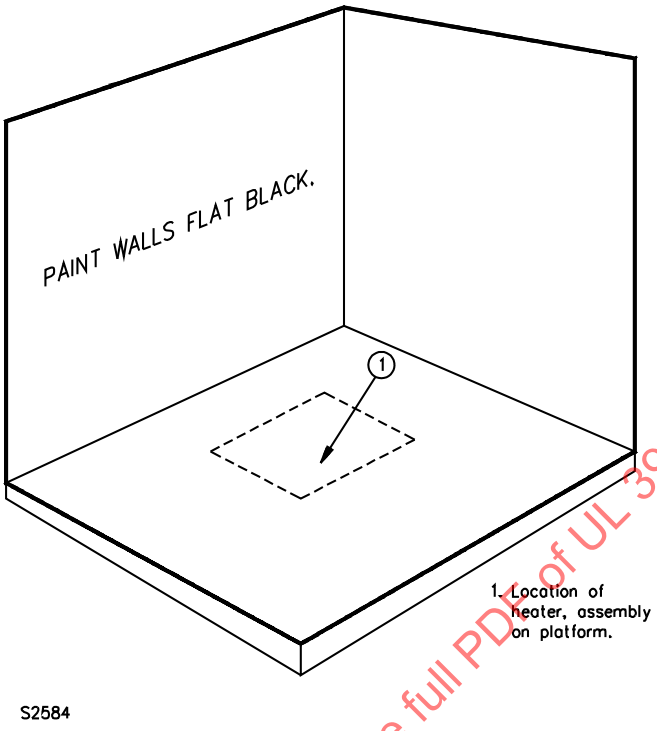
41 Enclosure

41.1 The furnace in the as-received condition is to be placed in a partial enclosure as specified in 41.2 – 41.4. The distances from the back, side, and top of the furnace and from the chimney connector to the walls and ceiling of the enclosure are to be as indicated in Table 40.1. If one side of the furnace may create higher wall temperatures than the other, that side of the furnace is to be directly opposite one wall.

41.2 The furnace is to be level. Leveling means are to be removed if detachable; or, if not detachable, they are to be adjusted to place the base of the furnace at the minimum allowable distance above the floor.

41.3 The partial enclosure is to be formed by two walls of wood boards that are trade-size 1 inch [nominal 3/4 inch (19 mm)] thick or plywood that is 3/4-inch thick, set at right angles and finished in flat black. See Figure 41.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to provide the minimum clearance above the furnace specified in Table 40.1. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the furnace. The walls are to be at the minimum distance specified in Table 40.1 from the side and back of the furnace. However, when the flue outlet is horizontal, the wall opposite the flue collar is to be at the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 42.1.

Figure 41.1
Test enclosure for standard clearances downflow and upflow furnaces

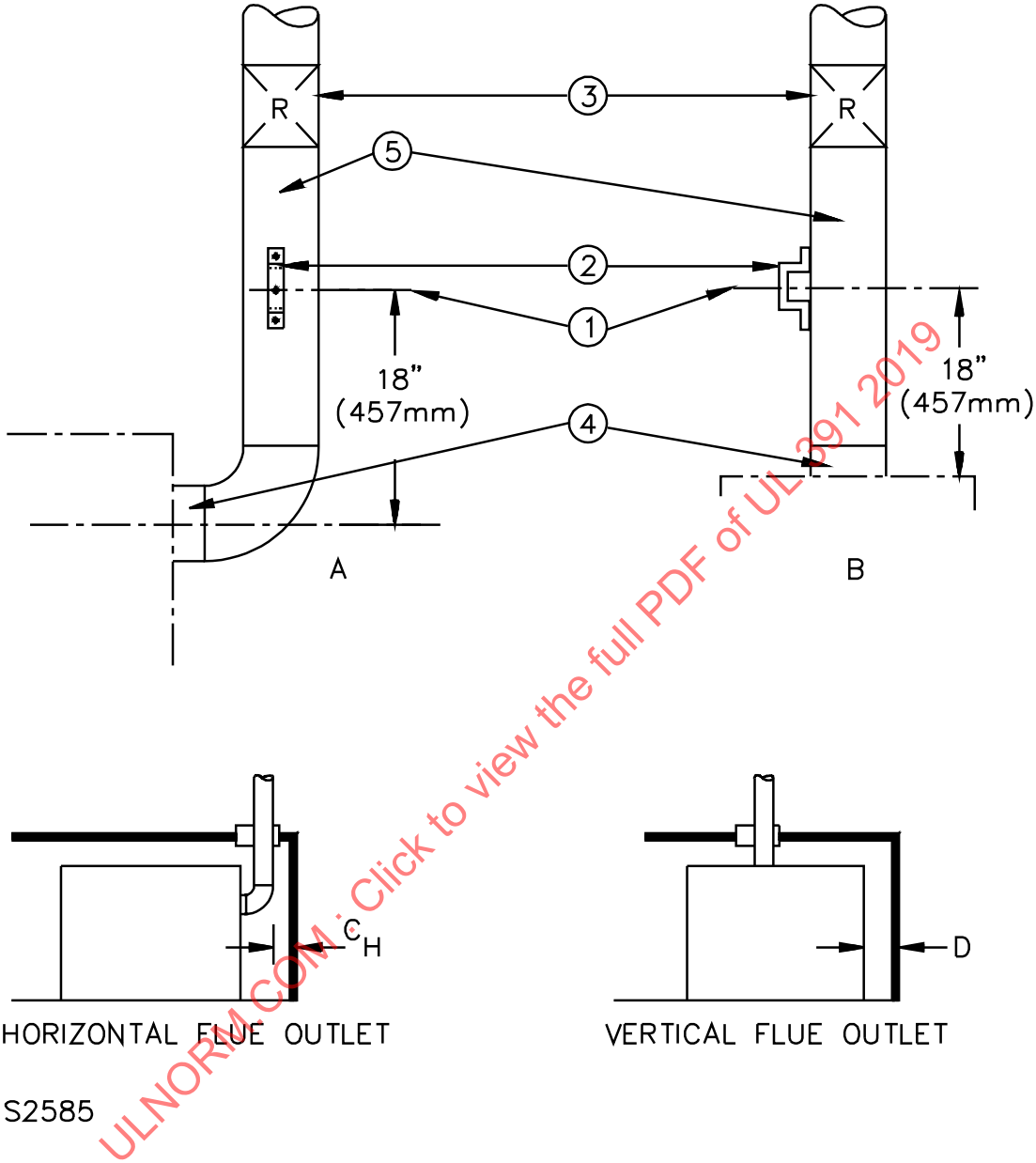


41.4 If the furnace is intended for direct installation on combustible flooring, the floor beneath the furnace is to be of white pine flooring that is trade-size 1 inch [nominal 3/4 inch (19 mm)] thick covered with one thickness of building paper and then with 3/4-inch-thick plywood that is unpainted or finished with a clear sealer.

42 Chimney Connector

42.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe not thicker than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure. The chimney connector is to be directly connected to and extended vertically above a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree sheet-metal elbow at the bottom of the vertical section. See Figure 42.1.

Figure 42.1
Chimney connectors – standard clearance test



1. Centerline of thermocouple.

2. Support bracket.

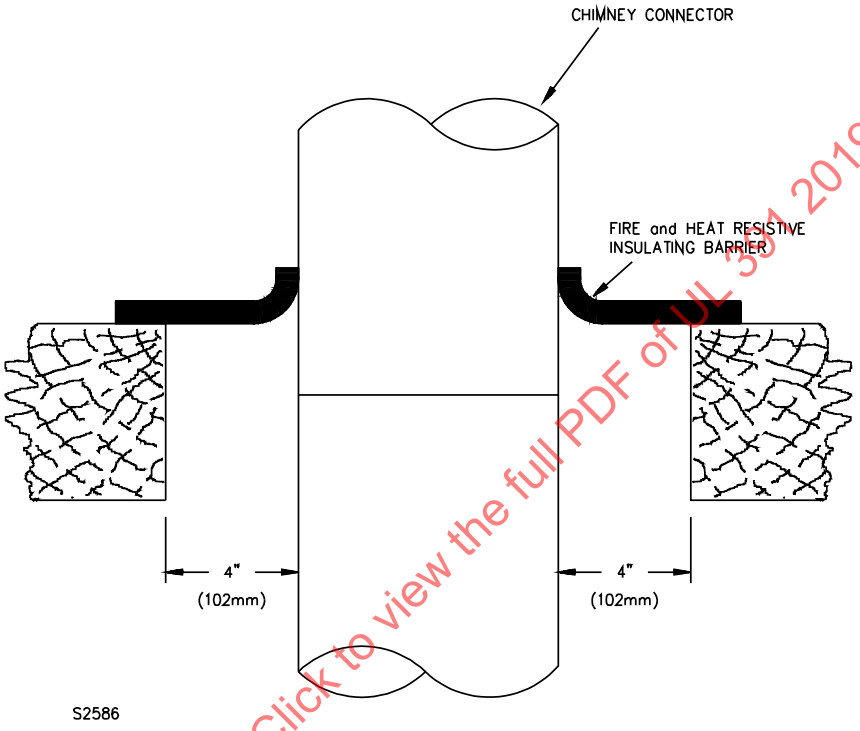
3. Draft regulator.

4. Flue collar.

5. Chimney connector, same nominal diameter as flue collar.

42.2 Where the chimney connector passes through the enclosure, an opening 8 inches (205 mm) larger than the chimney connector is to be cut in the enclosure, and the annulus thus formed is to be sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 42.2. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50 mm) from the outer edge of the annulus.

Figure 42.2
Sealing of annulus around chimney connector



42.3 A bracket for supporting the thermocouple used to measure flue-gas temperature is to be located as shown by item 2 of Figure 42.1.

42.4 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 42.1.

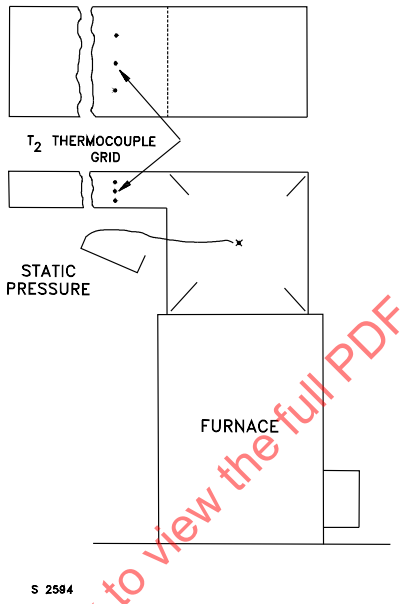
42.5 A built-in draft regulator included as part of the furnace is to be fixed in the position that allows maximum draft.

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

43 Supply-and Return-Air Plenums and Ducts – Forced-Air Furnace

43.1 Unless the supply plenum is an integral part of the furnace, a metal plenum chamber or bonnet having the same dimension as the warm-air outlet of the furnace is to be provided by the manufacturer for test purposes. A separate plenum is to be at least 18 inches (460 mm) tall and not shorter than required to obtain the minimum clearance specified in Table 40.1 from a ceiling located at least 7 feet, 6 inches (2.3 m) above the floor of the test enclosure. See Figure 43.1.

Figure 43.1
Plan for ducts for forced-air upflow furnaces



T_2 – Outlet-air temperature

43.2 The warm-air outlet opening is to be extended by ducting beyond the test enclosure and arranged to discharge away from the cold-air inlet of the furnace.

43.3 The size of the outlet duct is to be calculated for a velocity of approximately 900 feet (275 m) per minute of standard air [0.075 pound per cubic feet (1.2 kg/m^3)] based on a temperature rise of 50°C (90°F) through the furnace and on an output in Btu per hour (watts) equivalent to 50 percent of the manufacturer's rated input for solid-fuel-fired furnaces and 75 percent of the oil-input rate for combination oil-fired and solid-fuel-fired furnaces. Specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

43.4 Formulas derived from the information in 43.3 for computing the outlet air duct area are as follows:

Solid-Fuel-Fired Furnace –

Area ($inch^2$) = Btu per hour input x 0.00081

[Area (cm^2) = Watts input x 0.0000369]

Oil-Fired or Solid-Fuel-Fired Furnace –

Area ($inch^2$) = Btu per hour input x 0.00122

[Area (cm^2) = Watts input x 0.000054]

43.5 The test duct is to be rectangular, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar; however, the aspect ratio is not to exceed four to one. See Figure 43.1.

43.6 A thermocouple grid is to be located in each warm-air outlet duct as specified in Temperature Measurement, Section 50.

43.7 The cross-sectional area and shape of the air-inlet duct is to be equivalent to the cold-air inlet of the furnace.

43.8 The limit control, if furnished separately for mounting in a field-built plenum, is to be located as specified in the installation instructions furnished with the furnace.

TEST INSTALLATION FOR SUPPLEMENTARY CENTRAL FURNACES

44 General

44.1 A supplementary furnace intended for installation in conjunction with a gas- or oil-fired central furnace is to be installed in conjunction with a representative furnace (see 40.2). The installation of the two-furnace system is to be as described in Sections 40 – 43. Each furnace is to be installed with the clearances specified on its nameplate. The interconnecting air ducts shall be sized and installed in accordance with instructions provided with the supplementary furnace. The common outlet-air duct area is to be computed on the basis of the Btu-per-hour input rating (see 43.4) of the gas- or oil-fired central furnace. The thermocouple grid is to be located in the common outlet-air duct as specified in 50.8.

INSTRUMENTATION

45 Draft

45.1 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 plus or minus 0.0025 inch (0.064 mm). A gauge is to be checked for zero reading at the beginning and the end of each test.

46 Fuel Input

46.1 The fuel input rate to an oil burner is to be determined by a scale accurate to 0.01 pound (0.004 kg) or by a burette capable of the same resultant accuracy.

47 Power Measurement

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

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

48 Speed Measurement

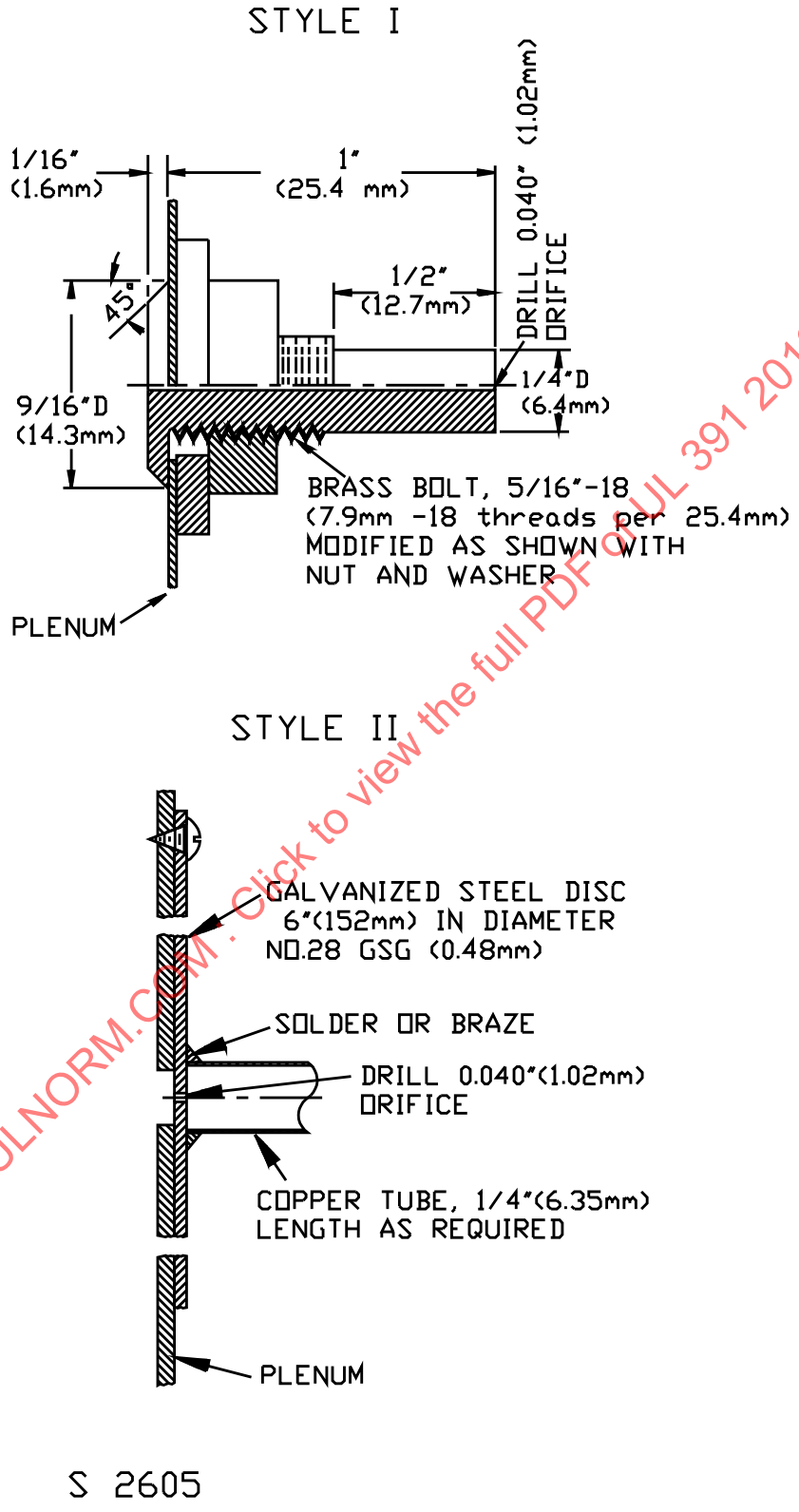
48.1 Mechanical or electronic means are to be used to measure the speed of a motor or of a mechanism driven by the motor. The load imposed by the counter is not to affect motor speed. A stroboscope is recommended for measuring speed of a motor of less than 1/8 horsepower (93 watts output).

49 Static Pressure

49.1 An inclined draft gauge with a pressure tap located as shown in Figure 43.1 is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of plus or minus 0.0025 inch (0.064 mm) and is to be capable of being read directly to 0.005 inch (0.13 mm).

49.2 The static pressure connection is to consist of one of the arrangements shown in Figure 49.1.

Figure 49.1
Static pressure pickup arrangements



50 Temperature Measurement

50.1 Temperatures are to be measured by thermocouples. However, the change-of-resistance method may be used to measure the temperature of motor windings or coils. The thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouple wire is to comply with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

50.1 revised September 17, 2013

50.2 Where thermocouples are used in the determination of temperatures in connection with the heating of electrical equipment, thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of indicating instrument are to be used whenever referee temperature measurements by means of thermocouples are necessary.

50.3 Thermocouples are to be placed on surfaces of the test enclosure at various locations as required to measure maximum temperatures during tests. Where the chimney connector passes through the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (150 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those specified in Table 57.1.

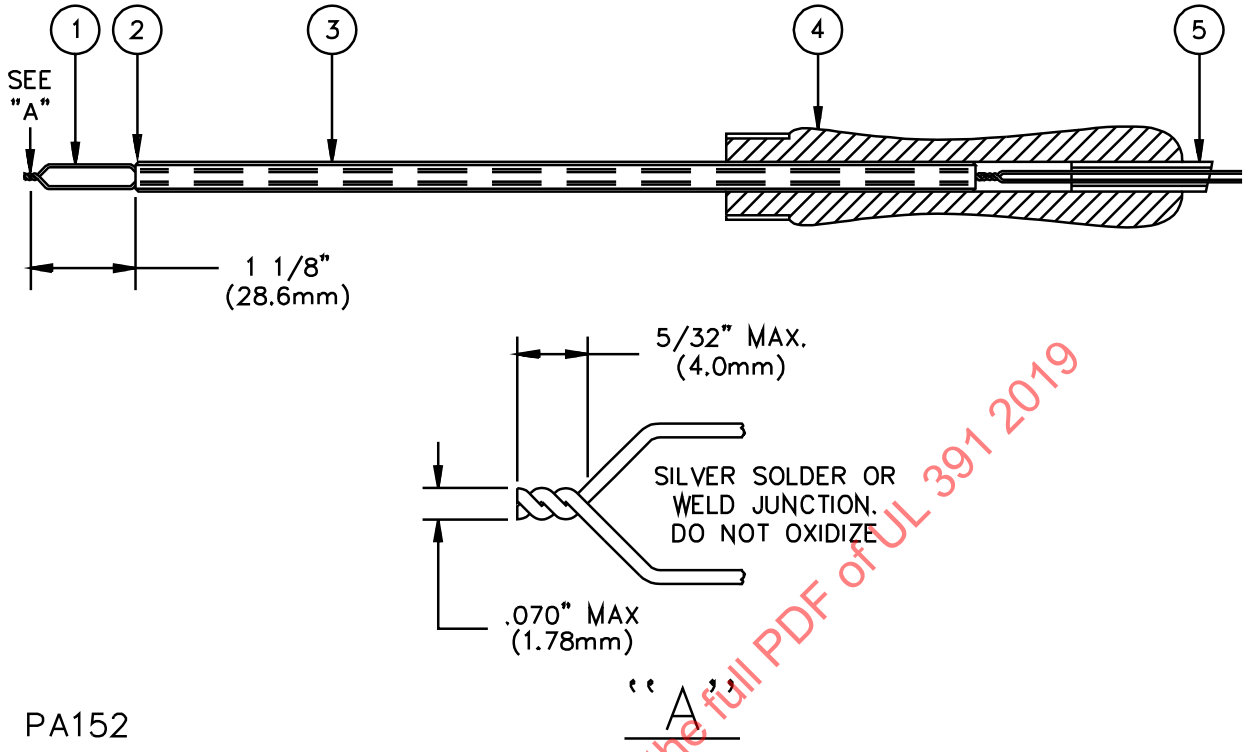
50.4 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material whose temperature is being measured. In most cases, thermal contact will result from taping or cementing the thermocouple in place; but where a metal surface is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

50.5 A thermocouple is to be secured to a wood surface by staples clipped over the insulated portion of the wire, and the tip of the wire is to be held in thermal contact with the surface by pressure-sensitive tape. However, where necessary, the thermocouple is to be applied to a surface of the furnace at a point of zero clearance.

50.6 A thermocouple may be cemented or taped to a surface not specified in 50.4 and 50.5 if thermal contact with the surface is maintained.

50.7 The flue-gas temperature is to be measured by a thermocouple, such as the one illustrated by Figure 50.1, inserted into the chimney connector as shown in Figure 50.2. 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 sealed in the position that allows maximum draft during all tests.

Figure 50.1
Standard thermocouple for flue-gas temperature



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

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

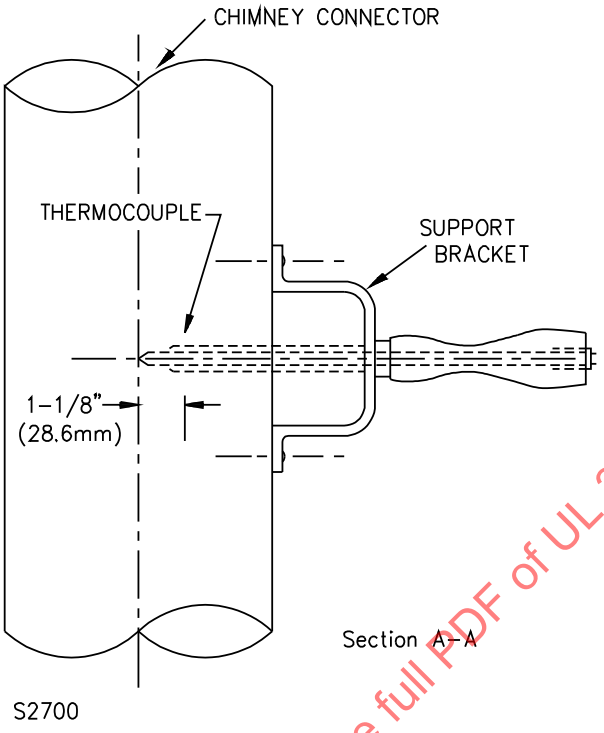
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

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

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

Figure 50.2
Flue gas thermocouple and support bracket



50.8 The outlet-air temperature in rectangular ducts connected to forced-air furnaces is to be measured by nine thermocouples of identical length and wired in parallel. The test-duct cross section is to be divided into three equal horizontal and three equal vertical areas, with a thermocouple located at the center of each of the nine areas thus obtained. The thermocouple grid is to be located in a plane perpendicular to the axis of air flow and at a position not more than 6 inches (150 mm) downstream from the location closest to the plenum where the direct path between any surface of the heat exchanger and any thermocouple is unobstructed. The duct is to extend at least 6 inches beyond the thermocouple grid. See Figure 43.1.

50.9 The inlet-air temperature is to be measured by a single thermocouple located in the center of the inlet duct.

50.10 The ambient temperature is to be measured by a thermocouple using wire not larger than 24 AWG (0.21 mm^2). The thermocouple is to be shielded from duct radiation and located on the lateral center 24 inches (610 mm) in front of the furnace and 24 inches above the floor of the test enclosure.

INITIAL TEST CONDITIONS

51 General

51.1 A furnace equipped with an air-circulating fan, the capacity of which is intended to be varied only by the installer, such as by using a belt-drive or a motor-speed control, is to be tested with the fan speed adjusted so that approximately the rated air delivery is obtained. This adjustment is to be maintained during all of the tests described in Sections 54 – 68.

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

51.3 If the results of a furnace test involving the operation of a limit control are likely to be affected by the temperature of the inlet air (see 50.9), the test is to be conducted under conditions that maintain the inlet-air temperature between 15.6 and 26.7°C (60 and 80°F).

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

51.5 Unless otherwise specified, a furnace is to be tested at the appropriate input potential specified in Table 51.1.

Table 51.1
Test voltages

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

51.6 A furnace equipped with an oil burner is to be fired at its rated Btu per hour (watts output), ±2 percent, with a grade of fuel for which the burner is rated. The draft of the flue collar is to be of a pressure recommended by the manufacturer. However, the draft is not to be more than 0.06-inch (1.5-mm) water column for burners fired at 5 gallons (18.9 L) per hour or less, nor more than 0.09-inch (2.3-mm) for burners fired at rates from 5 – 16 gallons (18.9 – 60.6 L) per hour.

52 Static Pressures for Tests

52.1 Table 52.1 defines the relation of furnace input to external static pressure, expressed in inches (mm) water column.

Table 52.1
Relation of furnace input to external static pressure

Output of furnace Btu per hour (W)[a]		External static pressure[b] inches (mm) water column
0 – 60,000	(23,500)	0.12 (3.65)
60,001 – 75,000	(23,500– 39,300)	0.15 (3.81)
75,001 – 150,000	(29,300 – 58,600)	0.20 (5.08)
150,001 – 280,000	(58,000 – 109,900)	0.25 (6.35)
280,001 or more	(190,900 –)	0.30 (7.62)

[a] For a combination oil-fired and solid-fuel-fired furnace, output is to be calculated as 75 percent of the rated Btu input of firing oil; for a solid-fuel-fired furnace, output is to be calculated as 50 percent of the manufacturer's rated input.

[b] For furnaces not equipped with air filters, add 0.08 inch (2.03 mm) to these values. A furnace may be tested at external static pressures in excess of those specified above, as recommended by the manufacturer.

53 Solid Fuels and Test Firing Procedures

53.1 General

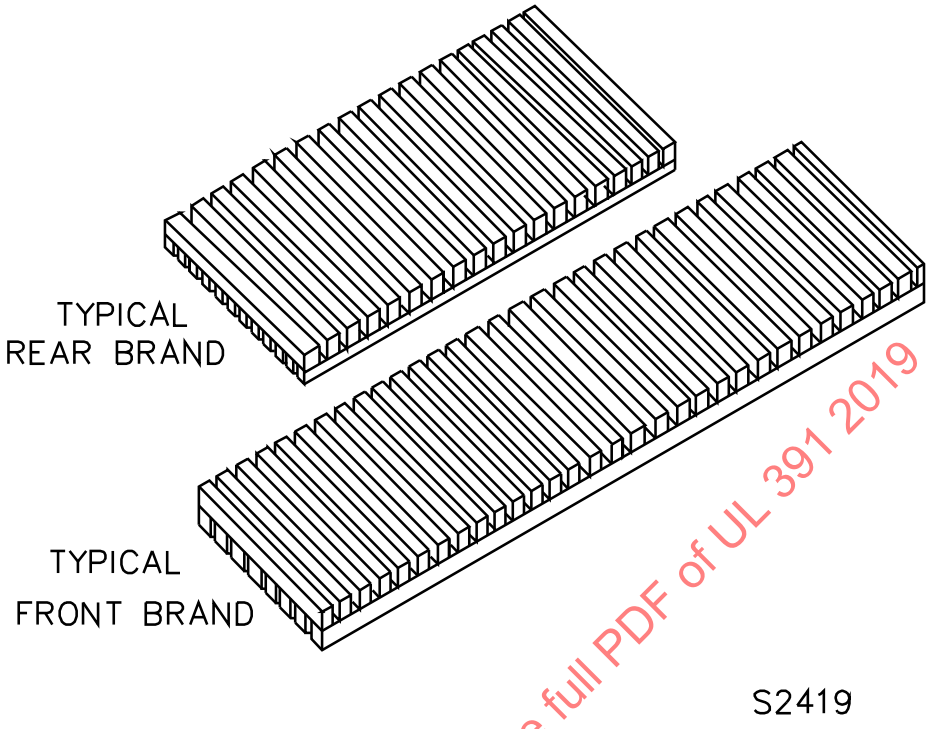
53.1.1 A furnace is to be fired with charcoal, firebrands, and fuel oil (if the furnace is equipped to fire oil), as designated in individual test sections.

53.1.2 The testing of a furnace with firebrands and charcoal covers the furnace for use with wood logs and coal. If a furnace is intended for use also with other types of solid fuels, such as biomass, sawdust, or corncobs, or is specifically intended to burn only other types of solid fuels, tests specified in Sections 54 – 59 may also be required burning such fuels in accordance with the instructions included with the furnace.

53.2 Firebrands

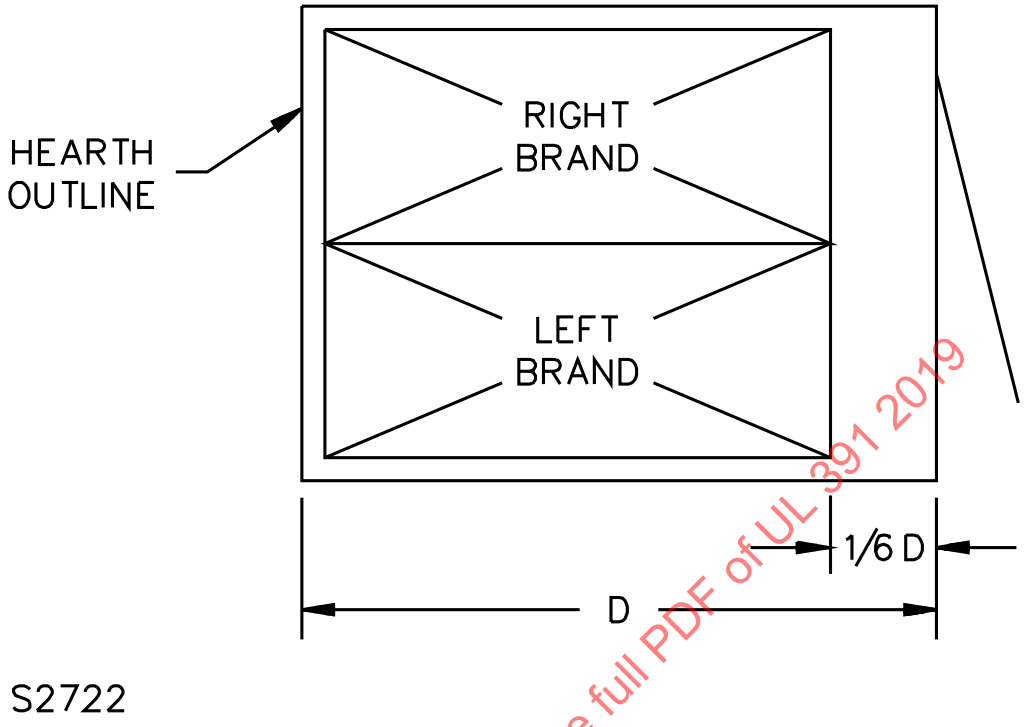
53.2.1 A firebrand is to be prepared in strips as illustrated in Figure 53.1 from dry (moisture content of 19 percent or less) strips of Douglas fir. Each strip is to be 3/4 by 3/4 inch (19.1 by 19.1 mm) in cross section and weigh 0.020±0.002 pound per cubic inch (554.0 ±55.4 kg/mm^3). The strips are to be placed 1 inch (25.4 mm) apart, on centers providing a 1/4-inch (6.35-mm) space between strips. The brands are to be conditioned in an oven at 105 – 150°F (40.5 – 66°C) for at least 16 hours prior to being burned, and the conditioned brands are to be used within 3 hours of removal from the oven.

Figure 53.1
Brands



53.2.2 Each brand is to have an area in the plan view equal to at least one-third of the total grate or hearth area. Its dimensions are to permit the front edge of the brand to be positioned horizontally in the hearth, as illustrated in Figure 53.2, and to be recessed from the feed door of the room-heater combustion chamber a distance of approximately one-sixth of the maximum grate or hearth depth.

Figure 53.2
Typical relation of brands to grate or hearth



53.2.3 Firebrands are to be fed to the fire at a rate of one brand every 7-1/2 minutes. If an ash pan is provided, it is to be emptied at 15 minute intervals. If coals build up in the fire chamber, they are to be raked level before adding the next brand. The rate of fueling is not to cause the height of fuel buildup to exceed either the top of the fire-chamber opening or the level designated by the manufacturer.

53.2.4 To produce flash-firing conditions, eight brands stacked four deep are to be added to the fire after equilibrium temperatures have been obtained by firing as described in 53.2.3.

53.2.5 Other than for the flash-fire test, whenever the use of firebrands is specified, hardwood logs may be used initially to bring the furnace to equilibrium temperature conditions (see 58.2.1). Once the equilibrium conditions are established, the firing is to include the use of firebrands in accordance with 53.2.3. If it is determined that the equilibrium temperatures produced by firing of hardwood logs are at least as high as those produced by the use of firebrands, the tests may be continued using the hardwood logs, maintaining a fully loaded fire chamber.

53.3 Charcoal

53.3.1 For test firings with charcoal, the furnace is to be loaded to a depth of approximately 6 inches (152 mm) with charcoal briquettes[a] formed in the shape of a 2.0- by 1.9-inch (50- by 48-mm) square pillow having rounded edges and a maximum thickness of 1.2 inches (30 mm). As such, briquettes are to have a count weight of 17 per pound (37 kg), a heat content (dry basis) of 11,500 Btu per pound (26,750 J/kg), and a moisture content of 5 percent.

[a]A type suitable for this test is manufactured by the Kingsford Company, P. O. Box 493, Pleasanton, California 94566.

53.3.2 Charcoal briquettes are to be added at 7-1/2 minute intervals to the fire in amounts that will maintain a 6-inch (152-mm) bed of fuel. The fuel is to be poked and stirred in an effort to maintain a maximum intensity of burning. If an ash pan is provided, it is to be emptied every 7-1/2 minutes.

53.3.3 Throughout the firing tests, spillage of combustion products or flame from the furnace meets the intent of the requirement only during fueling, in the form of sporadic wisps of smoke and flickers of flame not projecting more than 6 inches (152 mm) from the plane of the fuel-loading opening.

INITIAL TESTS

54 Combustion Test – Oil Burner and Furnace

54.1 A combination oil-fired and solid-fuel-fired furnace shall be capable of functioning uniformly as intended when firing oil without producing more smoke than anticipated after installation and adjustment in accordance with the manufacturer's instructions.

54.2 When the furnace is fired with fuel oil at rated input and operated under the conditions specified in the Operation Test, Section 55, until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established, the smoke in the flue gases shall not exceed that indicated by:

a) A No. 2 spot for furnaces firing a distillate fuel; and

b) A No. 4 spot for furnaces firing a residual-type fuel, as indicated on the Shell-Bacharach scale with the Model RDC smokemeter.

54.3 The thermal efficiency of the furnace shall be at least 75 percent when the furnace is tested as specified in 54.2.

55 Operation Test

55.1 When a forced-air central furnace is operated in the intended manner:

a) The furnace shall not produce a circulating-air temperature rise in excess of 100°C (180°F);

b) A limit control shall not function to reduce the rate of solid-fuel burning or shut off the oil burner, if the furnace is so equipped; and

c) The electrical input shall not exceed the value marked on the product nameplate.

55.2 When a supplementary central furnace is operated in the intended manner in conjunction with a representative furnace (see 44.1) and each is firing separately from or simultaneously with the other:

a) Neither the firing of the supplementary furnace nor the firing of the representative furnace nor the simultaneous firing of the two furnaces shall produce a circulating-air temperature rise in excess of 72°C (130°F);

b) A limit control shall not function to reduce the rate of solid-fuel burning or shut off the oil or gas burner of the representative furnace; and

c) The electrical inputs shall not exceed the value marked on the product nameplate.

55.3 A forced-air central furnace is considered to comply with the requirements of 55.1 and a supplementary central furnace is considered to comply with the requirements of 55.2 if:

$$T_2 - T_1 \leq T_L - 70°F\ (21°C)$$

in which:

T_1 = *inlet-air temperature (see 50.9);*

T_2 = *outlet-air temperature (see 50.8);*

T_L = *outlet-air temperature at which the limit control functions during the Limit Control Cutout Test, Section 56.*

55.4 Each limit control is to be bypassed to permit continued operation during this test. The furnace is to be placed in operation firing brands in accordance with 53.2.3 until an equilibrium outlet-air temperature is obtained. A thermostatic damper control and damper mechanism that complies with 36.2.4 and 36.2.5 is to be adjusted to the maximum setting allowed by its fixed stop and is to be permitted to function to control the rate of burning. A damper or shutter that is manually operated or that does not comply with 36.2.4 and 36.2.5, except as indicated in 55.6, is to be fixed in the fully open position. An operating control provided to comply with the requirements of 36.4.1(a) is to be permitted to function to control the rate of burning.

55.5 The warm-air duct outlet of a forced-air furnace is to be restricted symmetrically to maintain in the supply plenum an external static pressure of the appropriate value indicated in Table 52.1.

55.6 For combination oil-fired and solid-fuel-fired furnaces the test is to be repeated firing oil in one trial and, in another trial, oil and brands simultaneously. For supplementary furnaces the test is to be repeated firing fuels in the supplementary and central furnaces simultaneously. During the simultaneous firing of two fuels, thermostatic or other operating controls are to be permitted to function to cause the reduction of firing or shutoff of either fuel.

55.7 During the test, the total furnace electrical input and the electrical input of all components, except those having a pilot duty rating only, are to be measured.

55.8 When an appliance incorporates a general use receptacle connected to the same branch circuit as that supplying the appliance. The added load that the receptacle imposes on the appliance – 80 percent of the current rating of the receptacle – and its supply connection shall be taken into consideration when conducting the tests in 55.1 – 55.7.

Exception: When the receptacle is marked for a specific load in accordance with 71.8, the marked load is to be used in calculating the total power or current input.

56 Limit Control Cutout Test

56.1 General

56.1.1 When adjusted to the maximum setting allowed by a fixed stop, a limit control shall prevent a furnace from delivering air at a temperature in excess of:

a) 121°C (250°F), for a solid-fuel-fired furnace or a combination oil-fired and solid-fuel-fired central furnace.

b) 93°C (200°F), for a solid-fuel-fired, supplementary central furnace. Also, the operating control shall function at an outlet-air temperature lower than 93°C.

56.2 Combination oil-fired and solid-fuel-fired central furnaces

56.2.1 The limit control is to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting.

56.2.2 The furnace is to be placed in operation firing oil. The outlet-air duct is to be restricted symmetrically until the limit control functions. The restriction is to be removed to permit return of the furnace to the intended operation. The outlet-air duct is then to be restricted to obtain an outlet-air temperature 5.6°C (10°F) below that which will cause the limit control to function. If this restriction results in a static pressure greater than specified in Table 52.1, the restriction is to be relaxed to obtain the appropriate static pressure specified in Table 52.1. No further adjustment of the outlet-air duct restriction is to be made throughout this test.

56.2.3 A preliminary test is to be made to determine the extent to which the cold-air inlet must be blocked to produce the outlet-air temperature that will cause the control to function.

56.2.4 The restriction on the cold-air inlet is then to be relaxed to the degree necessary to permit continuous operation of the furnace until equilibrium outlet-air temperature is obtained.

56.2.5 The cold-air inlet is then to be gradually restricted for a period of 10 minutes until the limit control acts to shut off the main burner flame. The outlet-air temperature (T_L) is to be measured at the instant the limit control functions.

56.2.6 The furnace is to be allowed to operate until it recycles on the limit control. At the instant the limit control functions, the outlet-air temperature (T_L) is again to be measured.

56.2.7 The furnace is to be placed in operation again, simultaneously firing fuel oil and brands in accordance with 53.2.3 until equilibrium outlet-air temperature is obtained. Reduced firing of the solid fuel complies with the requirements if caused by the functioning of an operating control. The outlet-air duct then is to be gradually and symmetrically restricted over a period of at least 10 minutes until the limit control functions or until the static pressure specified in Table 52.1 is obtained before the limit control functions. If the limit control does not function at this time, the restriction of air flow is to be continued by gradually and symmetrically restricting the cold-air inlet until the limit control functions.

56.2.8 The outlet-air temperature (T_L) is to be measured at the instant the limit control functions.

56.3 Solid-fuel-fired central furnaces

56.3.1 A limit control relied upon to prevent excessive temperature is to be adjusted to the maximum setting allowed by its fixed stop.

56.3.2 The furnace is to be placed in operation firing brands in accordance with 53.2.3, with any manual or thermostatic operating control adjusted for maximum firing until equilibrium outlet-air temperature is obtained. The outlet-air duct is then to be gradually and symmetrically restricted over a period of at least 10 minutes until the limit control functions or the static pressure specified in Table 52.1 is obtained. If the specified static pressure is obtained before the limit control functions, reduction of air flow is to be continued by gradually and symmetrically restricting the cold-air inlet until the limit control functions.

56.3.3 The outlet-air temperature (T_L) is to be measured at the instant the limit control functions.

56.4 Supplementary central furnaces

56.4.1 Limit and operating controls provided for compliance with 36.3.1 are to be adjusted to the maximum settings allowed by their fixed stops. The limit control in the gas- or oil-fired central furnace with which the supplementary furnace is installed is to be bypassed to allow operation until the limit or operating control of the supplementary furnace functions to shut off the gas or oil burner.

56.4.2 The furnace is to be placed in operation firing brands in accordance with 53.2.3, with any manual or thermostatic control adjusted for maximum firing until equilibrium outlet-air temperature is obtained. The test is to be conducted as described in 56.3.2. The operating control is to be bypassed immediately after it functions in order to allow continuation of the test until the limit control functions.

56.4.3 The test is to be repeated by firing brands in the supplementary furnace at the same time that gas or oil is fired in the central furnace.

56.4.4 The outlet-air temperature is to be measured at the instants that the operating and limit controls function.

TEMPERATURE TESTS

57 General

57.1 When a furnace is tested in accordance with Sections 57 – 61, no part shall attain a temperature sufficient to:

a) Impair the effectiveness of required corrosion protection;

b) Impair operation of safety controls;

c) Impair 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 cause the furnace to present a risk of fire, electric shock, or injury to persons.

This requirement applies equally to a supplementary furnace and to a furnace that is fired with solid fuel during a loss of electrical power (58.3.1). The temperature rises at specific points shall not exceed those specified in Table 57.1 except as permitted in the footnotes to the table.

Table 57.1
Maximum temperature rises

Device or Material	Column 1		Column 2	
	Degrees		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 (178 mm) 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 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	95	171	140	252
b. In totally enclosed motors –				
Thermocouple or resistance method	100	180	140	252
4. Class B insulation on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) 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. Field-wiring terminals[c]	50	90	65	117
2. Points on or within terminal box which may be in contact with field wiring[c]	35	63	60	108
3. Capacitors				
Electrolytic type[d]	40	72	(Not specified)	
Other types[e]	65	117		
4. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated windings –				
Thermocouple method	65	117	115	208
b. Class 130 insulated windings –				
Thermocouple method	85	153	140	252
5. Sealing compounds	40°C (104°F) less than its melting point			

Table 57.1 Continued on Next Page

Table 57.1 Continued

Device or Material	Column 1		Column 2	
	Degrees		Degrees	
	C	F	C	F
6. Transformer enclosures[b] –				
a. Class 2 transformer	60	108	85	153
b. Power and ignition transformers	65	117	90	162
C. Insulated Conductors[f,g]				
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[f]			
D. Electrical Insulation – General[g]				
1. Class C electrical insulation material	Not specified			
2. Class H (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 of where deterioration will result in a risk of fire or electric shock	125	225	150	270
5. Thermoplastic material	25°C (77°F) less than its temperature rating			
6. Varnished cloth insulation	60	108	85	153
E. Metals				
1. Aluminum Alloys				
a. 1100(2S)	183	330	239	430
b. 3003(3S)	239	430	294	530
c. 2014, 2017, 2024, 5052[h]	294	530	350	630
2. Aluminum-coated steel, heat-resistant type[i]	572	1030	708	1275
3. Carbon steel-coated with type A19 ceramic	572	1030	628	1130
4. Galvanized Steel[j]	267	480	350	630
5. Low-carbon steel, cast iron[k,l,m]	461	830	517	930
6. Stainless Steel	686	1235	767	1380
Types 302, 303, 304, 321, 347	667	1200	748	1345
Type 309S	867	1560	950	1705
Type 310, 310B	894	1610	975	1755
Type 430	728	1310	808	1455
Type 446	961	1730	1042	1875
F. General				
1. Air Filter	50	90	97	175
2. Flue gases[n]	517	930	738	1330
3. Operating knobs, handles, and levers[o]				

Table 57.1 Continued on Next Page