UL 307A

STANDARD FOR SAFETY

Liquid Fuel-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles

UL Standard for Safety for Liquid Fuel-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles, UL 307A

Ninth Edition, Dated July 24, 2018

Summary of Topics

This revision of ANSI/UL 307A 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.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 10, 2018.

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

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UL 307A

Standard for Liquid Fuel-Burning Heating Appliances for Manufactured Homes and Recreational Vehicles

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The most recent designation of ANSI/UL 307A as a Reaffirmed American National Standard (ANS) occurred on October 8, 2018. 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 the following types of liquid fuel-burning appliances intended for installation in manufactured homes and recreational vehicles, including travel trailers, camping trailers, truck campers, motor homes, and park trailers.

a) Direct vent system type heating appliances that provide for complete separation between the indoor atmosphere and combustion system, including the air supplied for combustion by inherent design of the furnace and its venting system.

b) Vented heating appliances other than of the direct vent system type that provide for separation between the indoor atmosphere and combustion system, including the air supplied for combustion by an installation method. Such appliances can be used only in manufactured homes, not in recreational vehicles.

1.2 Requirements for the installation and use of these appliances are included in the following standards:

a) For Manufactured Homes – The Department of Housing and Urban Development Manufactured Home Construction and Safety Standards, Title 24 CFR, Part 3280, 1994.

b) For Recreational Vehicles – The National Fire Protection Association Standard for Fire Safety Criteria for Recreational Vehicles, NFPA 501C-1993.

1.3 An appliance constructed to burn liquid fuel or gas and a liquid fuel burning appliance constructed and designed so that it may be converted to burn gas by installation of a specific gas burner shall also comply with the applicable requirements in the Standard for Gas-Burning Heating Appliances For Manufactured Homes and Recreational Vehicles, UL 307B.

1.4 The term ″appliance″ as used in this standard refers to any heating appliance covered by this standard, such as a warm air central furnace, a wall furnace, a heating boiler, and a water heater.

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 is not required to comply with a specific requirement that:

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

b) Is superseded by a requirement in this standard.

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

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

3 Units of Measurement

3.1 Unless otherwise indicated, all voltage and current values mentioned in this standard are rms values.

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

4 Glossary

4.1 For the purpose of this standard, the following definitions apply.

4.2 ANTIFLOODING DEVICE – A primary safety control that causes fuel flow to be shut off upon a rise in fuel level. It is intended to operate to shut off the fuel flow before excessive fuel can be discharged into the appliance.

4.3 APPLIANCE FLUE – The flue passages within the appliance.

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

4.5 BURNER:

a) Automatically Lighted – One where fuel to the main burner is turned on and ignited by operation of an automatic control.

b) Manually Lighted – One where fuel to the main burner is turned on only by hand and ignited under supervision.

c) Mechanical-Atomizing Type – A power-operated burner that prepares and delivers the fuel and all or part of the air by mechanical process in controllable quantities for combustion. Some examples are air-atomizing, high- and low-pressure atomizing, horizontal-rotary atomizing, vertical-rotary atomizing, and vertical-rotary wall-flame burners.

d) Mechanical-Draft Type – A burner that includes a power driven fan, blower or other mechanism as the principal means for supplying air for combustion.

e) Natural-Draft Type – A burner that depends principally upon the natural draft created in the chimney to induce into the burner the air required for combustion.

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

4.6 CENTRAL FURNACE – A self-contained appliance for heating air by transfer of heat of combustion through metal to the air, and designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

4.7 CONTROL –

a) LIMIT – An automatic safety control responsive to changes in liquid level, pressure, or temperature and intended to be set beyond the operating range for limiting the operation of the controlled equipment.

b) OPERATING – A control, other than a safety control or interlock, to start or regulate burner firing according to demand and to stop or regulate firing on satisfaction of demand or upon reaching the intended temperature or pressure in the appliance being fired.

c) PRIMARY SAFETY – The automatic safety control intended to prevent abnormal discharge of fuel at the burner in case of ignition failure or flame failure.

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

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

4.8 DIRECT VENT SYSTEM APPLIANCE – An appliance which is constructed so that all air supplied for combustion, the combustion system of the appliance, and all products of combustion are completely isolated from the atmosphere of the space in which it is installed.

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

4.10 ELECTRICAL CIRCUITS –

a) HIGH-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage power limited circuit.

b) LOW-VOLTAGE (POWER LIMITED) CIRCUIT – A circuit involving a potential of not more than 30 volts alternating current, rms 42.4 volts direct current or ac peak, and supplied by:

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

2) Is limited to a maximum of 100 volt-amperes. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

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

4.11 FUEL OIL – Any hydrocarbon oil defined by Specifications for Fuel Oils, ASTM D396-1992.

4.12 FULL DRAIN – As applied to tanks, means the tank is emptied through its fuel-feed outlet at the bottom of the tank.

4.13 MANUFACTURED HOME – A factory built home constructed in accordance with the Department of Housing and Urban Development Manufactured Home Construction and Safety Standards, Title 24 CFR, Part 3280-1994.

4.14 PIPING – The word ″piping″ where used in this standard refers to either pipe or tubing or both.

a) PIPE – Refers to rigid metal pipe.

b) TUBING – Refers to semirigid metal tubing.

4.15 RECREATIONAL VEHICLE – A vehicular type unit primarily designed as temporary living quarters for recreational, camping, or travel use, that either has its own motive power or is mounted on or drawn by another vehicle. The basic types are:

a) Camping Trailer – A vehicular portable unit mounted on wheels and constructed with collapsible partial sidewalls that fold for towing by another vehicle and unfold at the campsite to provide temporary living quarters for recreational, camping, or travel use.

b) Motor Home – A vehicular unit designed to provide temporary living quarters for recreational, camping, or travel use, built on or permanently attached to a self-propelled motor vehicle chassis or on a chassis cab or van that is an integral part of the completed vehicle.

c) Park Trailer – A vehicular unit:

1) Built on a single chassis, mounted on wheels,

2) Designed to provide seasonal or temporary living quarters, and may be connected to utilities necessary for operation of installed fixtures and appliances,

3) Constructed to permit setup by user, using only hand tools, that may include lifting, pulling, and supporting devices, and

4) Having a gross trailer area not exceeding 400 square feet (37.2 m^2) when in the setup mode.

d) Travel Trailer – A vehicular portable unit, mounted on wheels, designed to provide temporary living quarters for recreational, camping, or travel use and of such a size or weight as not to require special highway movement permits when towed by a motorized vehicle, and with a living area of less than 220 square feet (20.4 m^2), excluding built-in equipment (such as wardrobes, closets, cabinets, kitchen units or fixtures) and bath and toilet rooms.

e) Truck Camper – A portable unit constructed to provide temporary living quarters for recreational, camping, or travel use, consisting of a roof, floor, and sides, and designed to be loaded onto and unloaded from the bed of a pickup truck.

4.16 ROOF JACK – A factory-made assembly for conveying flue gases through a roof and which includes a flue, insulating means, flashing, and cap.

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

a) Cleaning or replacing nozzles, atomizers and pilots.

b) Setting ignition electrodes.

c) Cleaning strainers or replacing strainer or filter elements.

d) Resetting safety control.

e) Replacing igniter cable.

f) Replacing or cleaning air filters.

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

4.19 VALVE –

a) BURNER-INPUT CONTROL – An automatic-control valve for regulating burner input.

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

c) MANUAL MAIN-FUEL SHUTOFF – A manually operated valve in the fuel line for the purpose of completely turning on or shutting off the fuel supply to the burner.

d) SAFETY SHUTOFF – A control valve that is automatically closed by the safety control system or by an emergency device. Such a valve may be of the automatic or manually opened type.

4.20 VENTED APPLIANCE – An indirect-fired appliance provided with means to accommodate a chimney or a roof-jack connector.

4.21 WATER HEATER – An appliance for supplying hot water for domestic or commercial purposes other than for space heating. Categories of water heaters are:

a) DOMESTIC STORAGE – A water heater that heats and stores water at a thermostatically controlled temperature for delivery on demand. Input rating may not exceed 200,000 British thermal units (Btu) per hour (59 kW).

b) COUNTER TYPE –

1) Flush Type – A vented automatic storage water heater with flat sides, top, front and back, which is primarily for flush installation in conjunction with or adjacent to a counter 36 inches (0.9 m) high, wherein the front and top of the heater casing are exposed.

2) Recessed Type – A vented automatic storage water heater with flat sides, top, front and back, which is for flush installation beneath a counter 36 inches (0.9 m) high, wherein the front of the heater casing is exposed.

3) Concealed Type – A vented automatic storage heater which is for flush installation beneath a counter top 36 inches (0.9 m) high, wherein the entire heater is concealed.

CONSTRUCTION – ALL APPLIANCES

5 Materials

5.1 Fuel-confining parts or operating parts, if failure of the parts will allow unsafe leakage of fuel or unsafe operation or prevent a safety device from functioning, shall be of metal having a melting point (solidus temperature) of not less than 950°F (510°C) and a tensile strength of not less than 10,000 pounds per square inch (psi) (68.9 MPa) at 400°F (204°C). Parts shall not sag, distort, melt, or show leakage of fuel during any of the tests specified herein. Piping shall be made of iron, steel, copper, or brass.

6 Assembly

6.1 An appliance shall be factory built as a group assembly and shall include all the essential parts necessary for its intended function when installed as intended. An appliance may be shipped as two or more subassemblies. See 6.8.

6.2 Appliances for manufactured homes supplying a heating medium, that is, air, steam, or water, through ducts or pipes only may be constructed to provide complete separation of the combustion system from the atmosphere of the manufactured home when the appliances are installed as intended in accordance with the manufacturer's instructions furnished with the appliance. Other types of appliances for manufactured homes and all appliances for recreational vehicles shall provide for complete separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle by inherent construction of the appliance. Air-intake assemblies and flue-gas outlet assemblies conforming to these requirements (see Sections 9 and 20, respectively) shall be provided as components of these appliances. See 83.3.

6.3 The complete separation of the combustion system of a fuel-burning appliance from the atmosphere of a manufactured home or recreational vehicle is obtained by the appliance being constructed and installed so that:

a) All air supplied for combustion,

b) The combustion system of the appliance, and

c) All products of combustion are completely isolated from the atmosphere of the manufactured home or recreational vehicle.

An appliance that provides such complete separation of the combustion system of the atmosphere of the manufactured home or recreational vehicle by inherent construction is referred to as a ″direct vent system appliance.″

6.4 If such isolation in a manufactured home only is obtained by installation of the appliance in a compartment isolated from the indoor atmosphere, doors, panels, and any other access openings serving the enclosure are to communicate only to the outdoors.

6.5 Conformance of a direct vent system appliance with 6.3 is not intended to preclude designs including parts which, when opened or removed, may permit the combustion system to communicate with the atmosphere of the manufactured home or recreational vehicle, provided:

a) The appliance is not operable when such part is opened or removed,

b)Compartment doors or access panels are hinged to the compartment in a manner not likely to permit or invite their removal, and an interlock switch is provided that will automatically open the circuit when the door or panel is opened and that will automatically close the circuit when the door or panel is closed – the construction of the interlock switch is such that service personnel can manually close the circuit for servicing but the switch will automatically return to its intended position when the door or panel is closed, that is, be in a position to automatically open the circuit when the door or panel is reopened – and the interlock switch is wired in the power circuit to the appliance or in the combustion-detector circuit of the primary safety control, or

c) A combination of two or more compartment doors or access panels and interlock switches that provide protection equivalent to the preceding are furnished, in which case only one of the doors or panels need be hinged to the compartment.

6.6 A burner compartment of an appliance intended to conform to the requirements of 6.3 or 6.4 by following the criteria outlined in 6.5 (a) and (c) shall include a marking that can be seen when the door or access panel is open. The marking shall be in contrasting colors and shall contain the word ″WARNING″ and the following or equivalent: ″Risk of Electric Shock – This Compartment Must Be Closed Except When Servicing.″ The word ″WARNING″ shall be in letters not less than 19/64 inch (7.5 mm) high, and the balance of the statement in letters not less than 7/32 inch (5.6 mm).

6.7 An appliance may include an opening, communicating with the combustion system, needed for the user to light or start the appliance, provided the opening does not exceed a 28 square inch (181 cm^2) cross-sectional area and has an attached cover plate. The cover plate is to be self-closing and equipped with a means such as a latch or spring to hold it firmly in the closed position. The cover plate shall be clearly marked with a statement equivalent to ″Keep Closed When Appliance Is In Service.″ The marking shall be in letters not less than 5/32 inch (3.9 mm) high. A manual reset shall be resettable without dismantling the appliance or removing any part of it if such dismantling or removal nullifies the complete separation of the combustion system from the atmosphere of the manufactured home or recreational vehicle.

6.8 Air-intake assemblies and flue-gas outlet assemblies for direct vent system appliances shall be an integral part of the appliance, or each assembly shall be constructed for direct attachment to the appliance.

6.9 An appliance, if not assembled by the manufacturer as a unit, shall be arranged in as few subassemblies as practicable. Each subassembly shall be capable of being incorporated readily into the final assembly without requiring alteration, threading, welding or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe installation or operation of the appliance, shall be arranged and constructed to permit them to be incorporated into the final assembly, without need for alteration and alignment, only in the correct relationship with each other; or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

6.10 A radiation shield or baffle employed for limiting temperatures shall be assembled as part of the appliance; or be part of a subassembly that must attach to the appliance for its intended operation; or be such that the appliance cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

6.11 An appliance shall be such that, for any intended installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to prevent unsafe temperatures is not required.

6.12 An appliance for recessed, horizontal, through-the-wall, alcove, or closet installation shall provide for maintaining the minimum clearance required between the bottom, sides and back of the appliance and between concealed surfaces of the wall or partition in which or to which the appliance is to be installed. Spacers shall be of such strength and bearing surface as to maintain required clearance from such construction.

6.13 Appliances for alcove or closet installation, such as upflow and downflow central furnaces, and boilers, are considered to conform to 6.12, if spacers are located at least at one level to provide essentially continuous interference with adjoining construction as done, for example, by an extended base or support. Appliances for recessed installation in an interior wall or through an outside wall may require spacers at more than one level, or more than one spacer on each surface of the appliance, to maintain the required clearance.

6.14 Integral spacers, where required on the appliance, shall be of such strength and bearing surface as to maintain the required clearance. A sheet steel spacer shall have a minimum thickness of 0.032 inch (0.81 mm) unless equivalent strength and rigidity are obtained with lesser thickness. A spacer shall be attached to the appliance by welding, riveting, or equally permanent means.

6.15 An appliance for recessed, alcove, or closet installation shall be such that no portion of the products of combustion nor any portion of the heated circulating air or air from the space being heated will be discharged into spaces within walls, floor, or ceiling. Openings in the jacket, top or sides through which the chimney or vent connector extend shall afford compliance with this requirement.

6.16 A constant level valve assembly, not enclosed within the appliance casing nor otherwise protected, shall withstand a load of 100 pounds (45 kg) when tested as described in 6.17, without altering its position by more than 3 degrees in any horizontal or vertical plane.

6.17 The valve is to be joined to the appliance as intended and fuel lines integral with the appliance attached. A 100 pound (45 kg) weight or load is to be applied uniformly without impact to the main body of the valve assembly. Successive applications of the load are to be made vertically and horizontally in any direction. Upon removal of the load after each application, the position of the valve assembly with respect to the appliance is to be within the limits specified in 6.16.

6.18 An appliance equipped with a vaporizing burner shall be such that, when the appliance is level, the minimum distance between the designed maximum oil level in the burner maintained by the primary safety control and the level of the lowest point at which overflow may occur is not less than 3/4 inch (19.1 mm).

6.19 Parts, when adjustable or movable, shall be provided with locking devices to prevent accidental shifting.

6.20 Screws or bolts used to attach parts which are detached for care or servicing of the appliance shall be capable of holding upon the application of the torques indicated in Table 6.1 after removal and replacement.

Table 6.1
Maximum torque requirements for screws

Screw size	(mm)	Torque, pound-inches (N·m)	
No. 8	(4.2)	20	(2.3)
No. 10	(4.8)	25	(2.8)
1/4 inch	(6.4)	100	(11.3)
5/16 inch	(7.9)	200	(22.6)
3/8 inch	(9.5)	350	(39.5)
7/16 inch	(11.1)	550	(62.1)
1/2 inch	(12.7)	800	(90.3)
9/16 inch	(14.3)	1200	(135.5)

6.21 Parts of an appliance requiring attention, manipulation, or adjustment in usage shall be accessible.

6.22 Bolts, nuts, screws, except sheet-metal screws, and other threaded parts used in the general assembly of the appliance shall have threads conforming to the Standard for Unified Inch Screw Threads, ANSI B1.1-1989.

6.23 The construction of an appliance shall be such as to prevent products of combustion from coming in contact with thermal insulation.

6.24 Sheet steel parts of the appliance, except where otherwise specified in these requirements, shall have a minimum thickness of 0.013 inch (0.33 mm) if uncoated or 0.016 inch (0.41 mm) if galvanized. This applies to parts such as radiation shields and liners not exposed to combustion products, air intake tubes, and the like, unless greater strength and rigidity are required for the application.

6.25 A removable cover for an access opening that maintains, with the cover closed, required separation between the combustion system and the atmosphere of the manufactured home or recreational vehicle, and a removable flue collector box, shall fit tightly and shall, together with any gasket material:

a) Be made of a material rated for the temperature to which it is exposed,

b) Show no evidence of deterioration or damage as a result of tests of the appliance, and

c) Be formed and cut to prevent parts from blocking air openings of the burner(s) and pilot.

7 Accessibility for Servicing

7.1 An appliance shall be constructed to afford accessibility to those parts and controls requiring attention, manipulation, or adjustment in usage.

7.2 An appliance shall be built to allow cleaning of parts such as interior surfaces of burners, heating surfaces in contact with combustion products, fuel inlet, and oil strainers, without major dismantling of the appliance or removal of those parts required by 6.9 to be factory assembled.

7.3 The removal of access panels, burners, caps, plugs, and the like, specifically constructed to permit ready removal and replacement for servicing, are not considered major dismantling as described by 7.2.

7.4 Accessibility achieved with the use of simple tools shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the appliance is installed as recommended by the manufacturer. The arrangement of parts in the assembly removed for servicing shall be such that their restoration, following removal, will not necessitate realignment to secure their proper relationship with other parts of the assembly. Special equipment that may be required for servicing to be done by the operator shall accompany the appliance to the user.

7.5 A forced air heating appliance intended to be connected to a supply duct(s) may include means for measuring static pressure developed within the appliance casing. Such connection shall consist of a pipe or tubing connector fitting with a removable cap or plug and shall be located in the warm air outlet end of the appliance and be accessible after the appliance is installed in accordance with the manufacturer's instructions.

Exception: The cap or plug need not be provided if the orifice in the appliance casing is 0.040 inch (1.02 mm) in diameter or less. See Figure 47.1.

7.6 The heads and nuts of bolts, and the threads of screws, which must be removed to permit the removal of clean-out plates shall not be placed where they are in contact with flue-gases.

Exception: Bolts made of Type 430 stainless steel or material equally resistant to heat and corrosion and brass nuts are exempt from this requirement.

7.7 The flue-gas passageways of air-heating appliances shall be accessible for cleaning when:

a) The products of combustion are drawn below the level of the burner.

b) The temperature of the combustion products is less than 250°F (121°C) when the appliance is operated within ±2 percent of the manufacturer's Btu per hour (W) input rating, or

c) The width of any flue-gas passage is less than 1-1/2 inches (38.1 mm).

8 Burner Equipment

8.1 An oil burner for a liquid fuel-burning appliance shall conform to the applicable requirements included in the Standard for Oil Burners, UL 296.

8.2 A burner or part that at any time contains an open pool of fuel, a semienclosed valve, or an integral tank shall be of splash-proof construction. The burner or part shall be such that, when at rest, fuel will not under conditions of use (with flame burning or extinguished) discharge from such burner or part when the appliance is tilted in any direction to an angle of not more than 3 degrees from the horizontal. Oil fuel may be discharged below the floor of a manufactured home or recreational vehicle. Under such circumstances, if such an assembly or part is subject to variations in fuel flow rate or to changes in combustion characteristics when off level, it shall function in the intended manner.

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

9 Air-Intake Assemblies

9.1 The requirements in this section are applicable to all types of appliances, that is, direct vent system appliances and appliances that provide for separation of the combustion system from the indoor atmosphere (isolation) by an installation method.

Exception: 9.3 and 9.12 are applicable only to appliances intended for installation in manufactured homes that provide for isolation by an installation method.

9.2 An appliance shall be provided with a combustion air intake. The intake for an appliance equipped with a draft regulator shall also provide air for draft regulator dilution. An intake shall communicate with the outside atmosphere.

9.3 If two intakes are employed to provide air as required by 9.2, both shall be located in the same floor, roof, or wall of the manufactured home, or both shall terminate in the same pressure zone in an appliance enclosure inside the manufactured home.

9.4 An air-intake assembly to the underside of a manufactured home or recreational vehicle shall extend at least 7 inches (177.8 mm) below the upper surface of the floor. An air-intake assembly through the roof of a manufactured home or recreational vehicle shall be such that, when the assembly is installed as intended, the air entrance will be at least 6 inches (152.4 mm) above the top surface of the roof and the exit will be at least 6 inches below the top surface of the roof.

9.5 An air-intake assembly for installation through an outside wall of a manufactured home shall be capable of being extended from 2 inches (50.8 mm) to 4-3/4 inches (121 mm) beyond the inside face of the wall and shall not project beyond the outside wall more than 3 inches (76.2 mm).

9.6 An air-intake assembly for an appliance intended only for installation through an outside wall of a recreational vehicle shall be capable of being extended at least 2 inches (50.8 mm) beyond the inside face of the wall and shall not project beyond the outside wall more than 3 inches (76.2 mm). The appliance shall be marked in compliance with 73.1(m).

9.7 If a telescoping slip-fit connection is used in the air-intake tube to provide for installation in walls of varying thickness, the minimum overlap shall be 1-1/4 inches (31.8 mm).

9.8 If a slip-fit is used at the connection of an air-intake tube with the appliance, the minimum overlap shall be 1/2 inch (12.7 mm), and means shall be provided to position the tube with respect to the wall structure.

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

9.10 An air entrance located beneath the floor and having a free area of at least 10 square inches (65 cm^2) with no cross-sectional dimensions less than 1-1/2 inches (38.1 mm) is considered to comply with 9.9 without additional guarding or shielding.

9.11 The design and path of an air intake shall provide the intended amounts of combustion air to burners and of dilution air to any draft regulator.

9.12 The free area of openings to the outdoors in combustion air and dilution air-intake assemblies to be installed in the wall of an enclosure of a manufactured home in which an appliance, other than a direct vent system appliance, is to be installed shall not be less than 1 square inch (645 mm^2) for each 5000 Btu per hour (1464 W) of the total input rating of all appliances to be in the enclosure.

9.13 The minimum cross-sectional dimension of an internal air passage in an air-intake assembly shall be not less than 1/2 inch (12.7 mm).

9.14 The top or plane of any concealed combustion air or ventilation opening(s) shall be not less than 2 inches (50.8 mm) above the floor level. The bottom of such openings shall be not less than 1 inch (25.4 mm) above the floor level unless all performance provisions can be met with the bottom of the opening blocked to a distance 1 inch (25.4 mm) above the floor.

9.15 Openings in perforated or expanded metal panels provided over openings for combustion air, circulating air, or draft hood relief shall be not less than 1/4 inch (6.4 mm) diameter. If the openings in such panels are other than circular in shape, they shall be of such size that will permit entrance of a No. 3 DMS (5.4102 mm) drill.

10 Base

10.1 The base of an appliance shall be constructed to provide for the support of the appliance. A base or frame shall be constructed of metal or material which provides strength, durability, and flame retardancy equivalent to metal.

10.2 An appliance shall be provided with facilities to permit secure and ready attachment to the floor or structure of the manufactured home or recreational vehicle. If unique bolts, screws, or other parts are needed for that purpose, they shall be furnished with the appliance.

10.3 If means are required for leveling and alignment, they shall be included with the appliance.

10.4 If subbase is furnished as a separate assembly, it shall be marked to indicate the correct position of the appliance with respect to the subbase. A separate subbase which cannot be assembled incorrectly with respect to the appliance need not be marked.

10.5 The base, subbase, or duct connector of a downflow appliance shall be constructed for installation on flammable flooring material and shall establish and maintain not less than the required clearance between vertical surfaces of the plenum or duct to be attached thereto and the floor construction. A spacer shall extend at least 3/4 inch (19.1 mm) below the upper surface of the floor on which the appliance is to be installed.

10.6 The use of spacers in the form of separate blocks or shims is not considered to be in compliance with 10.5.

11 Drip Pan or Tray

11.1 An oil-fired appliance having a burner or part which at any time contains an open pool of oil or a semienclosed valve, or integral tank, even though considered splash-proof, shall be provided with a drip pan or tray. Such drip pan or tray shall be designed to collect oil discharged from such parts and shall retain or drain such oil to the underside of the mobile home or recreational vehicle when the appliance is tilted in any direction to an angle of not more than 3 degrees from the horizontal.

11.2 The drip pan or tray shall be provided with a conduit or passageway arranged to drain any collected oil. It shall be supplied as part of the appliance or as a separate single subassembly. The conduit or passageway shall have an internal diameter of not less than 5/16 inch (7.9 mm).

12 Casing

12.1 The outer casing or jacket shall be made of steel or equivalent material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) if uncoated, or 0.023 inch (0.58 mm) if galvanized, or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

12.2 Access panels which need to be removed for service and accessibility shall be constructed to permit repeated removal and replacement without causing damage or impairing any required insulating value.

12.3 A removable panel through which air is drawn for combustion shall be constructed so as to prevent it being attached in a manner that may cause a risk of fire or injury to persons.

12.4 A removable panel shall be constructed so that it will not be interchangeable with other panels on the same appliance when interchange may cause a risk of fire or injury to persons.

12.5 The casing shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor.

Exception: An opening is permitted if it is intended to be permanently connected to a circulating air distribution duct or to an intake assembly.

12.6 An appliance and its return air system shall be constructed so that the negative pressure created by an air circulating fan cannot affect the combustion air supply or act to draw products of combustion into the circulating air.

13 Radiation Shields

13.1 A radiation shield or liner shall be constructed, formed, and supported to provide for its intended positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion by heat-resistant paint, galvanizing, or the like if its deterioration may cause excessive temperature when the appliance is tested in compliance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the appliance is tested under these requirements.

14 Materials In Air Handling Compartments

14.1 General

14.1.1 Materials in a compartment handling air for circulation through a duct system shall not have a flame spread rating of more than 25 nor a smoke developed rating of more than 50 when tested in accordance with the test method for fire hazard classification of building materials in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. This requirement does not apply to the following:

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

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

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

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

e) Molded or formed components made of polymeric materials, not liners, in such quantity that the total surface area of such materials in the compartment does not exceed 10 square feet (0.9 m^2). See 14.1.7.

14.1.2 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.

14.1.3 The supporting surface to be used in the fire hazard classification test of adhesives is to be of asbestos-cement board or metal. Other materials requiring support may be supported using metal rods or bars or 2 inch (50.8 mm) hexagonal mesh-wire with metal bars or rods.

14.1.4 Thermal or acoustic insulating material shall be securely positioned if loosening may reduce or block air flow to cause temperatures or pressures in excess of those acceptable in the temperature tests or if loosening will result in reduction of electrical spacings below the required values, short-circuiting, or grounding. Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air.

14.1.5 A mechanical fastener for each square foot (929 cm^2) of exposed surface is considered to securely position insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads may be used to provide protection for leading edges against damage from effects of the velocity of moving air. Rigid or semirigid sheets of insulating material may not require fastening to the extent needed for less rigid material or protection of leading edges if the material possesses inherent resistance to damage.

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

14.1.7 Polymeric materials exempted by 14.1.1(e) shall not have a flame spread rating of more than 25 or shall conform to the requirements of the flammability test in 41.1 – 41.5.

14.2 Air filters

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

14.2.2 Means shall be provided to retain and support an air filter in the intended position in or on the appliance.

15 Combustion Chamber

15.1 The combustion chamber and flueways of an air-heating appliance shall be constructed of cast iron or sheet steel. Sheet steel, if used, shall be such as to assure strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to ANSI C1010 hot-rolled sheet steel having a minimum thickness of 0.032 inch (0.81 mm), except that an air-heating appliance having a maximum rated input not in excess of 50,000 Btu per hour (14.6 kW) may have a minimum thickness of 0.026 inch (0.66 mm).

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

16 Radiator

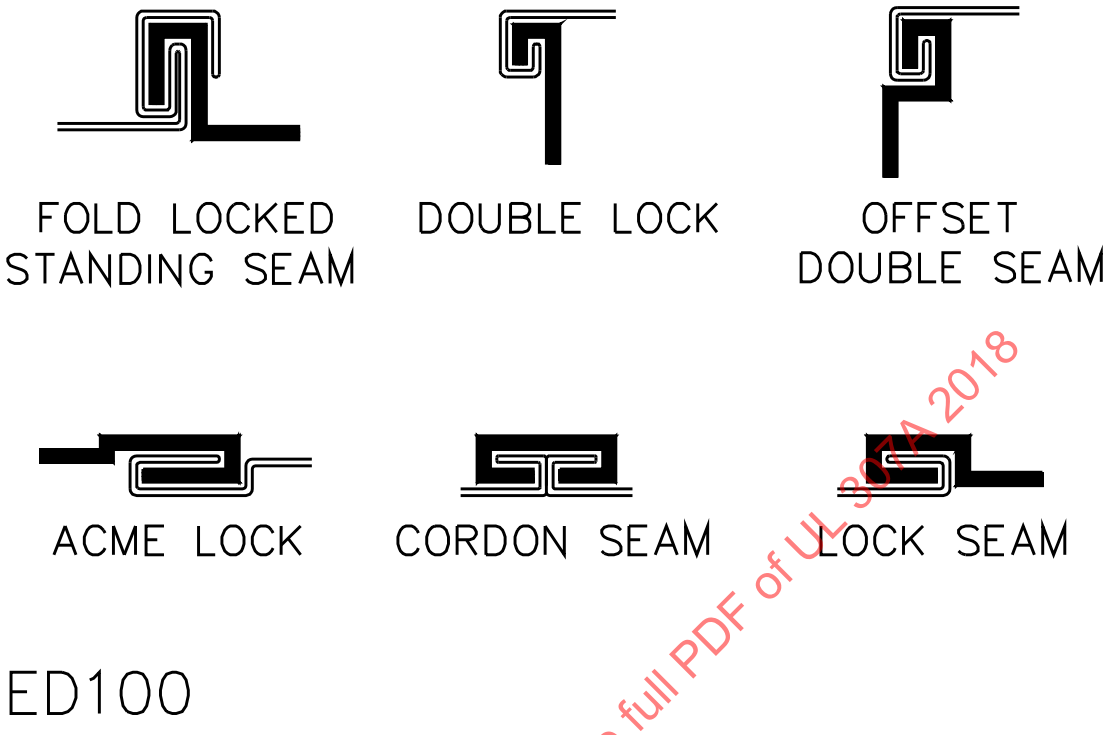
16.1 A radiator of an air-heating appliance shall be made of material not lighter than that designated in 15.1 for a combustion chamber.

17 Heating-Surface Joints

17.1 Joints in heating surfaces shall be substantially tight, as attained by being welded, lock-seamed, machined and bolted, or riveted. A joint shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

17.2 Examples of some acceptable lock seams are illustrated by Figure 17.1.

Figure 17.1
Types of acceptable lock-seams



18 Baffles

18.1 A flue baffle shall be fixed in position and shall be accessible for cleaning. A flue baffle which is removable for cleaning shall be of such construction as will facilitate its removal and permit replacement only in its intended position. It shall be made of material not lighter than that designated in 15.1 for a combustion chamber.

18.2 A baffle located in a flue-gas passage or other passage exposed to combustion products, the failure of which would not cause hazardous operation, yet is considered replaceable, shall be observable and subject to replacement without dismantling of the appliance.

18.3 Where it is necessary to remove a flue baffle to clean the flueway, the flue baffle of an internal-flue type water heater shall be designed for removal within a clearance above the floor of 6-1/2 feet (2.0 m), or 2 feet (610 mm) above the flue collar on a heater taller than 4-1/2 feet (1.3 m).

19 Flue Collar

19.1 A flue collar shall be substantial and arranged to permit secure attachment of a connector.

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

20 Flue-Gas Outlet Assembly

20.1 A flue-gas outlet assembly to convey flue gases to the outside shall be furnished with each appliance. A connector shall be furnished, if required, to connect the flue collar of the appliance to the flue-gas inlet of the outlet assembly.

20.2 A connector to a roof jack shall be of a length required to connect to an appliance installed in a manufactured home having at least a 7 foot (2.1 m) ceiling height.

20.3 A flue-gas outlet for an appliance shall not terminate beneath a manufactured home or recreational vehicle.

20.4 The flue-gas conveying conduit of a flue-gas outlet assembly for an appliance exhausting flue gases at a temperature of 1000°F (538°C) or less, measured at the flue collar during the applicable Continuous Operation Temperature Test, Sections 56 and 57, shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to the materials in Table 20.1.

Table 20.1
Materials

Material	Minimum thickness, inch	(mm)
Low carbon steel coated with A19 ceramic	0.0254	(0.645)
Aluminum-coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy	0.0254	(0.645)
Type 430 stainless steel	0.012	(0.30)

20.5 A flue-gas conveying conduit of a connector, if shielded or encased or otherwise hidden when the appliance is installed, shall be made of material equivalent to that required for the flue-gas conveying conduit of flue-gas outlet assemblies.

20.6 An outer casing or other structural part of a flue-gas outlet assembly or connector exposed to the weather (exclusive of flue-gas conveying conduit) shall be made of material having durability and resistance to corrosion, fire, and heat equivalent to that of galvanized steel, 0.018 inch (0.46 mm) thick, and have a coating of zinc conforming with the coating Designation G90 in Table I of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may, in case of question, be established in accordance with the Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ANSI/ASTM A90-1993. Such parts that are always inside the structure shall conform to 13.1.

20.7 Parts of flueways shall be joined in a manner to prevent disengagement and shall be tight when tested in accordance with these requirements.

20.8 If a slip-fit is used at the connection of a connector with the appliance, the minimum overlap shall be 1-1/4 inches (31.8 mm), the minimum overlap of the connector at the roof jack shall be 3 inches (76.2 mm), and the construction at the outer ends of the connector shall be such as to assure a secure and reasonably gas-tight connection at the time of installation.

20.9 The assembly shall be provided with a cap to prevent the entrance of debris or rain into the flue-gas conveying pipe and into any air passages terminating at the exterior of the manufactured home or recreational vehicle.

20.10 A cap shall be designed so that flue-gas or air passages are not likely to be obstructed by soot accumulation, by leaves or debris falling or blown onto it, or by birds.

20.11 A flue-gas outlet and combustion air-intake combined in one assembly and intended for installation through the roof or outside wall of a manufactured home or recreational vehicle shall be designed for varying thicknesses of roof and wall construction in accordance with 9.4 – 9.6.

21 Control Circuits

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

21.2 The requirement of 21.1 does not apply to a circuit within a safety control or to the extension of a circuit to a separate element of the control, such as a flame-sensing device.

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

22 Controls

22.1 Application

22.1.1 All safety controls shall be accessible.

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

22.1.3 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or allowing firing of the appliance without the protection of each of the required safety controls.

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

22.2 Combustion air control

22.2.1 If an automatically operated air control is provided, the arrangement shall be such that, in case of failure, combustion shall be established as intended or the fuel shall be shut off before an unsafe condition can occur.

22.2.2 An appliance equipped with a forced- or induced-draft fan, or both, shall be arranged to provide combustion as intended or the fuel shall be shut off after failure of the air supply before an unsafe condition can occur.

22.2.3 An appliance equipped to change the firing rate automatically shall automatically proportion the air supply with the fuel, if necessary, to produce stable and complete combustion at all firing rates.

22.3 Limit control

22.3.1 An air-heating appliance shall be equipped with a limit control to prevent temperatures in excess of the intended range.

22.3.2 The limit control shall be in addition to and shall function at a higher value than any operating control or thermostat.

22.3.3 At the maximum setting allowed by a fixed stop, the limit control for a warm air heating appliance shall permit an outlet air temperature not in excess of the maximum safe temperature as determined by test, but not more than 200°F (93.3°C).

22.3.4 A boiler assembly shall be provided with limit controls to prevent excessive pressure in steam boilers or excessive temperatures in hot water boilers. In addition, a boiler shall be furnished with a control which will prevent operation of the burner assembly in the event of low water in the boiler. Limit controls shall be in addition to and set at a higher value than any operating control(s).

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

22.3.6 The maximum setting of a limit control allowed by a fixed stop for a heating boiler shall permit a pressure of not more than 15 pounds per square inch gauge (psig) (103 kPa) in a steam boiler, or a water temperature of not more than 250°F (121°C) in a hot water boiler. Such boilers are stamped with the ASME Code Symbol H.

22.3.7 The limit control of a water heater shall have a fixed stop and shall function when the temperature of the water is not more than 210°F (98.9°C) when the heater assembly is tested as described herein. Furthermore, when the control functions, the water temperature shall be above that maintained by the temperature regulating control.

22.3.8 A water heater provided with a continuous-burning pilot fire during the standby burning period shall not permit a water temperature in excess of 100°F (55.6°C) above room temperature when tested as specified.

22.3.9 The limit control of a heating boiler or warm-air heating appliance shall be a recycling-type control, except that an auxiliary limit control on a central furnace may be a manual-reset type. The limit control for a water heater shall be of a manual-reset type.

22.3.10 A downflow appliance shall be constructed and arranged so that a risk of fire or injury to persons will not result from reverse air flow.

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

22.3.12 The requirements of 22.3.11 are intended to avoid interposing other controls in the limit-control circuit if the failure of these other controls may create the risk of fire or injury to persons that the limit control is intended to prevent.

22.3.13 An appliance equipped with a vaporizing burner shall be designed to avoid pooling of the burner upon functioning of the limit control.

22.3.14 The limit control or controls shall be factory located on the appliance.

22.4 Primary safety control

22.4.1 A heating appliance shall be equipped with a primary safety control that complies with the Standard for Automatic Electrical Controls for Household and Similar Use – Part 2: Particular Requirements for Burner Ignition Systems and Components, UL 372.

WIRING METHODS – ALL APPLIANCES

23 Field Wiring

23.1 General

23.1.1 Provision shall be made for connection of a wiring system that, in compliance with the National Electrical Code, ANSI/NFPA 70-1993, will provide for connection of fixed equipment.

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

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

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

Table 23.1
Size of junction boxes

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

23.1.5 Wiring terminals or leads not less than 6 inches (152.4 mm) long shall be provided for connection of field-wiring conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70-1993 corresponding to the marked rating of the assembly.

23.1.6 Leads may be less than 6 inches (152.4 mm) in length if it is evident that the use of a longer lead may result in damage to the lead insulation.

23.1.7 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or to internal wiring if such stress may cause the lead to separate from its termination or may result in damage to the lead from sharp edges. Each lead shall withstand a pull of 10 pounds (44 N) for 1 minute without damage to the assembly.

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

23.1.9 Stranded conductors at terminals shall be prevented from contacting other uninsulated live parts and from contacting dead-metal parts, such as by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. Open slot-type connectors shall not be used unless they are designed to prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

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

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

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

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

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

23.1.15 A wire-binding screw shall thread into metal.

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

23.1.17 Conductors intended for connection to a grounded neutral line shall be identified, such as finished in 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 metallic-plated coating, substantially white in color and shall be readily distinguishable from other terminals, or it shall be identified in some other manner, such as on an attached wiring diagram.

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

23.1.19 A box or enclosure in which field-installation conductors are to be connected as specified in 23.1.17 and 23.1.19 shall be located so that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the appliance is tested in compliance with these requirements.

23.1.20 Wiring to be done in the field where permitted between the appliance and devices not attached to the appliance, or between separate devices which are field installed and located, shall comply with these requirements if done with Type T wire enclosed in conduit or with metal-clad cable.

23.2 Grounding

23.2.1 The equipment grounding terminal or lead shall be located in the field wiring compartment and shall be suitable for connection of an equipment-grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70-1993, for the rating of the power supply circuit to be connected.

23.2.2 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.

23.2.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked G, GR, GROUND, GROUNDING, 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 is unlikely to be removed during servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply:

a) A marking shall be additionally provided indicating EQUIPMENT GROUND, and

b) The connector shall be identified by a green color, or both.

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

23.3 Cord connected appliances

23.3.1 An appliance intended for cord connection to the power supply shall be provided with a flexible cord and attachment plug of the grounding type, and of the type, voltage rating, ampacity, and current rating consistent with the rating and intended operation of the appliance.

23.3.2 The marked current rating of a cord-connected appliance shall not exceed 80 percent of the current rating of the attachment plug.

23.3.3 A cord-connected appliance shall employ a grounding-type attachment plug that complies with the ANSI/NEMA designations in Table 23.2.

Table 23.2
Attachment plugs

Attachment plug rating, amperes, volts	ANSI/NEMA designation[a]
15, 125	5-15P
20, 125	5-20P
15, 250	6-15P
20, 250	6-20P

[a] As part of the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6-1988.

23.3.4 A cord-connected appliance shall employ a Type SJ, SJO, SJT, or SJTO power-supply cord rated for use at a voltage not less than the rated voltage of the appliance. The ampacity of the cord as specified in the National Electrical Code, ANSI/NFPA 70-1993 shall not be less than what is required by the appliance.

23.3.5 The length of a power-supply cord shall not be less than 6 feet (1.82 m) and not more than 7 feet (2.13 m). The length is to be measured between the point at which the cord exits the appliance and the attachment plug.

23.3.6 The power-supply cord shall be provided with a strain relief means so that stress of the cord will not be transmitted to terminals, splices, or internal wiring. If a metallic cord rip is provided, it shall not contact uninsulated live parts or reduce spacings within the enclosure if the cord is moved inward. The cord shall not be subject to damage by moving parts if it can be moved inward. See Strain Relief Test, Section 69.

23.3.7 The edges of the entry hole for the power-supply cord, including the cord entry hole in a bushing, shall be smooth and rounded, and without burrs, fins or sharp edges that may damage the cord insulation. The power-supply cord shall be routed to reduce the risk of damage to the cord insulation.

23.3.8 The power-supply cord shall be attached to the appliance in a manner and location where it cannot be run through holes in walls, ceilings, and floors when it is connected to the manufactured home or recreational vehicle's power supply outlet.

23.3.9 The power-supply cord shall be attached to the appliance in a manner and location where it cannot be concealed behind the walls, ceilings, and floors when it is connected to the manufactured home or recreational vehicle's power supply outlet.

24 Factory Wiring

24.1 The wiring of high-voltage and safety-control circuits shall comply with the requirements of 24.2 – 24.27.

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

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

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

24.5 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as specified in 24.18 and 24.19.

24.6 Group A of Table 24.1 includes some wiring materials intended for use if enclosed as specified in 24.5.

Table 24.1
Typical wiring materials

Group	Type of wire, cord, cable or appliance wiring material with insulation thickness corresponding to wire sizes specified	Wire size		Insulation thickness	
		AWG	(mm^2)	inch	(mm)
A	RFF-2, TF, TFF, TFN, TFFN, SFF-2, RH, RHH, RHW, HW, XHHW, MTW, THW, MTW, THWN, TW, PF, PFG, PFF, PGFF, THW or thermoplastic appliance wiring material	10 & 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	(53.5)	5/64	(2.0)
		2/0	(67.4)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.2)	5/64	(2.0)

Table 24.1 Continued on Next Page

Table 24.1 Continued

Group	Type of wire, cord, cable or appliance wiring material with insulation thickness corresponding to wire sizes specified	Wire size		Insulation thickness	
		AWG	(mm^2)	inch	(mm)
B	S, SE, SEO, SOO, STO, STOO, SJ, SJE, SJEO, SJOO, SJTO, SJTOO, SO, ST, SJO, SJT, or appliance wiring material with thermoplastic or neoprene insulation, with insulation thicknesses shown at the right corresponding to the wire sizes indicated.	18	(0.82)	4/64	(1.6)
		16	(1.3)	4/64	(1.6)
		14	(2.1)	5/64	(2.0)
		12	(3.3)	5/64	(2.0)
		10	(5.3)	5/64	(2.0)
		8	(8.4)	6/64	(2.4)
		6	(13.3)	8/64	(3.2)
Thermoplastic wiring materials, as specified 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, 8.4 mm^2), are considered equivalent to the wiring material specified 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.				

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

24.8 If flexible metal conduit is used it shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.4 m) within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (0.9 m) where flexibility is necessary.

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

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

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

24.12 A splice is to be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials, may be employed as specified in Group A of Table 24.1.

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

24.14 Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

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

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

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

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

a) It is not practical to do the wiring in accordance with 24.6.

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

c) The length of cord exterior to the assembly is not more than 4 inches (101.6 mm) and strain relief is provided.

24.19 Cords or appliance wiring material as reference in Group B of Table 24.1 may be employed if the wiring is enclosed by an appliance casing conforming to all of the following:

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

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

c) Openings are not closer than 6 inches (152.4 mm) to the wiring unless metallic barriers or baffles are placed between the wiring and the openings. Louvered openings of a kind which serve to protect the wiring from mechanical damage from outside the compartment and which are so formed as to assist in confining an electrical disturbance to within the compartment are exempt from this requirement. To conform with these requirements the louvers should be of a drawn metal of a form to completely obscure viewing of the wiring within the compartment when viewed from the horizontal outside the compartment, and the openings shall be located so an object falling vertically cannot enter the compartment through the louvered openings.

d) Where flammable material other than electrical insulation is located within the compartment the wiring is separated from such material and the material will not sustain combustion upon removal of the ignition source. An air filter may be employed within the enclosure.

24.20 In applying the requirement of 24.19, an opening which is always intended to be connected to an air duct may be considered as closed.

24.21 Cords and other wiring material permitted in accordance with 24.18 and 24.26 shall be supported and arranged to avoid being physically damaged, such as by closely following surfaces. Strain relief, where required, shall be provided.

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

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

24.24 To provide an acceptable unbushed opening in sheet metal usually requires rolling and or extrusion of the metal around the opening, or the insertion of a grommet conforming to 24.21.

24.25 Except as indicated in 24.26, conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected, wired for connection to one supply line shall withstand the conditions of a short circuit test without creating a risk of fire or electric shock. See Short Circuit Test, Section 66.

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

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

b) Conductors which are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length provided the appliance will be protected by a 60-ampere fuse or smaller. See Short Circuit Test, Section 66. This applies to any of the wiring materials specified in this standard, including those enclosed in raceways, or

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

24.27 Factory wiring of a low-voltage safety circuit may be done with SP-2 cord having all-neoprene insulation, SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or low-energy safety control wire, if such wiring is located in a cavity or compartment of an appliance and is shielded from damage.

25 Separation of Circuits

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

25.2 Segregation of insulated conductors as specified in 25.1 may be accomplished by clamping, routing, or equivalent means which results in permanent separation from insulated or uninsulated live parts of a different circuit.

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

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

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short circuiting may result in a risk of fire, electric shock or injury to persons, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that Type T, RF-2, or equivalent conductors are or will be installed when wired in compliance with the National Electrical Code, ANSI/NFPA 70-1993.

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

a) If the number of openings in the enclosure does not exceed the minimum required for 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 25.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) If more than the minimum number of openings are provided, the possibility is to be investigated of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit.

25.5 To determine if a device complies with the requirements of 25.3, it is to be wired as it would be in service and in doing so slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

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

25.7 A metal barrier shall have a thickness at least as great as that specified by Tables 29.1 and 29.2, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be 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.

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

26 Bonding for Grounding

26.1 Exposed or accessible noncurrent-carrying metal parts, which are liable to become energized and which may be contacted by the user or by service personnel during service operations performed when the equipment is energized, shall be electrically connected to the point of connection of an equipment grounding terminal or lead.

26.2 Except as specified in 26.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing, and piping valves, and the like shall be bonded for grounding if they may be contacted by the user or serviceman.

26.3 Metal parts, as specified below, need not be grounded:

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

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

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

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

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

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

26.6 Metal-to-metal hinge bearing members are considered as a means for bonding a door for grounding.

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

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

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

26.8 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or by welding, soldering or brazing with materials having a softening or melting point greater than 454°C (849°F). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

26.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 26.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

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

26.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than specified by 26.12 – 26.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 26.1 twice the current equal to the rating of the branch circuit overcurrent device required to protect the equipment, and

b) During a short circuit test in series with a fuse of proper rating. See Short Circuit Test, Section 66.

Table 26.1
Duration of current flow, bonding-conductor test

Rating of overcurrent device, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4

26.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as specified in 26.11, the size of the conductor or strap shall be in compliance with Table 26.2.

Table 26.2
Bonding wire conductor size

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

[a] Or equivalent cross-sectional area.

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

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

ELECTRICAL COMPONENTS – ALL APPLIANCES

27 General

27.1 Electrical components and wiring shall be arranged:

a) To avoid contact with water from humidifiers,

b) To avoid oil or water from dripping or running on them during usage, and

c) To avoid water dripping or running from a pipe connection required to be uncoupled for servicing the appliance.

27.2 Attachment plugs or separable connectors shall not be used in a circuit where the breaking or making of the circuit by such devices may result in a risk of fire, electric shock or injury to persons.

28 Mounting of Electrical Components

28.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning except as specified in 28.2 and 28.3.

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

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

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

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

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

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

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

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

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

29 Electrical Enclosures

29.1 Uninsulated live high-voltage parts shall be enclosed or guarded to prevent accidental contact by persons during use of the equipment in compliance with 36.1 – 36.12.

29.2 Sheet metal complying with Tables 29.1 and 29.2 is considered acceptable for the enclosure of electrical components.

29.3 If the design and location of components and the strength and rigidity of the outer cabinet warrant, an individual enclosure thinner than specified in Tables 29.1 and 29.2 may be employed.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	(15)		(15)	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
35.0	(88.9)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	(13)		(13)	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)		(11)	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)		(10)	

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

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

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

3) An enclosure surface loosely attached to a frame, e.g., with spring clips.

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

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

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness inches (mm)
Maximum width[b] inches	(cm)	Maximum length[c] inches	(cm)	Maximum width[b] inches	(cm)	Maximum length inches	(cm)	
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 which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

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

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

3) An enclosure surface loosely attached to a frame, e.g., with spring clips.

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

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

29.4 Terminal housings of motors, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, ANSI/NFPA 70-1993.

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

29.6 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) 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.

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

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

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

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

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

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

b) 0.027 inch (0.69 mm) steel or 0.032 inch (0.81 mm) nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimension.

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

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

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

29.14 All intended mounting positions of the appliance are to be considered when determining compliance with the requirements of 29.12.

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

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

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

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

a) For an opening that has a minor dimension (see 29.20) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 29.1.

b) For an opening that has a minor dimension of 1 inch (25.4 mm) or more, such a part or wire shall be spaced from the opening as specified in Table 29.3.

Exception: A motor need not comply with these requirements if it complies with the requirements in 29.17.

Figure 29.1
Articulate probe with web stop

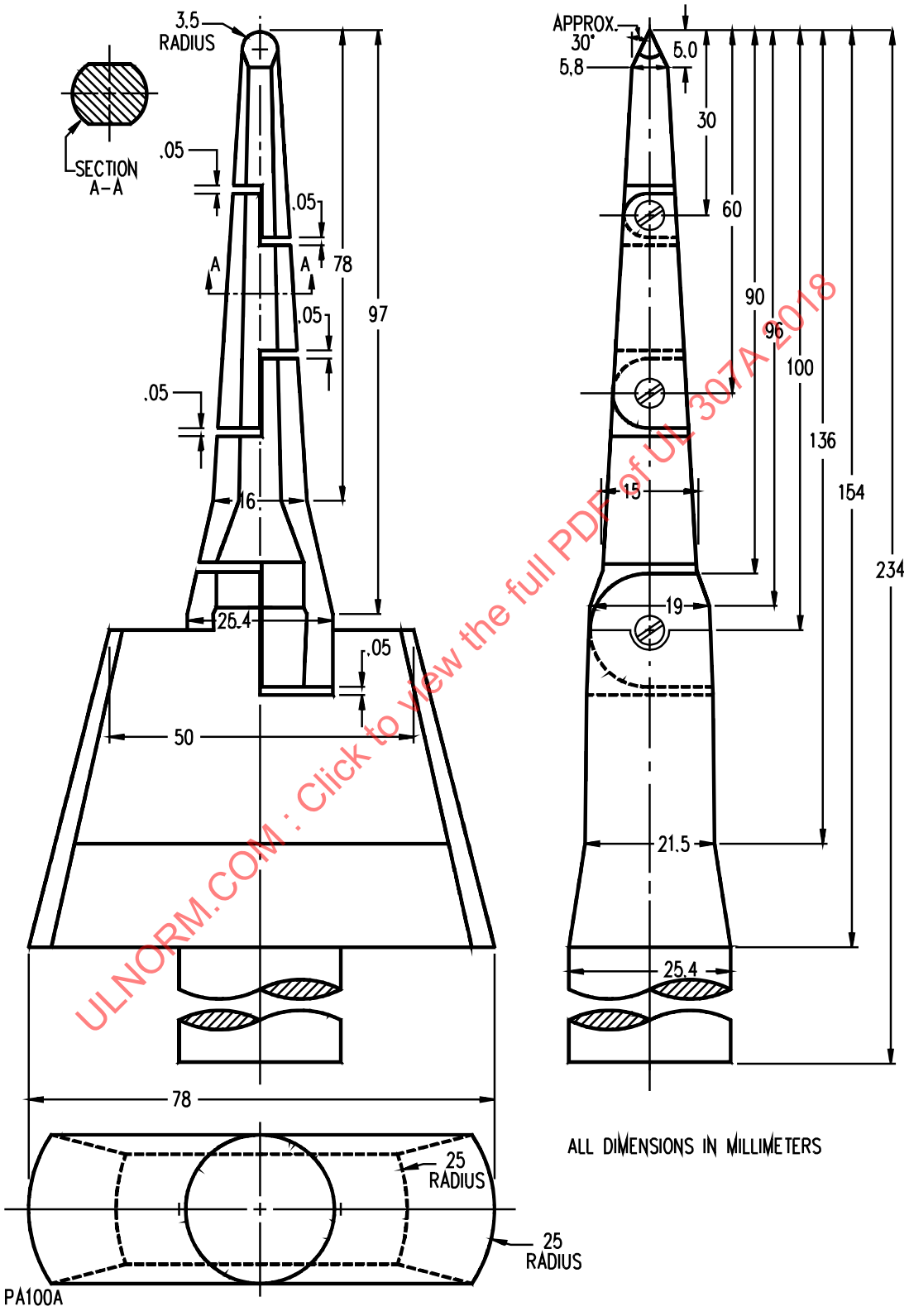


Table 29.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening[a]		Minimum distance from opening to part	
inches[b]	(mm)	inches	(mm)[b]
3/4	(19.1)[c]	4-1/2	(114.0)
1	(25.4)[c]	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
d		30	(762.0)

[a] See 29.20.
[b] Between 3/4 inch (19.1 mm) and 2-1/8 inches (54.0 mm), interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch (25.4 mm) applies to a motor only.
[d] More than 2-1/8 inches (54.0 mm), but not more than 6 inches (152.4 mm).

29.17 With respect to a part or wire as mentioned in 29.16, in an integral enclosure of a motor as mentioned in the exception to 29.16:

a) An opening that has a minor dimension (see 29.20) less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 29.4;

2) In a directly accessible motor (see 29.20), an uninsulated live part cannot be contacted by the probe illustrated in Figure 29.3; and

3) In an indirectly accessible motor (see 29.20), an uninsulated live part cannot be contacted by the probe illustrated in Figure 29.2.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 29.3.

Figure 29.2
Probe for uninsulated live parts

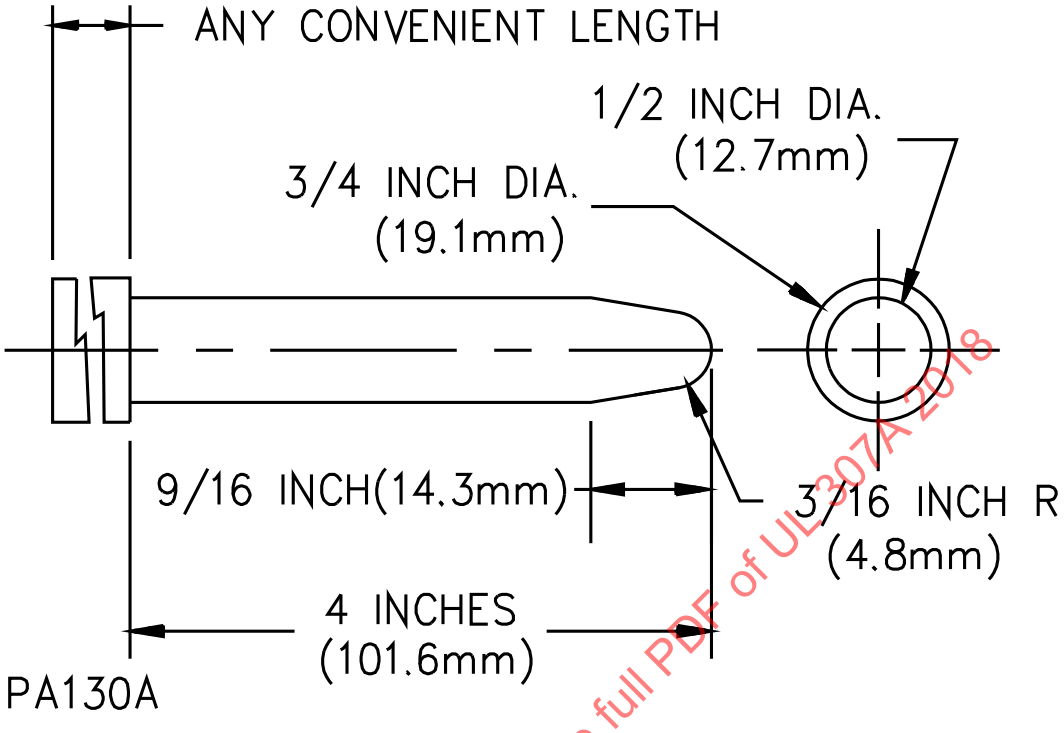


Figure 29.3
Articulate probe

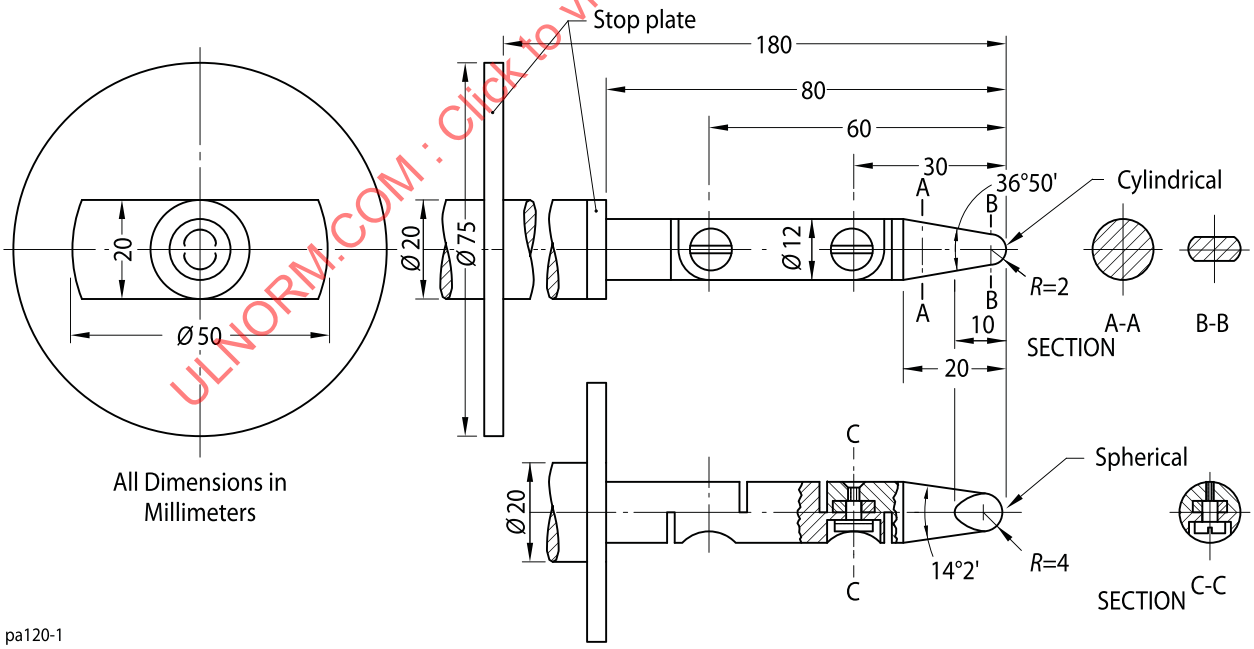
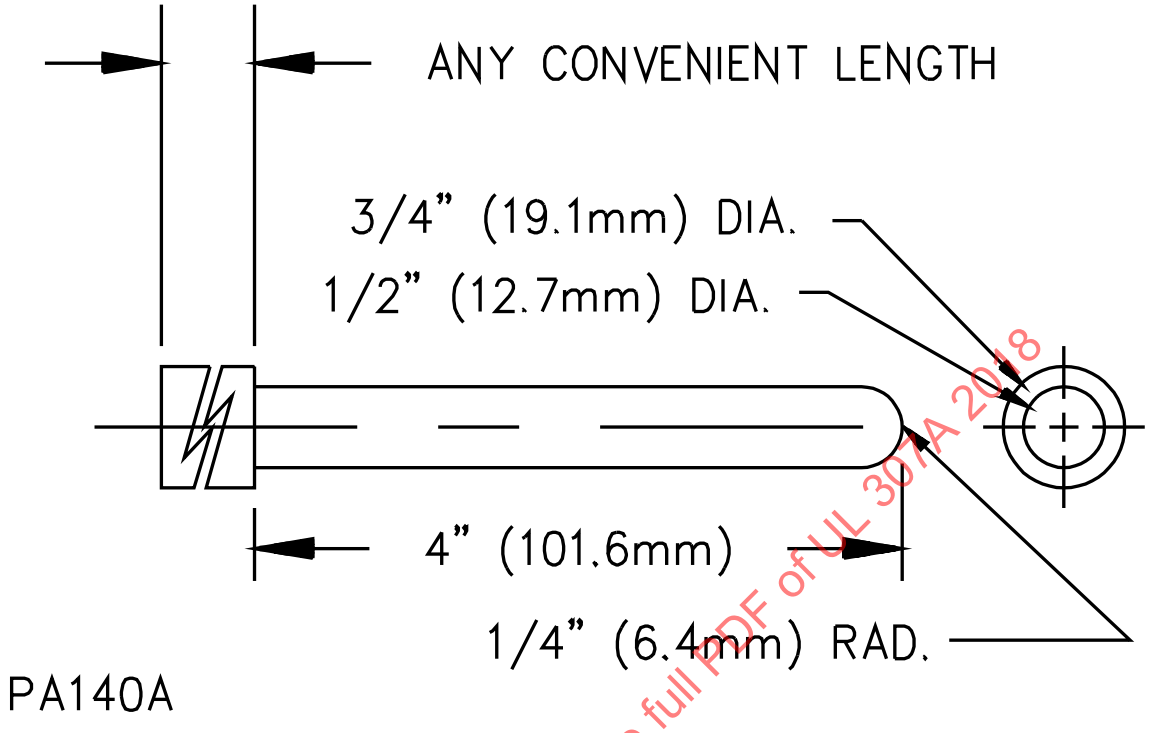


Figure 29.4
Probe for film coated wire



29.18 The probes mentioned in 29.16 and 29.17 and illustrated in Figures 29.1 – 29.4 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 29.1 and 29.3 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

29.19 The probes mentioned in 29.18 and 29.20 shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

29.20 With reference to the requirements in 29.16 and 29.17, 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.

29.21 With reference to the requirements in 29.17, an indirectly accessible motor is a motor that is:

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

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

29.22 During the examination of a product to determine whether it complies with the requirements in 29.16 or 29.17, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

29.23 With reference to the requirements in 29.16 and 29.17, insulated brush caps are not required to be additionally enclosed.

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

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

29.26 The assembly shall be so arranged that an overcurrent protective device, such as a fuse, the intended functioning of which requires renewal, can be replaced and manual-reset devices can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device. See 29.30.

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

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

29.29 A fuseholder shall be so designed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (101.6 mm), other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or similar material employed for this purpose shall be not less than 0.028 inch (0.71 mm) in thickness.

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

Exception: A hinged cover is not required if the only fuses enclosed are:

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

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

c) Fuses in low-voltage circuits.

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

29.32 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and require some effort on the user's part to open it is considered to be an acceptable means for holding the door in place as required in 29.31.

29.33 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box at least 1/2 inch (12.7 mm). A construction with affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

29.34 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152.4 mm) apart.

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

29.36 Terminals of a low-voltage safety device within an appliance compartment or cavity to which factory wiring is connected need not be otherwise enclosed if such terminals are recessed and located so that the terminals are shielded from accidental shorting or damage.

30 Motors and Motor Overload Protection

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

30.2 Overcurrent protective devices as specified in 30.1 are overcurrent protective devices that comply with the requirements of the National Electrical Code, ANSI/NFPA 70-1993, as follows:

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

Motors with a marked service factor not less than 1.15	125 percent
Motors with a marked temperature rise not over 104°F (40°C)	125 percent
All other motors	115 percent

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

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

Motors with a marked service factor not less than 1.15	140 percent
Motors with a marked temperature rise not over 104°F (40°C)	140 percent
All other motors	130 percent

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

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

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

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

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

30.8 Motors shall not exceed the temperature rise specified in Table 55.1 when tested as specified herein.

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

30.10 Interruption of the circuit to a motor by the overcurrent or overtemperature protective device shall not result in the risk of fire, electric shock or injury to persons or in discharge of fuel. If a burner depends solely upon an electric valve to stop the flow of fuel to the burner, the interruption of the circuit to the motor by the protective device shall also cause the interruption of the circuit to the valve. The device which interrupts the circuit to the valve may be independent of the motor circuit.

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

30.12 A motor shall have no openings permitting a drop of liquid, or a particle falling vertically onto the motor, to enter the motor.

30.13 Compliance with the requirement of 30.12 may be provided by the motor frame or by other enclosure, structure, or shield, or by a combination of two or more such items, and is to be determined with the motor applied to the assembly.

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

30.15 The requirements specified in 30.14 will necessitate the use of a barrier of nonflammable material under an open type motor unless:

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

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

1) Open main winding,

2) Opening starting winding,

3) Starting switch short-circuited, and

4) Capacitor shorted, permanent split capacitor type, or

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

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

30.16 The barrier specified in 30.15 shall be:

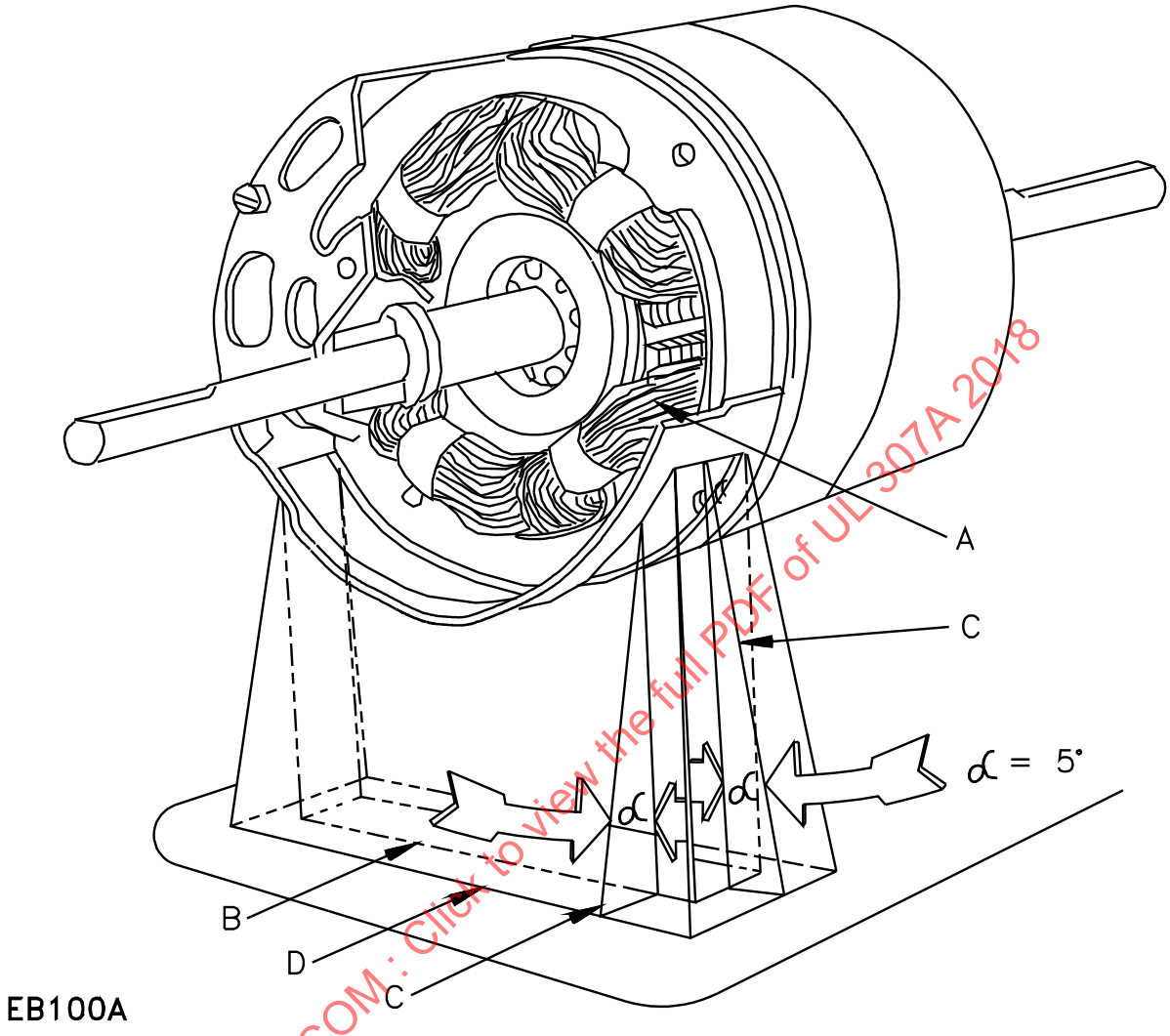
a) Horizontal,

b) Located as specified in Figure 30.1, and

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

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

Figure 30.1
Location and extent of barrier



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

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

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

1) Tangent to the motor winding,

2) 5 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.

30.17 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short Circuit Test, Section 66.

31 Capacitors

31.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 31.2 and 31.3, the container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

31.2 The individual container of a capacitor may be of sheet metal thinner than specified in 31.1 or material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance and provided that such box, case, and the like is acceptable for the enclosure of current-carrying parts.

31.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead-metal parts by moisture-resistant insulation not less than 0.028 inch (0.71 mm) thick, except as indicated in 34.6. Otherwise, it shall be separated from dead-metal parts by spacings in accordance with Table 34.1.

31.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 66.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 66.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

32 Electrical Insulating Material

32.1 Material for the mounting of current-carrying parts shall be of moisture resisting 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 not as the sole support for uninsulated live parts of other than low-voltage circuits.

33 Switches and Controllers

33.1 Except as indicated in 33.2, a controller(s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

33.2 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 600 volts or less, and with not more than 6 amperes full-load current for each motor.

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

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

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

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

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

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

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

SPACINGS – ALL APPLIANCES

34 High-Voltage Circuits

34.1 Except as noted in paragraphs below, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead-metal part shall be not less than the values indicated in Table 34.1.

Table 34.1
Minimum spacings

Ratings		Minimum spacings[d]					
Volt-amperes	Volts	Through air		Over surface		To enclosure[c]	
		inch	(mm)	inch	(mm)	inch	(mm)
0 – 2000	0 – 300[a]	1/8[b]	(3.2)	1/4	(6.40	1/4	(6.4)
More than 2000	0 – 150	1/8[b]	(3.2)	1/4	(6.4)	1/2	(12.7)
	151 – 300	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
	301 – 600	3/8	(9.5)	1/2[c]	(12.7)	1/2	(12.7)

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

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

[c] Includes metal fittings for conduit or cable which are factory installed or which may be field installed.

[d] 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.

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

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

34.4 The spacing requirements in Table 34.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component which is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, are to be those indicated in the table.

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

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

35 Low-Voltage Circuits

35.1 The spacings for low-voltage electrical components which are installed in a circuit which includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in hazardous operation of the appliance shall comply with the following.

35.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 34.5.

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

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

35.5 The spacings in low-voltage circuits which do not contain devices such as indicated in 35.1 are not specified.

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

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

PROTECTION OF USERS AND SERVICE PERSONNEL – ALL APPLIANCES

36 General

36.1 An uninsulated high-voltage live part and hazardous moving parts shall be located, guarded, or enclosed so as to minimize the likelihood of accidental contact by personnel performing service functions which may have to be performed with the equipment energized.

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

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

b) Resetting control trip mechanism,

c) Operating manual switches, or

d) Adjusting air-flow dampers.

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

36.3 The requirements of 36.1 are not applicable to mechanical service functions which are not performed with the equipment energized.

36.4 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 hazardous moving parts are:

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

b) Not located within 6 inches (152.4 mm) on any side or behind the mechanism, unless guarded.

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

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

a) The components are located with respect to the access opening in the outer cabinet so that the farthest component in the control assembly is not more than 14 inches (355.6 mm) from the plane of the access opening.

b)Uninsulated live parts outside the control assembly projected clear space, except for live parts within a control panel, or unguarded hazardous moving parts are located not closer than 6 inches (152.4 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

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

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

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

36.7 Components in a low-voltage circuit are to comply with the requirements of 36.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

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

a) Coils of controllers,

b) Relays and solenoids,

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

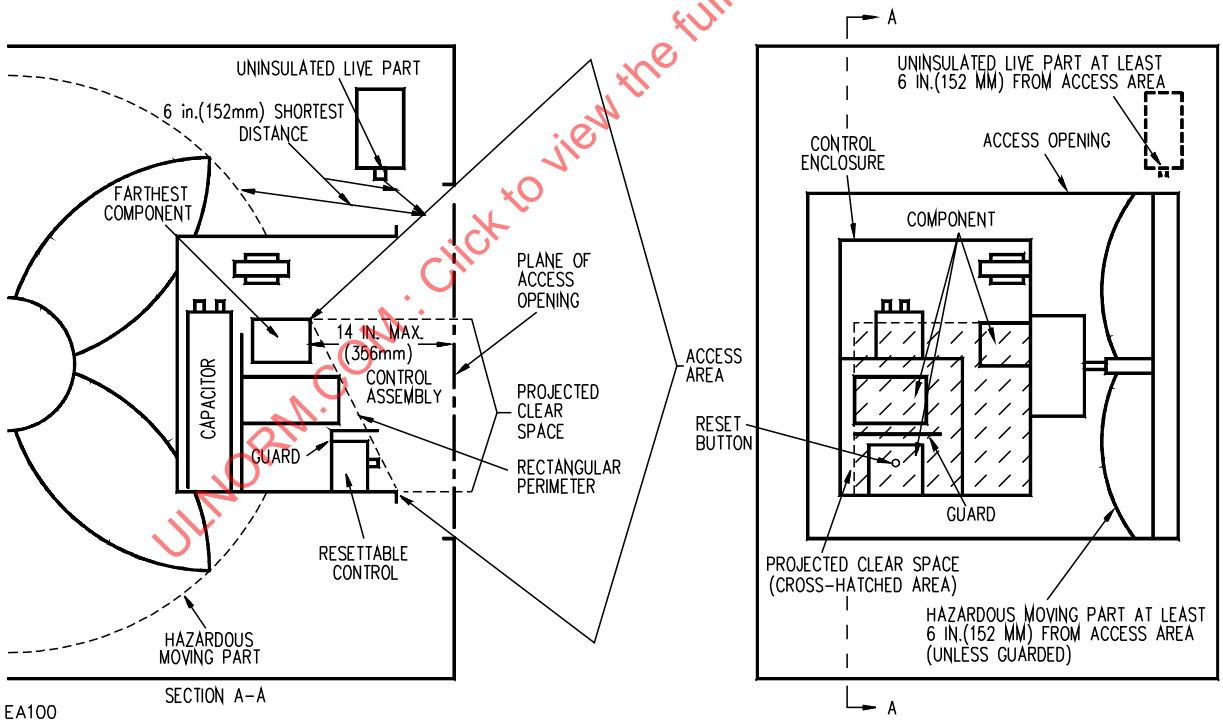
d) Enclosed motor windings,

e) Insulated terminals and splices, and

f) Insulated wire.

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

Figure 36.1
Accessibility and protection



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

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

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

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

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

36.11 The distance from an opening in a required guard or enclosure to the moving part mentioned in 36.9 shall be in accordance with Table 36.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 36.1
Dimensions in 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	(114.0)
1	(25.4)	6-1/2	(165.0)
1-1/2	(38.1)	10-1/2	(267.0)
2	(50.8)	14-1/2	(368.0)
Over 2 inches	(Over 50.8)	30	(762.0)

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

36.12 A moving part is not to be considered when judging compliance with 36.1 and 36.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

CONSTRUCTION – SPECIFIC APPLIANCES

37 Central Furnaces

37.1 A horizontal furnace intended for suspended installation shall be provided with brackets or hangers to support the furnace from its basic frame or structure.

37.2 A furnace intended for installation in the cooled-air path, downstream from a cooling coil, shall conform to the following:

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

b) The fire-box liner shall resist deterioration from being wetted by condensation.

c) Condensation shall not drip on burner parts or other corrodible parts if corrosion of any such parts is likely to cause hazardous operation.

d) The heat exchanger and appliance flue shall contain no traps or pockets in which condensation may collect.

37.3 Connections between the heat exchanger and the casing which encloses circulating air shall be constructed to prevent leakage of combustion products into the circulating air.

37.4 Provision shall be made to permit removal and replacement of the filters and oiling the motor and blower bearings without dismantling or removing any portion of the flue gas conveying system. For removal of the blower assembly, it is permissible to disconnect the flue gas conveying system.

38 Heating Boilers

38.1 A boiler shall be constructed, equipped, inspected, tested, and marked in accordance with the applicable Section of the ASME Boiler and Pressure Vessel Code, Section IV, Heating Boilers.

39 Water Heaters

39.1 Temperature-regulating control

39.1.1 A water heater shall be controlled by means of a temperature-regulating control.

39.1.2 A temperature-regulating control shall be capable of operation under rated electrical load or inherent load for 30,000 cycles of operation without any mechanical or electrical failure, impairment of operation, or apparent damage. Any change in calibration as a result of the operation test shall not exceed ±10°F (±5.6°C).

39.1.3 At the maximum setting allowed by a fixed stop, the temperature regulating control of a water heater shall limit the water temperature to not more than 194°F (90°C).

Exception: When the temperature-regulating control or controls and the limit control have cutout temperature tolerances not greater than ±5°F (±2.8°C), the maximum water temperature shall be 200°F (93.3°C).

39.1.4 An adjustable temperature regulating control shall be set at the factory to a control position corresponding to a 120°F (49°C) or lower setting. This setting is approximate in the case of a marking that reads ″Low-Medium-High″ or the equivalent, instead of directly in degrees Fahrenheit or Celsius.

39.1.5 A water heater equipped with a nonadjustable temperature-regulating control shall be set at 120°F (49°C) or lower.

Exception: A water heater equipped with a nonadjustable temperature-regulating control that is set above 120°F (49 °C) at the factory shall be provided with the Scald Hazard Label Marking described in 73.18 and shown in Figure 73.1.

39.2 Limit control

39.2.1 A water heater shall be provided with an automatic fuel shutoff system, e.g., temperature limit control, actuated by high-water temperature as an integral part of the heater. The shutoff system shall be of the manual reset type and shall be arranged to interrupt all fuel supply to the heater before the water has attained a temperature as specified in 22.3.7.

39.2.2 A manual-reset mechanism shall be accessible for resetting. A location behind an access cover in the jacket of the water heater is acceptable.

39.2.3 The automatic fuel shutoff system shall have no operating parts in common with the temperature-regulating device or control mentioned in 39.1.1, but a common mounting bracket or a common enclosure may be employed for both devices.

39.2.4 Immersion-type, temperature-limiting, devices shall be located so that the temperature-sensitive element is immersed in the water within the tank and controls the temperature of the water within the top 6 inches (152.4 mm) of the tank.

39.2.5 Surface-mounted, limit controls shall be mounted and located so that the temperature-sensitive element senses the water temperature within the top 6 inches (152.4 mm) of the tank. Such surface-mounted, temperature-sensitive elements shall be insulated or located so as to isolate them from flue gas heat or other ambient conditions that are not indicative of stored water temperature.

39.3 Water storage vessels

39.3.1 The water vessel shall withstand a hydrostatic test pressure of 300 psi (2.1 MPa), or its rated hydrostatic test pressure, whichever is greater, without developing leakage or visible permanent distortion, or the tank shall carry the symbol of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. The working pressure shall be not more than 50 percent of the hydrostatic test pressure. If the vessel is of steel, the inside surfaces shall be protected against corrosion by galvanizing, porcelain enameling, or the equivalent.

39.3.2 A storage vessel shall be equipped with a valve to facilitate emptying the tank.

39.3.3 Hot and cold water connections shall be clearly identified.

39.3.4 A storage tank shall have an opening for installation of a temperature-and-pressure relief valve. The opening:

a) Shall be located:

1) In the top of the tank, or

2) With its centerline in the upper 6 inches (152.4 mm) of the side.

b) Shall be separate from the openings for water connections.

c) Shall be threaded in conformity with the Standard for Pipe Threads General Purpose (Inch), ANSI/ASME B1.20.1-1983.

d) Shall accommodate a 3/4 inch (19.1 mm) or larger trade-size pipe. See ANSI/ASME B1.20.1-1983.

39.4 Materials contacting water

39.4.1 A nonmetallic material in contact with water shall comply with the requirements in the National Sanitation Foundation Standard for Plastic Piping System Components and Related Materials, NSF No. 14-1990, with regard to toxicity, waste, color, solubility, and odor.

39.5 Dip tubes

39.5.1 Dip tubes, if used, shall be provided with an antisiphoning hole located so that when the dip tube is installed, the hole will be within 6 inches (152.4 mm) of the top of the tank.

39.5.2 A dip tube having a specific gravity less than 1.0 shall be held in place by a positive means that will limit any vertical displacement to not more than 1/4 inch (6.4 mm).

39.5.3 A nonmetallic dip tube shall be investigated to determine its acceptability for the service, particularly with respect to solubility, brittleness, and resistance to deformation, collapse, and sagging, at temperatures likely to be encountered in service. See Nonmetallic Dip Tube Tests, Section 68.

39.5.4 Nonmetallic dip tubes shall be permanently marked with the manufacturer's name or identifying symbol and the lot number.

39.5.5 A nonmetallic material for a dip tube shall have a specific gravity greater than 0.94.

PERFORMANCE – ALL APPLIANCES

40 General

40.1 An appliance shall comply with the applicable requirements for performance as described herein using any grade or type of fuel recommended by the manufacturer of the appliance. Each size and type of appliance, or a number of sizes and types to be representative of the entire range of sizes and types are to be subjected to all or part of the tests prescribed herein. An appliance is to be tested with each optional piece of equipment (recommended for use by the manufacturer) which affects the performance of the equipment.

40.2 An appliance of a type not described specifically herein shall be tested in accordance with the intent of these requirements.

40.3 An appliance employing burners or parts which may be affected in their fuel-burning rate, operation, or calibration if the appliance is out of level shall perform in accordance with these requirements when the appliance is tested out of level at any and all angles of tilts of not more than:

a) Two degrees from the horizontal during the tests in Sections 49, 58 – 60, and 67, and

b) Three degrees from the horizontal during the Air Flow Test – Horizontal Appliances, Section 63.

40.4 In addition to the following tests, the appliance shall be tested in accordance with the requirements of 6.16, 6.17, 6.20, 14.1.7, 26.11, 39.1.2, and 39.3.1.

41 Flammability Test

41.1 Samples are to consist of at least three of each part, or of sections of each part as large as is practical to test. Sections should include the thinnest portions of the parts. Preferred sample size is 1/2 by 5 inches (12.7 by 127 mm) when practical and convenient.

41.2 The test flame is to be obtained by means of a Tirrill or Bunsen laboratory type burner having a nominal tube diameter of 3/8 inch (9.5 mm) and a length above the primary air inlets of approximately 4 inches (102 mm). The flame is to be adjusted to an overall height of 5 inches (127 mm) with an inner blue cone of 1-1/2 inches (38.1 mm). The area in which the test is to be conducted is to be shielded from drafts.

41.3 The part or section is to be arranged with the major axis of the sample area vertical, exposing thin sections to the maximum sweep of flame if practical. The test flame is to be applied to a lower edge of the specimen with the flame 20 degrees from the vertical. The flame is to be applied for 5 seconds and removed for 5 seconds until five such cycles of exposure have been completed. The specimen shall not continue to burn for more than 1 minute following the last exposure to the flame nor shall any material fall from the specimen during the test. Complete destruction of the sample is not acceptable.

41.4 An essentially identical set of samples is to be aged in a full-draft, circulating air oven at the aging temperature and time determined by the use of the finished part in accordance with Table 41.1.

41.5 The samples shall be removed from the oven at the end of exposure and subjected to the flammability test. The samples shall not show weakening, embrittlement, or other evidence of deterioration, which could prevent the intended operation of the assembly, and shall comply with the requirements of the flammability test.

Table 41.1
Aging temperature and time

Intended use[a]	Maximum normal operating temperature		Aging temperature,		Aging time,
	°C	(°F)[b]	°C	(°F)	hours
Enclosure (indoor only)	65	(149)	90	(194)	168
Enclosure	75	(167)	90	(194)	1440
Enclosure	85	(185)	95	(203)	1440
Enclosure	95	(203)	105	(221)	1440
Enclosure	100	(212)	121	(250)	1440
Structural	50	(122)	75	(167)	1440
Structural	75	(167)	100	(212)	1440
Structural	100	(212)	121	(250)	1440

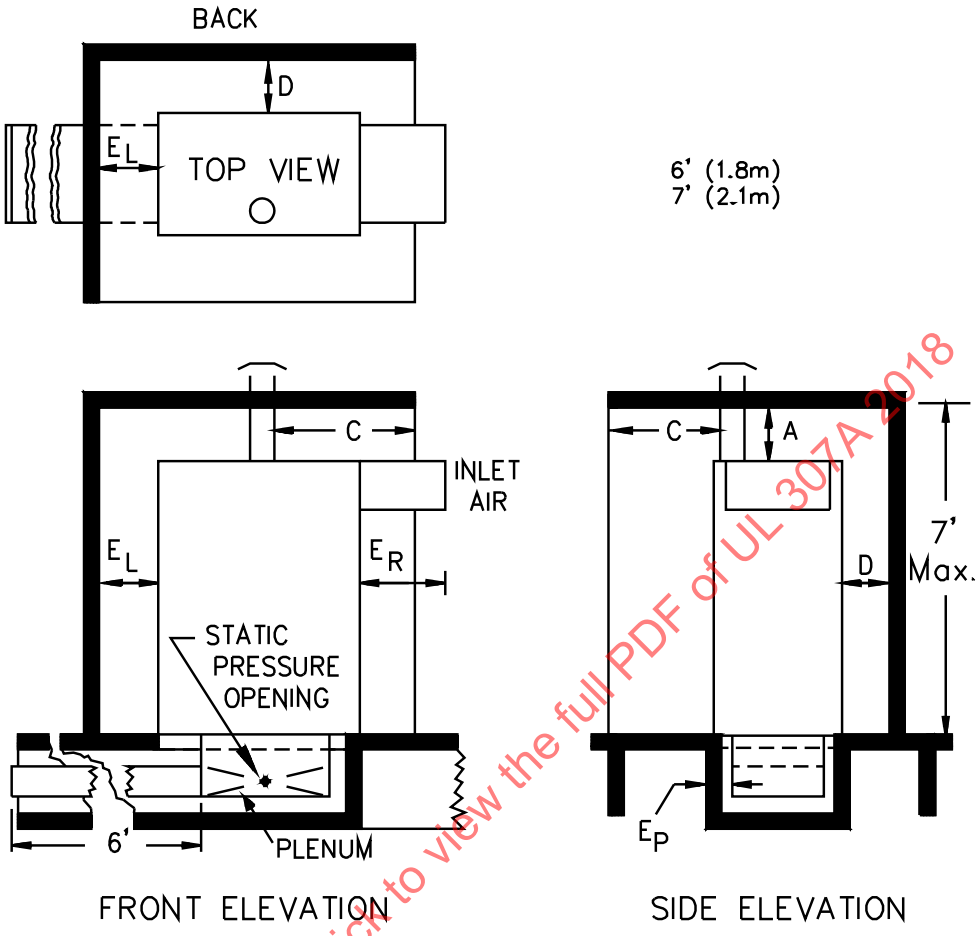
[a] If a material is used as both an enclosure and a structural part, it is to be subjected to the aging condition shown for structural parts.

[b] If normal operating temperature is between two values shown in table, the higher of these two values is used in determining the aging conditions.

42 Test Installation – Corner Location

42.1 A nonrecessed direct vent system appliance may be tested for installation in a room corner. The appliance is to be placed in a partial enclosure in the as-received condition, as described below. The distance from the chimney or vent connector and the distance from the back, side, and top of the appliance to the walls and ceiling of the enclosure are to be as indicated in Figure 42.1. If integral spacers are provided, the clearance may be other than specified, but not more than 2 inches (50.8 mm). When one side of the appliance may create a higher wall temperature than the other, that side of the appliance is to be directly opposite one wall.

Figure 42.1
Test enclosure – downflow furnace corner location clearances



A – From top of appliance.

C – From flue-gas outlet assembly.

D – From back of appliance, 0, 1, or 2 inches (0, 25, or 51 mm).

E_L – From left side of appliance 0, 1, or 2 inches (0, 25, or 51 mm) for left-hand corner installation, otherwise 24 inches (609.6 mm) or less.

E_P – Clearance from any side of supply plenum and warm-air duct within 3 feet (0.9 m) of appliance to be 0, 1/4, 1/2, 3/4, or 1 inch (0, 6.4, 12.7, 19.1, or 25.4 mm).

E_R – From right side of appliance, 0.1 or 2 inches (0.25 or 51 mm) for right-hand corner installation, otherwise 24 inches (610 mm) or less.

42.2 The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the appliance to the ceiling specified by the manufacturer, but the ceiling height is to be not more than 7 feet (2.1 m).

42.3 The partial enclosure is to be formed by walls of nominal 1 inch (3/4 inch) (19.1 mm) wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. A ceiling and floor of equivalent construction are to be placed above and below the partial enclosure. The height of the walls is to be as shown. All joints are to be tight or sealed. The walls of the partial enclosure are to extend as shown.

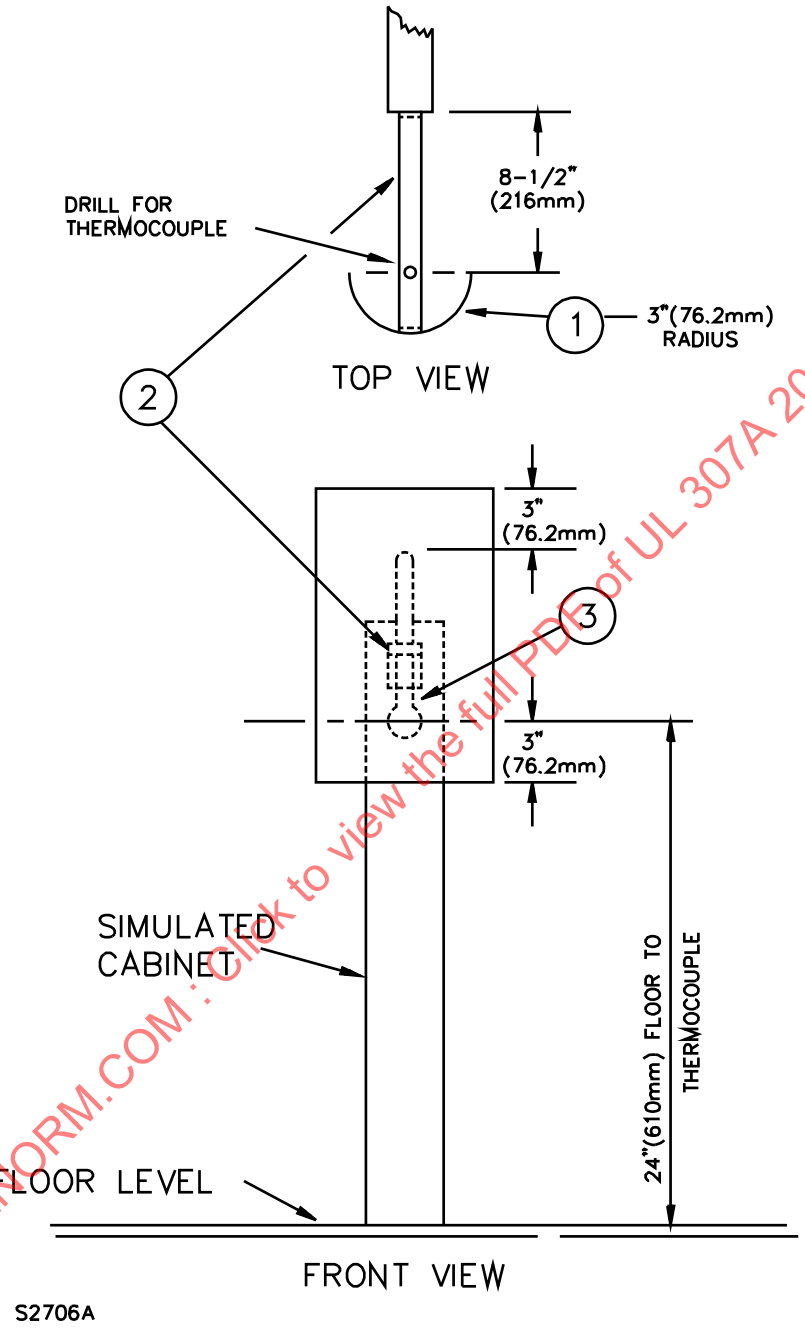
42.4 For a downflow furnace, a structure made of nominal 1 inch (3/4 inch) (19.1 mm) lumber or 3/4 inch (19.1 mm) plywood representing a floor and joint structure is to be placed around the warm-air outlet plenum and duct. The clearance between the plenum and duct and the enclosure is to be 0 or 1/4, 1/2, 3/4, or 1 inch (6.4, 12.7, 19.1, or 25.4 mm). The structure is to extend the full length of the duct. See Figure 42.1.

42.5 A thermocouple is to be placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test enclosure as indicated in Figure 42.2.

Exception: For horizontal furnaces, the thermocouple for measuring room temperature is to be located midway between the floor and ceiling of the test enclosure.

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

Figure 42.2
Room temperature thermocouple



1. Bright aluminum No. 24 MSG or 0.020 inch (0.51 mm) minimum thick baffle, 6 inches (152.4 mm) longer than (3).

2. Bracket material, 1/8- by 1-inch (3.18 by 25.4 mm) strap iron.

3. Thermocouple, supported by bracket.

43 Test Installation – Upflow, Downflow, and Horizontal Furnaces for Alcove or Closet Location

43.1 Direct vent system appliances may be tested for installation in an alcove or closet. Appliances that provide for separation of the combustion system from indoor atmosphere by an installation method shall be tested in a simulated closet arranged to isolate the appliance from the interior atmosphere.

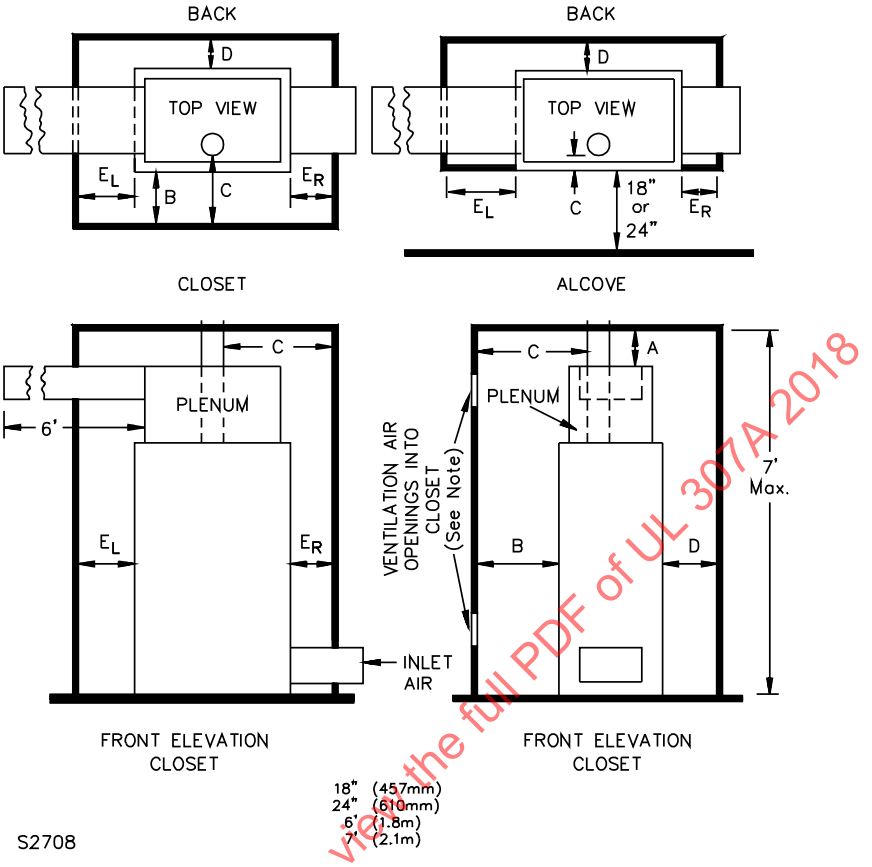
43.2 The furnace is to be installed in an enclosure, as described below, in the as-received condition, with clearances as specified by the manufacturer, to walls and ceiling of the test enclosure. Clearances to back and side walls are to be not more than 2 inches (50.8 mm). The specified clearances are to be maintained when the furnace is placed in the enclosure as close to such vertical walls as the construction of the appliance will permit. The ceiling height of the enclosure is to be that required to obtain the specified clearance from the top of the appliance to the ceiling, but in no case is the ceiling height to be more than 7 feet (2.1 m). See:

Figure 43.1 – Upflow appliances.

Figure 43.2 – Downflow appliances.

Figure 43.3 – Horizontal appliances.

Figure 43.1
Test enclosure for alcove or closet installation upflow heating appliances



A – From top of appliance casing or plenum.

B – From front of appliance.

C – From flue-gas outlet assembly.

D – From back of appliance, 2 inches (50.8 mm) or less.

E_L – From left side of appliance, 2 inches (50.8 mm) or less.

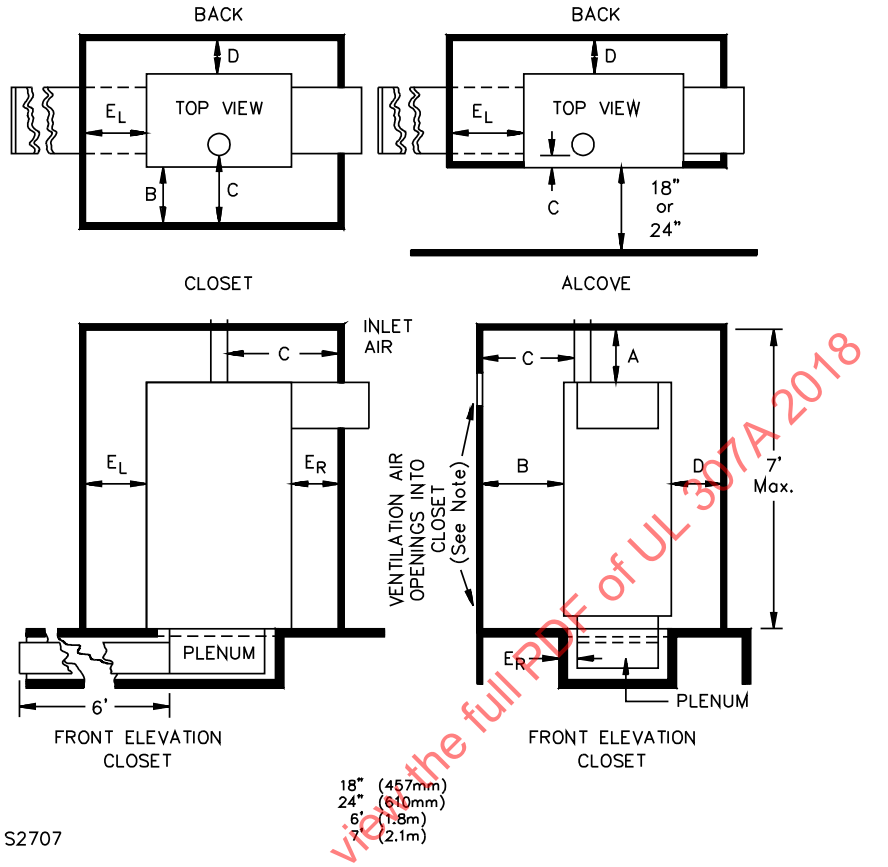
E_R – From right side of appliance, 2 inches (50.8 mm) or less.

E_P – Clearance from any side of supply plenum and warm-air duct within 3 feet (914 mm) of appliance, 0, 1/4, 1/2, 3/4, or 1 inch (0, 6.4, 12.7, 19.1, or 25.4 mm).

F – From bottom of suspended-type appliance.

Note – The ventilating openings and any door into a closet are intended to be extended to the outside of the manufactured home if the appliance is not of a design inherently separating the combustion system from the atmosphere of the manufactured home (direct vent system appliance).

Figure 43.2
Test enclosure for alcove or closet installation downflow heating appliance



A – From top of appliance casing or plenum.

B – From front of appliance.

C – From flue-gas outlet assembly.

D – From back of appliance, 2 inches (50.8 mm) or less.

E_L – From left side of appliance, 2 inches (50.8 mm) or less.

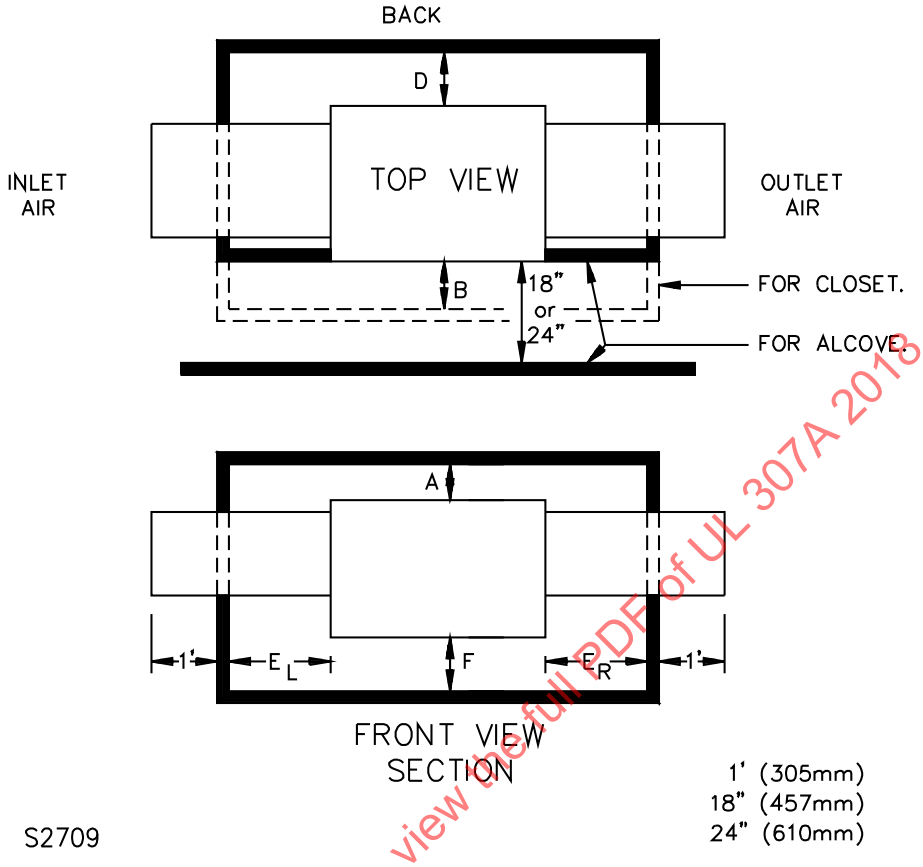
E_R – From right side of appliance, 2 inches (50.8 mm) or less.

E_P – Clearance from any side of supply plenum and warm-air duct within 3 feet (914 mm) of appliance, 0, 1/4, 1/2, 3/4, or 1 inch (0, 6.4, 12.7, 19.1, or 25.4 mm).

F – From bottom of suspended-type appliance.

Note – The ventilating openings and any door into a closet are intended to be extended to the outside of the manufactured home if the appliance is not of a design inherently separating the combustion system from the atmosphere of the manufactured home (a direct vent system appliance).

Figure 43.3
Test enclosure for alcove or closet installation horizontal heating appliance



A – From top of appliance casing or plenum.

B – From front of appliance.

C – From flue-gas outlet assembly.

D – From back of appliance, 2 inches (50.8 mm) or less.

E_L – From left side of appliance, 2 inches (50.8 mm) or less.

E_R – From right side of appliance, 2 inches (50.8 mm) or less.

E_P – Clearance from any side of supply plenum and warm-air duct within 3 feet (914 mm) of appliance, 0, 1/4, 1/2, 3/4, or 1 inch (0, 6.4, 12.7, 19.1, or 25.4 mm).

F – From bottom of suspended-type appliance.

Note – The ventilating openings and any door into a closet are intended to be extended to the outside of the manufactured home if the appliance is not of a design inherently separating the combustion system from the atmosphere of the manufactured home direct vent system appliance.

43.3 The walls, floor, and ceiling of the enclosure are to be made of nominal 1 inch (3/4 inch) (19.1 mm) wood boards or 3/4 inch (19.1 mm) thick plywood. The walls are to be vertical and at right angles. The interior surfaces of the walls, floor, and ceiling are to be finished in flat black. All joints in the enclosure are to be sealed.

43.4 For alcove installation test, the enclosure is to be three-sided, leaving the front side of the appliance casing exposed. Any remaining opening around the casing from side to side and from floor to ceiling is to be closed with 3/4 inch (19.1 mm) plywood if the appliance is not provided with a frame or panel for this purpose. The side walls are to terminate flush with the front of the appliance, and a wall is to be placed opposite the open side of the enclosure at a distance of 18 or 24 inches (457 or 610 mm), as specified by the manufacturer for testing purposes. If it is judged that such installation may create higher temperatures at some locations, an appliance may also be tested with one side wall of the enclosure extended 18 inches (457 mm) beyond the front of the appliance, in which case there is to be no wall placed opposite the front of the appliance.

43.5 For closet installation test, a simulated door is to be provided for the enclosure. Such door is to be made of 3/4 inch (19.1 mm) thick plywood, the interior surfaces of which are to be finished in flat black. If the door is to be provided with openings, they are to be placed at locations with respect to the appliance in accordance with the manufacturer's installation instructions.

43.6 For a downflow furnace, a structure made of nominal 1 inch (3/4 inch) (19.1 mm) lumber or 3/4 inch (19.1 mm) plywood representing a floor and joist structure is to be placed around the warm-air outlet plenum and duct. The clearance between the plenum and duct and the enclosure is to be 0 or 1/4, 1/2, 3/4, or 1 inch (6.4, 12.7, 19.1, or 25.4 mm). The structure is to extend the full length of the duct. See Figures 43.1, 43.2, and 43.3.

43.7 The room temperature is to be measured by a thermocouple not heavier than 24 AWG (0.21 mm^2) suitably shielded from direct radiation. For alcove installation, the thermocouple is to be placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test enclosure, except for a horizontal furnace the thermocouple is to be located midway between the floor and ceiling of the test enclosure. For closet installation, the thermocouple is to be placed in the center of the lower ventilating opening into the closet when the manufacturer's instructions recommend that such openings be provided, otherwise the thermocouple is to be placed as specified above for alcove installation.

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

44 Supply and Return Ducts – Forced-Air Appliances

44.1 Unless the supply plenum is an integral part of the appliance, the appliance is to be tested with a metal plenum having the same dimensions as the discharge opening of the appliance.

44.2 The height or depth of a separate plenum is to be such that the clearance from the plenum and warm-air duct to surface of the test enclosure will be in accordance with 42.2 and 43.2. See Figures 42.2, 43.1, 43.2 and 43.3.

44.3 Any opening through which a warm-air duct passes from the enclosure is to be of such size that the edges of the opening will clear the duct 5/16 inch (7.9 mm) and the space filled with insulating material and sealed.

44.4 The size of the outlet duct is to be calculated for approximately 900 feet/minute (275 m/minute) of standard air, 0.075 pound/feet^3 (1.2 kg/m^3) with the designed temperature rise through the appliance and based on an output equivalent to 75 percent of the rated input [Btu per hour (0.293 × W)]. Specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

44.5 The outlet duct area may be calculated by means of the applicable following formula:

$$A_1 = (Btu/hour)_{input} \times \frac{0.11}{T_F} \quad or \quad A_2 = W_{input} \times \frac{0.0000277}{T_c + 17.8}$$

Where:

A_1 = Area in inch$_2$; A_2 = Area in mm^2.

T_F = 85°F or the designed temperature rise.

T_c = 29.4°C or the designed temperature rise.

The area for 85°F (29.4°C) temperature rise may be used in tests for other temperature rises.

44.6 The test duct is to be rectangular in shape, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar, but the aspect ratio is not to exceed four to one.

44.7 The warm-air duct outlet is to be arranged to discharge away from the cold-air inlet of the appliance, also, away from the air inlet to the test enclosure for closet installation. The inlet and outlet ducts should be positioned at 90 to 180 degrees apart.

44.8 A horizontal furnace is to be tested with the outlet duct arranged as indicated by Figure 43.3.

44.9 A thermocouple grid, see 47.6.6, is to be located in each warm-air outlet duct in a plane within 6 inches (152.4 mm) downstream from the position closest to the plenum where any couple will not see any surface of the heat exchanger. The duct is to extend at least 6 inches (152.4 mm) beyond the thermocouple grid.

44.10 The cross-sectional area and shape of an air inlet duct are to be equivalent to the cold-air inlet of the appliance. If a central furnace is of the direct vent system type, the return air inlet of the furnace need not be extended to the exterior of the alcove or closest provided it complies with 12.6.

45 Test Installation – Heating Boilers and Water Heaters

45.1 A heating boiler or a water heater is to be tested for installation in a manner similar to that prescribed for upflow furnaces.

45.2 The room temperature is to be measured by a thermocouple placed centrally 15 inches (381 mm) in front of the appliance and 24 inches (610 mm) above the floor of the test structure as indicated in Figure 42.2.

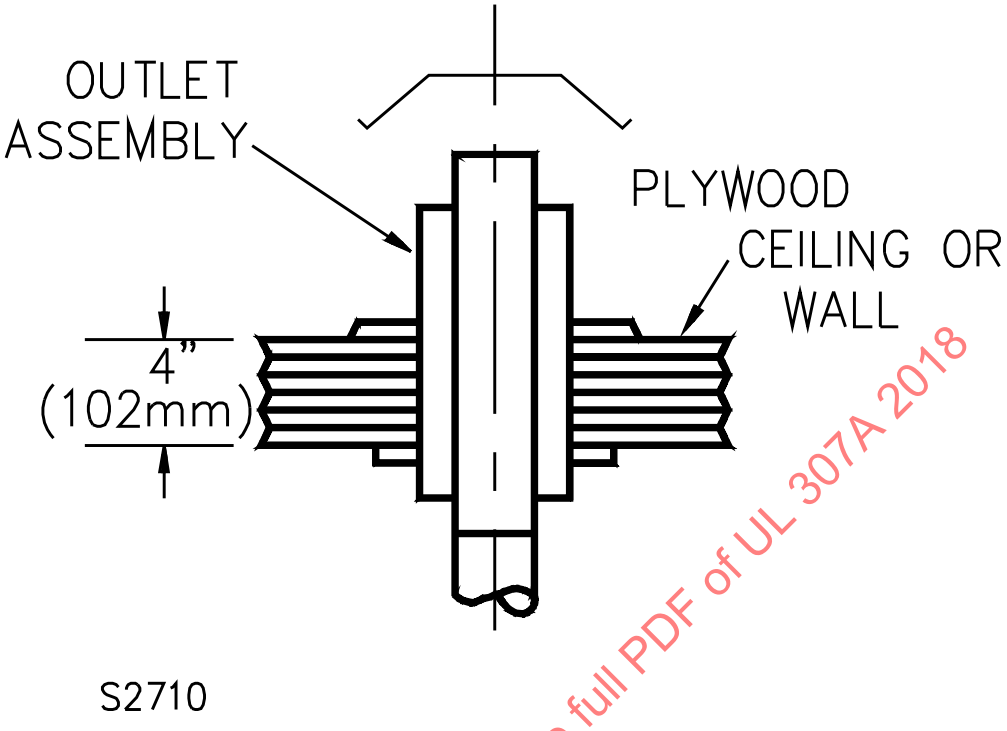
Exception: For a closet installation, the thermocouple is to be placed in the center of the lower ventilation opening into the closet when the manufacturer's instructions recommend that such opening be provided.

46 Flue-Gas Outlet Assembly

46.1 The outlet assembly furnished by the manufacturer with each appliance is to be installed in accordance with the instructions furnished with the appliance. The ceiling or wall opening is to conform to the outside surfaces of the outlet assembly with ceiling or wall material placed at zero clearance to those parts. Temperatures on the surface of the outlet assembly at points of contact with ceiling or wall material are to be determined. See Figure 46.1.

46.2 A primary safety control or draft regulator furnished separately for mounting in the flue-gas outlet assembly is to be placed in the position specified in the manufacturer's instructions. An adjustable draft regulator, if provided, is to be adjusted in accordance with instructions furnished with the appliance.

Figure 46.1
Flue-gas outlet assembly test installation



47 Instrumentation

47.1 Draft measurement

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

47.2 Fuel input measurement

47.2.1 The fuel input rate to a mechanical-atomizing oil burner during a test is to be determined by a scale accurate to 0.01 pound-mass (0.004 kg) or a burette capable of the same resultant accuracy.

47.3 Power measurement

47.3.1 The total electrical input to an appliance is to be measured in amperes.

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

47.4 Speed measurement

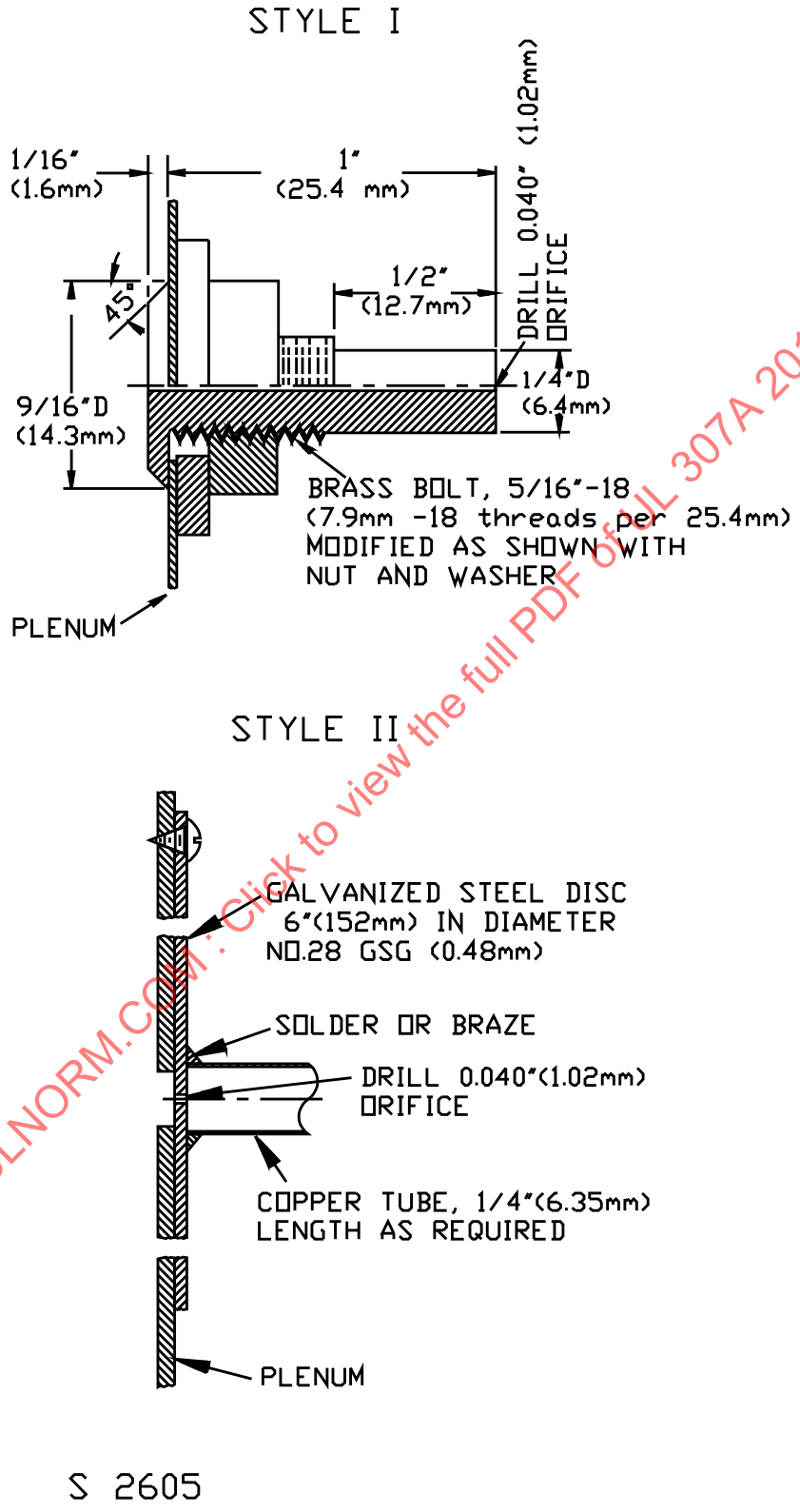
47.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or of the mechanism driven by it. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (93 W) output.

47.5 Static pressure measurement

47.5.1 An inclined draft gauge is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of ±0.0025 inch (±0.064 mm) and is to be capable of being read directly to 0.005 inch (0.13 mm). Unless otherwise specified, all references to static pressure measurements herein refer to static pressure in the outlet plenum.

47.5.2 The static pressure connection in the outlet plenum is to consist of one of the arrangements shown in Figure 47.1. An additional static pressure connection as described in 7.5 may be furnished as a permanent part of the appliance.

Figure 47.1
Static pressure pickup arrangements



47.6 Temperature measurement

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

47.6.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Temperatures on the surface of the flue-gas outlet assembly at points of contact with ceiling material are to be determined. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 55.1.

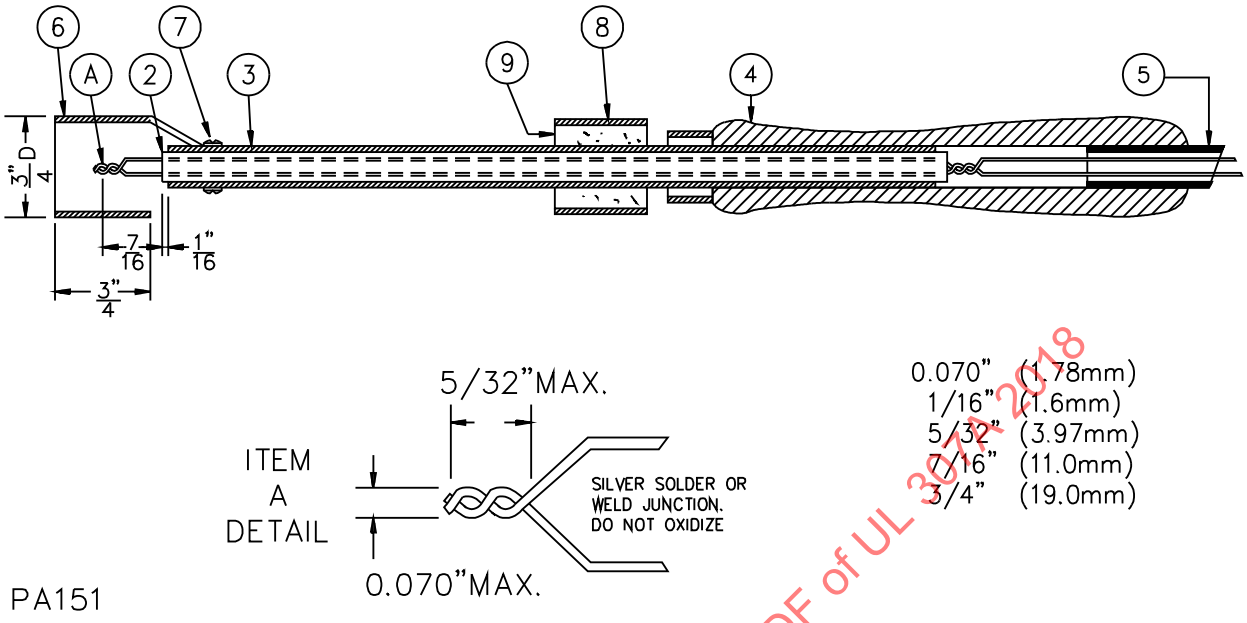
47.6.3 A thermocouple junction and adjacent thermocouple lead wire are to be held in contact with the surface of the material on which the temperature is being measured in a manner assuring accurate temperature determinations. In most cases, such thermal contact will result from securely taping or cementing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

47.6.4 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with pressure-sensitive tape over the tips to maintain it against the surface of the wood.

Exception: For zero clearance, the thermocouples are to be applied to surfaces of the appliance at points of zero clearance.

47.6.5 The flue-gas temperature is to be measured by a shielded thermocouple, such as illustrated by Figure 47.2, located in the flue-gas passage not more than 3 inches (76.2 mm) downstream from the flue-gas outlet of the appliance. There is to be no draft control between the appliance and the point where the flue-gas temperature is measured. If a draft control is incorporated in the appliance, it is to be dependably sealed in the position allowing maximum draft during all tests.

Figure 47.2
Standard shielded thermocouple for flue-gas temperature



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

2. 1 – Leeds & Northrup Standard 714B, or equal, 1/4 inch (6.35 mm) outside diameter of 2-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, 5/16 inch (33.3 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing by 2 inches (50.8 mm).

6. 22 AWG (0.36 mm^2) bright stainless steel shield.

7. Wire strap.

8. 20 AWG (0.51 mm^2) sheet-metal holder.

9. Ceramic fiber bushing.

47.6.6 The outlet-air temperature in rectangular ducts connected to a forced-air furnace is to be measured by nine thermocouples of identical length 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 centrally in 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 within 6 inches (152.4 mm) downstream of the location closest to the plenum where any couple will see any surface of the heat exchanger. The duct is to extend at least 6 inches (152.4 mm) beyond the thermocouple grid.

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

47.6.8 The outlet water temperature of a water heater is to be measured by a thermocouple placed in the storage vessel so that the water temperature 1 inch (25.4 mm) from the outlet connection may be determined.

48 Initial Test Conditions

48.1 General

48.1.1 The appliance is to be set up for test in the appropriate enclosure and manner described in a preceding section of these requirements. See Figures 42.1 – 43.3.

48.1.2 When an appliance is to be equipped with air filters, they are to be in place.

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

48.1.4 An appliance 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 in the following tests, is to be tested with the adjustable device in the position or positions likely to develop maximum temperatures or to disclose a malfunction.

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

48.1.6 The appliance is to be fired at its rated Btu per hour (W) appliance input, ±2 percent, with a fuel for which the appliance is designed.

48.1.7 An appliance equipped with a vaporizing oil burner is to be arranged for firing at maximum input, as well as at the manufacturer's recommended high-fire input, ±2 percent, the latter if the appliance is not equipped with a limit control.

a) The recommended high-fire input is the oil flow rate recommended by the manufacturer, which rate is to be not less than 90 percent of the maximum input.

b) The maximum input is the oil flow rate allowed by the fuel-metering device when adjusted to its maximum allowable setting. This value is determined by adding any plus tolerance allowed in maximum valve flow.

48.1.8 Unless otherwise specified in the paragraphs describing the tests, appliances are to be tested at the potentials indicated in Table 48.1.

Table 48.1
Test voltages

Rated	Normal test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
Other	Rated

48.1.9 No. 1 fuel oil having a viscosity conforming to Table 48.2 is to be used for firing vaporizing burners.

Table 48.2
Viscosity

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

48.1.10 The firing rate at high fire is to be equivalent to the rated input of the appliance.

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

48.2 Static pressure for tests

48.2.1 The static pressure for all test shall be as indicated in Table 48.3.

Table 48.3
Relation of appliance input to external static pressure

Input to appliance, btu per hour, (watts)	External static pressure[b] inches (mm) water column			
	Temperature of outlet air determined by function of limit control			
	Above 165°F	(73.9°C)	165°F	(73.9°C) or less
55,000 (16,000) and under	0.10	(2.5)	0.20	(5.1)
Over 55,000 (16,000) to 80,000 (23,400)	0.12	(3.1)	0.24	(6.0)
Over 80,000 (23,000) to 100,000 (29,300)	0.15	(3.8)	0.30	(7.6)

[a] Measured at static pressure connection located in supply plenum.

[b] An appliance may be tested at an external static pressure in excess of those specified as recommended by the manufacturer.

48.2.2 If adjustable oil shutoff controls are provided, they are to be adjusted to the maximum allowed timing for shutoff.

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

48.2.4 The draft of the flue collar is to be as recommended by the manufacturer, which is to be not less than 0.02 inch (0.5 mm) water column.

49 Combustion Test – Burner and Appliance

49.1 An appliance shall operate uniformly and shall not produce smoke in excess of that specified in 49.3 when it is operated in accordance with 49.2 and 49.3.

49.2 The appliance is to be fired at a high-fire input rate for at least 15 minutes or until equilibrium combustion conditions are obtained. Combustion air adjustment is made normally on high fire and no change is to be made for other firing rates unless changed automatically or unless the instructions on the appliance so state, in which case correlation of the calibrations of fuel and air adjustment are to be included with those instructions.

49.3 When the appliance is fired at rate input and such that the stack loss is not more than 25 percent and operated until steady-state combustion conditions have been established, the smoke in the flue gases shall not exceed that indicated by a No. 2 spot on the Shell-Bacharach smoke scale with the Model RDC smokemeter.

50 Operation Tests

50.1 The limit control shall act to shut off the fuel to the main burner(s) when the outlet air of a warm-air heating appliance reaches a temperature not in excess of that specified by 22.3.3 and when the temperature or pressure in a heating boiler reaches a value not in excess of that specified in 22.3.6, as determined by the Limit-Control Cutout Test, Section 51. The limit control and operating control of a water heater shall act to limit the water temperature not in excess of that specified in 22.3.7 – 22.3.8, as determined by the appropriate tests herein.

50.2 A warm-air, heating appliance equipped with a limit control when fired at rated input, shall be capable of continuous operation without the limit control functioning to cause reduction in the input when the appliance is tested as described herein.

50.3 No flame shall burn outside the combustion chamber when the appliance is tested in accordance with the requirements in Sections 51 – 64.

51 Limit-Control Cutout Test – Warm-Air Appliances and Boilers

51.1 The limit control is to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting. A thermocouple is to be attached to a warm-air appliance limit-control sensing element at its midpoint with the thermocouple leads arranged so that the calibration of the control is not impaired. The appliance is to be fired until steady-state conditions are attained.

51.2 Each warm-air outlet of a central furnace is to be restricted symmetrically to raise the outlet air temperature to a value not more than 10°F (5.5°C) below the temperature that will cause the limit control to function. The static pressure in the supply plenum is to be not more than the appropriate value indicated in Table 48.2.

51.3 A preliminary test is to be made to determine the degree of blocking the cold-air inlet and/or warm-air outlet required to produce the air temperature that will cause the limit control to function. The blocking is then to be relieved to the degree required to permit continuous operation of the appliance and the appliance operated until a substantial equilibrium outlet-air temperature is obtained. If the appliance is equipped with a single cold air inlet grille, not intended to be connected to a return air duct system, the total area of the grille may be blocked with layers of cloth attached progressively to a frame such as described in 58.5.

51.4 The degree of blocking is then to be gradually increased over a period of 10 minutes until the limit control acts to shut off the main burner. The outlet air temperature (T_L), at the instant the limit control functions, is to be measured. The temperature (T_L) of the limit-control sensing element is to be measured over the period beginning with the instant the limit control functions and ending when the sensing element temperature recedes from the maximum it attained. The outlet air temperature thus obtained is not to exceed the values specified in 22.3.3. Also, after the limit control functions, its sensing element is not to attain a temperature that will adversely affect the limit-control calibration.

51.5 The outlet of a boiler is to be restricted to raise the temperature or pressure until the limit-control functions. For this test, a thermostat or other operating control is to be bypassed. The temperature of the water in a water boiler is not to exceed the value specified in 22.3.6. The pressure in a steam boiler is not to exceed the value specified in 22.3.6.

52 Water-Heater Temperature Control Test

52.1 A storage-type water heater is to be filled with water at temperature of 65 ±5°F (18.3 ±2.8°C). An adjustable temperature-regulating control is to be adjusted to the maximum setting allowed by the fixed stop. A thermocouple or thermometer is to be installed 3 inches (76.2 mm) below the top of the storage vessel for measuring the temperature of the stored water. A pressure-relief device followed by a quick-acting valve is to be installed on the outlet connection of the storage vessel. A flow restriction, calibrated to permit a flow rate of 5 gallons/minute (18.9 liters/minute), is to be connected to the outlet of the valve. A water-pressure regulator is to be located in the water supply line to the heater and adjusted so that at full flow the pressure at the inlet connection to the heater will be maintained at the value required to deliver a steady flow rate of 5 gallons/minute (18.9 liters/minute) during test draw periods. During the test, the inlet-water temperature is to be maintained at 65 ±5°F (18.9 ±2.8°C). The heater is to be fired at rated high-fire input with the inlet-water valve opened and the outlet-water valve closed, until the temperature control functions to reduce the fuel supply to the burner to a minimum. Water is to be then drawn immediately at the rate of 5 gallons/minute (18.9 liters/minute) until the control functions to turn on the fuel supply to the burner, and the maximum outlet-water temperature is recorded. This operation is to be repeated until a constant or continually receding outlet water temperature is attained. The maximum outlet water temperature is not to exceed 194 or 200°F (90 or 93.3°C) as indicated in 39.1.3 at any time during the test.

52.2 The heater, if equipped with a burner which operates on pilot fire when the thermostat reduces the fire, is to be allowed to continue operation following the test described above, but with the inlet-water valve shut off and the outlet-water valve open, until equilibrium or continually receding water temperatures are obtained. The temperature of the water at the top of the heater is to be not more than 100°F (55.6°C) above room temperature.

53 Limit-Control Cutout Test – Water Heater

53.1 With the heater installed as in, Test Installation-Heating Boilers and Water Heaters, Section 45, the temperature regulating control is to be made inoperative. The heater is to be fired at rated high-fire input with the inlet-water valve opened and the outlet-water valve closed, until the limit control functions. The water temperature measured in accordance with 47.6.8 is not to exceed 210°F (98.9°C), but shall be greater than that obtained in the Water-Heater Temperature Control Test, Section 52.

54 Continuity of Operation Test– Warm-Air Appliances

54.1 The limit control is to be bypassed to permit continued operation during this test. The appliance is to be placed in operation. A variable speed air circulating fan is to be adjusted so that approximately rated air delivery is obtained.

54.2 Each warm-air duct outlet of a forced air appliance to be so equipped is to be restricted symmetrically to maintain an external static pressure in the supply plenum of the appropriate value indicated in Table 48.2.

54.3 If an appliance is intended for installation with an optional number of warm-air outlets, all except the minimum number of outlets to be always employed are to be closed.

54.4 Operation of the appliance is to be continued until equilibrium outlet air temperature is obtained. The inlet-air Temperature (T_1), the outlet-air temperature (T_2), and the limit-control sensing element temperature (T_2) are to be measured. Also, the electric current input to the appliance is to be measured and recorded, and the static pressure at the appliance static pressure connection (see 47.5.2) is to be measured and recorded. The inlet-air temperature (T_1) is to be measured by a thermocouple located in the center of the air inlet opening and shielded from direct radiation from hot surfaces of the appliance.

54.5 To be in conformance with 50.2, the firing of the appliance is not to be interrupted by any control device included as part of the appliance.

54.6 The performance of a central furnace is to be such that when temperatures are measured:

T_2 minus T_1 is not more than T_L minus 70°F (21°C) where:

T_1 = Inlet-air temperature, degrees F or C.

T_2 = Outlet-air temperature, degrees F or C.

T_L = Outlet-air temperature at which limit control functioned in Limit-Control Cutout Test – Warm-Air Appliances, Section 51, degrees F or C.

70°F (21°C) = Assumed maximum inlet-air temperature demanding continuous firing of central furnace or wall furnace at high-fire input.

55 Temperature Test

55.1 When a heating appliance is tested in accordance with these requirements, no part shall attain a temperature which will damage required corrosion protection, adversely affect operation of safety controls, impair the value of required thermal or electrical insulation, or cause creeping, distortion, sagging, or similar damage when such damage to the material or part may cause the appliance to become unsafe for use. The temperature rises at specific points shall be not greater than those specified in Table 55.1 unless otherwise indicated.

Table 55.1
Maximum temperature rises

Materials and components	Column 1		Column 2	
	°C	(°F)	°C	(°F)
A. Motors[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 in diameter (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 and universal motors:				
a. In open motors:				
Thermocouple method	65	(117)	115	(208)
Resistance method	75	(135)	115	(208)
b. In totally enclosed motors:				
Thermocouple method	70	(126)	115	(208)
Resistance method	80	(144)	115	(208)
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of more than 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 systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current 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)

Table 55.1 Continued on Next Page

Table 55.1 Continued

Materials and components	Column 1		Column 2	
	°C	(°F)	°C	(°F)
B. Components				
1. Capacitors:				
a. Electrolytic type[d]	40	(72)	(Not specified)	
b. Other types[e]	65	(117)		
2. Field wiring	35	(63)	60	(108)
3. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated winding;				
Thermocouple method	65	(117)	115	(208)
b. Class 130 insulated winding:				
Thermocouple method	85	(153)	140	(252)
4. Sealing compounds	40°C(72°F) less than its melting point			
5. Transformer enclosures[b]				
a. Class 2 transformers	60	(108)	85	(153)
b. Power and ignition transformers	65	(117)	90	(162)
C. Wiring				
1. Insulated Conductors	25°C(45°F) less than the temperature rating		10°C(18°F) less than the temperature rating[f]	
2. Flexible cords – Types SJ, SJO, SJT including surfaces of the appliance which the cord may contact[i]	35	(63)	60	(108)
D. Electrical Insulation – General[f,g]				
1. Class C electrical insulation material	Not specified			
2. Class (180) electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	(117)	90	(162)
4. Phenolic composition used as electrical insulation or as parts where malfunction will result in a risk of fire or electrical shock	125	(225)	150	(270)
5. Thermoplastic material	25°C (45°F) less than its temperature rating			
6. Varnished cloth insulation	60	(108)	85	(153)
E. Metals				
1. Aluminum alloys –				
a. 1100	183	(330)	239	(430)
b. 3003	239	(430)	294	(530)
c. 2014, 2017, 2024, 5052	294	(530)	350	(630)
2. Aluminum-coated steel[h]	656	(1180)	767	(1380)
3. Carbon Steel Sheet, Cast Iron	517	(930)	683	(1230)
4. Carbon steel – Coated with Type A19 ceramic	572	(1030)	628	(1130)
5. Galvanized steel[c]	267	(480)	350	(630)
6. Stainless steel –				
Types 302, 303, 304, 316, 321, 347	767	(1380)	878	(1580)
Type 309	961	(1730)	1072	(1930)
Type 310	1017	(1830)	1128	(2030)
Type 405	683	(1230)	795	(1430)
Type 403, 409, 410, 416	572	(1030)	683	(1230)
Type 430	711	(1280)	822	(1480)
Type 442	877	(1580)	933	(1680)
Type 446	961	(1730)	1072	(1930)

Table 55.1 Continued on Next Page

Table 55.1 Continued

Materials and components	Column 1		Column 2	
	°C	(°F)	°C	(°F)
7. Zinc Castings	89	(160)	145	(260)
F. General:				
1. Air Filter	50	(90)	97	(175)
2. Flue gases	517	(930)	738	(1330)
3. Oil in constant level valve or tank	14	(25)	22	(40)
4. Surfaces of heater ot points of zero clearance to test structure	50	(90)	97	(175)
5. Surface of floor beneath and within 3 feet (0.91 mm) of heater to be classified for installation on combustible floors	50	(90)	97	(175)
6. Surfaces of test enclosure (ceiling, walls, and the like)	50	(90)	97	(175)

[a] The motor diameter is to be measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, or the like, used solely for motor cooling, mounting, assembly, or connection.

[b] Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (such as a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation or more than 2 layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of the coil (not including universal motors) where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum by the following amounts, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

1. 5°C (9°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
2. 10°C (18°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
3. 15°C (27°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.
4. 20°C (36°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.

[c] The specified maximum temperature rises apply if the galvanizing is required as a protective coating, or the reflectivity of the surface is utilized to reduce the risk of fire.

[d] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F).

[e] A capacitor which operates at a temperature higher than a 65°C (117°F) rise may be evaluated on the basis of its marked temperature rating.

[f] For conductors having a temperature rating of 200°C (392°F) or higher, the rise may be equal to the temperature rating.

[g] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and found to have special heat-resistant properties.

[h] When the reflectivity of aluminum-coated steel is utilized to reduce the risk of fire, the maximum allowable temperature rise is 830°F (461°C).

[i] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70-1990. The maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question where Column 1 temperature rise are specified, and the maximum allowable temperature rise where Column 2 temperature rises are specified is to be based on the heat resistant properties of the insulation.

56 Continuous Operation Temperature Test – Central Heating Appliances

56.1 The limit control is to be bypassed to permit continued operation during this test. The appliance is to be fired at rated input.

56.2 The outlet-air temperature of a central furnace is to be:

a) 88°F (48.9°C) above inlet-air temperature for central furnaces equipped with a limit control that does not permit an outlet-air temperature in excess of 165°F (73.9°C).

b) 123°F (68.4°C) above inlet-air temperature for central furnaces equipped with a limit control that permits an outlet-air temperature in excess of 165°F (73.9°C), but not more than 200°F (93.3°C).

56.3 The outlet-air temperature of central furnaces is to be established by gradually restricting the circulating air flow until the outlet-air temperature reaches the applicable value specified in 56.2, ±5°F (±2.8°C). The static pressure in the supply plenum of a forced-air appliance is to be not more than twice the appropriate value specified in Table 48.2. Any restriction of a return air inlet grille, not intended to be connected to a return air duct system, is to be accomplished by layers cheesecloth applied progressively. The cloth is attached to a frame such as specified in 58.5.

56.4 For boilers designed for hot-water use only, the feed water inlet is to be throttled during the test until the water temperature at the outlet of the boiler has reached the value determined in compliance with 22.3.6, but not less than 200°F (93.3°C). The feed water then is to be supplied at such a rate as to maintain the temperature at the boiler outlet within ±5°F (±2.8°C) of the specified value. A stream boiler is to be maintained at a pressure not less than 14 psig (96.6 kPa), and the feed water is to be supplied to maintain a relatively constant water level in the gauge glass. If the temperature of the boiler assembly components or the test enclosure are affected during the test by the feed-water temperature, the temperature of feed water measured at the inlet to the boiler is to be maintained 20°F (11.1°C) below the outlet-water temperature for hot-water boilers and not less than 180°F (82.2°C) for stream boilers. Boilers intended for either hot water or steam are to be tested as steam boilers.

56.5 Firing of the boiler is to be continued until equilibrium temperatures are attained as evidenced by no changes in temperature rises for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

56.6 During the test, the temperature rise above room temperature for any item is not to exceed the value specified for that Column 1 of Table 55.1.

56.7 If the boiler is equipped with a burner operating on pilot or low fire during standby periods, the following additional test is to be conducted.

56.8 The limit control is to be operative and adjusted to the specified setting and the minimum differential. See 22.3.6. The pilot or low-fire, oil-metering valve is to be adjusted to its maximum allowable setting. The boiler is to be fired at rated high-fire input and draft. The water inlet and the outlet of the boiler are to be gradually closed. CAUTION – A relief valve shall be used during this test. The burner is to be allowed to fire until equilibrium or continuously receding temperatures are attained.

56.9 The water temperature in the boilers shall not exceed the inlet-air temperature by more than 100°F (55.6°C). The temperature rises above inlet-air temperature shall not exceed the values specified in Column 1 of Table 55.1.

57 Continuous Operation Temperature Test – Water Heaters

57.1 The temperature control is to be bypassed to permit continued operation during this test.

57.2 The heater is to be fired at rated input. The flow of water through the heater is to be regulated to maintain the outlet water at a temperature of 10 ±5°F (5.6 ±2.8°C) below the outlet-water temperature that causes the temperature regulating control to function when adjusted to its maximum setting.

57.3 Firing of the heater is to be continued until equilibrium temperatures are attained as evidenced by no changes in temperature rises for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

57.4 During this test, the temperature rise above room temperature for any item is not to exceed the value specified for that Column 1 of Table 55.1.

58 Blocked Register Temperature Test

58.1 This test is to be conducted on central furnaces provided with a return air register or air opening forming a part of or in close proximity to the appliance casing and intended for alcove or closet installation.

58.2 The bypass is to be removed from any limit control, and it and any fan control are to be adjusted to the maximum allowable temperature setting and minimum differential. An adjustable register shutter is to be set at any allowable setting producing maximum temperatures. Any auxiliary warm-air outlet ducts are to be closed.

58.3 A central furnace is to be fired at a fuel input not more than that required to maintain the limit-control sensing element at a temperature measured in degrees F (if temperatures are measured in degrees C, use number within parenthesis) equivalent to 70 (21) plus T_{L2} minus T_1 where T_1 and T_{L2} are the values obtained during the Continuity of Operation Test – Warm-Air Appliances, Section 54.

58.4 When equilibrium temperatures have been attained, each main grille or register is to be covered progressively, using the frame described below, to the extent of 25, 50, 75, and 100 percent of its area, starting from any edge of the grille or register.

58.5 The frame is to consist of three layers of cheesecloth, of weight 16 – 17 yard^2/pound (29.5 – 31.3 m^2/kg), count 28 by 24, stretched taut over a wood frame of a size and shape larger than the external dimensions of the grille or register. The frame is to be made of nominal 1- by 2-inch (3/4 by 1-1/2 inch) (19.1 by 38.1 mm) lumber. The cheesecloth is to be attached to one face of the frame. The frame is to be placed so that the cheesecloth is in direct contact with the outer surface of the grille or register. The frame is to remain in place for each trial until equilibrium temperatures are attained or failure becomes evident.

58.6 An appliance designed to provide a pilot fire is to be operated at maximum allowable pilot fire until equilibrium temperatures are attained. Each grille or register of an oil-fired appliance then is to be progressively covered as indicated in 58.4.

58.7 A manually regulated appliance is to be fired at any fuel input rate between OFF or pilot-fire rate and high-fire input permitted by allowable adjustment of the metering device until equilibrium temperatures are attained. Each grille or register then is to be progressively covered as indicated in 58.4.

58.8 The tests described in 58.4, 58.6, and 58.7 are to be repeated with one or more auxiliary grilles open.

58.9 To be in conformance with 55.1, the cheesecloth is not to ignite or char during the tests. Furthermore, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the first shutoff effected by the limit control; or, if the limit control does not function, during the period terminating 1 hour after the coverage is applied. Thereafter,the temperature rises are not to exceed the values specified in Column 1, Table 55.1, except that a motor may attain a temperature not in excess of 208°F (116°C) above room temperature during any part of these tests.

59 Blocked Outlet Temperature Test

59.1 This test is to be conducted when an appliance is intended to be provided with warm-air outlet ducts.

59.2 The bypass is to be removed from the limit control, and it and the fan control are to be adjusted to the maximum temperature setting and minimum differential.

59.3 The appliance is to be fired and the flow of circulating air regulated to maintain an outlet air temperature, which will allow continuous operation of the appliance, without operation of the limit control, while maintaining a static pressure in a supply plenum not more than the appropriate value indicated in Table 48.2. After steady-state, air-temperature conditions are attained, the following test is to be conducted.

59.4 The warm-air outlets of the ducts are to be uniformly restricted to close 80 percent of the cross-sectional area of the duct and the appliance allowed to be cycled by the limit control if of the automatic-reset type or otherwise to function as it will. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

59.5 If the appliance is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature shall not exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the first shutoff effected by the limit control. Thereafter, the temperature rises shall not exceed the values specified in Column 1, Table 55.1, except that a motor may attain a temperature not in excess of 208°F (116°C) above room temperature during any part of this test. See 55.1.

59.6 If the appliance is of a type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 55.1.

59.7 If the appliance is equipped with a vaporizing burner which does not include a means to avoid pooling and which may be ignited from a pooled condition, the following additional test is to be conducted.

59.8 The appliance is to be readied so that it can be operated under the conditions described in 59.2 and 59.3 to begin this test. An integral oil tank is to be filled. The warm-air outlets of the ducts are to be uniformly restricted to close 80 percent of their open area. The burner is to be pooled to the maximum fuel level allowed by the fuel-control device, i.e., constant-level valve. The main-burner flame is to be lighted and the appliance is then allowed to be cycled by the limit control if of the automatic-reset type or otherwise to function as it will. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

59.9 If the appliance is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the main-burner flame was lighted. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 55.1, except that a motor may attain a temperature of 208°F (115°C) above room temperature during any part of the test. See 55.1.

59.10 If the appliance is of a type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above inlet-air temperature during the test are not to exceed the values specified in Column 2, Table 55.1. See 55.1.

59.11 During this test, no flame is to burn outside the combustion chamber.

60 Blocked Inlet Temperature Test

60.1 This test is to be conducted when an appliance is provided with a return air inlet intended to be connected to ducts.

60.2 The appliance is to be operated under the conditions described in 59.2 and 59.3 to begin this test.

60.3 The appliance inlet air opening or filter is to be gradually and uniformly restricted until the limit control functions. Then the appliance is to be allowed to operate until equilibrium temperatures have been attained.

60.4 During this test, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the first shut off effected by the limit control. Thereafter the temperature rises are not to exceed the values specified in Column 1 of Table 55.1, except that a motor may attain a temperature not in excess of 208°F (116°C) above room temperature during any part of this test. See 55.1.

61 Fan Failure Temperature Test

61.1 A fan-type, warm-air appliance is to be operated under the conditions described in 59.2 and 59.3 to begin this test.

61.2 The circulating air fan drive is to be disengaged unless the fan is directly attached to the driving motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The appliance is then allowed to be cycled by the limit control if of the automatic-reset type. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

61.3 If the appliance is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature shall not exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the first shutoff effected by the limit control. Thereafter, the temperature rises shall not exceed the values specified in Column 1, Table 55.1, except that a motor may attain a temperature not in excess of 208°F (116°C) above room temperature during any part of this test. See 55.1.

61.4 If the appliance is of a type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 55.1. See 55.1.

61.5 If the appliance is equipped with a vaporizing burner which may be ignited from a pooled condition, the following additional test is to be conducted even though the appliance is equipped with a means to avoid pooling.

61.6 The appliance is to be readied so that it may be operated under the conditions described in 59.2 and 59.3 to begin this test. An integral fuel tank is to be filled.

61.7 The circulating air fan drive is to be disengaged unless the fan is directly attached to the driving motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The burner is to be pooled to the maximum fuel level allowed by the fuel control device, i.e., constant level valve, the main burner flame ignited, and the appliance allowed to function as it will. The appliance is then allowed to be cycled by the limit control if of the automatic-reset type. If the appliance is of the downflow type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

61.8 If the appliance is not equipped to avoid pooling and of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature shall not exceed the values specified in Column 2, Table 55.1, during the period terminating 1 hour after the main-burner flame was lighted. Thereafter, the temperature rises shall not exceed the values specified in Column 1, Table 55.1, except that a motor may attain a temperature not in excess of 208°F (116°C) above room temperature during any part of this test. See 55.1.

61.9 If the appliance is not equipped to avoid pooling and a type equipped with an auxiliary manual-reset limit control, and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 55.1.

61.10 If the appliance is equipped with a device to avoid pooling, the temperature rise limits given in Table 55.1 do not apply, but the appliance is not to show any manifestation of a risk of fire. A part damaged as a result of the test is not to be cause for hazardous operation of the appliance when attempts to operate the appliance are made following the test.

61.11 During this test, no flame is to burn outside the combustion chamber.

62 Stalled Fan Motor Temperature Test

62.1 This test is to be conducted on a fan-type appliance only if the impedance of the circulating air fan motor provides the overcurrent protection for that motor. Only the fan motor temperatures need be recorded.

62.2 The appliance is to be operated under the conditions described in 59.2 and 59.3 to begin this test.

62.3 The rotor of the fan motor is to be locked, while the appliance is temporarily de-energized. The appliance is to be immediately reenergized and allowed to remain energized until the fan motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test. The maximum temperature rise above room temperature attained by the motor during the test shall be not more than 225°F (125°C).

62.4 If the appliance is equipped with a vaporizing burner which does not include a means to avoid pooling and which may be ignited from a pooled condition, the rotor of the fan motor is to be locked, the burner is to be pooled to the maximum fuel level allowed by the fuel-control device, i.e., constant-level device, the main burner flame lighted, and the appliance allowed to function as it will. The appliance is allowed to remain energized until the fan-motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test. The maximum temperature rise above room temperature attained by the motor during the test shall be not more than 225°F (125°C).

63 Air Flow Test – Horizontal Appliances

63.1 During operation of an appliance from a cold start, either the limit control or the fan control shall operate to prevent an air temperature in excess of 90°F (50°C) above room temperature under conditions of reverse air flow through the appliance.

63.2 This test is to be conducted on horizontal central furnaces.

63.3 A rectangular duct, the same size as the inlet air opening of the appliance, is to be attached to the return air inlet of the appliance and extended vertically by a 90 degree elbow to a distance of 6 feet (1.8 m) above the top of the return-air opening of the appliance. The appliance is to be arranged to operate against the appropriate external static pressure value indicated in Table 48.2. The limit control and fan switch, if adjustable, are to be adjusted to the maximum temperature setting and minimum differential.

63.4 Air temperature is to be measured by three individual bead-type 24 AWG (0.21 mm^2) thermocouples located in a plane of the return air (inlet air) connection of the appliance on a horizontal line one-third of the distance below the top of the return air opening of the appliance. One thermocouple is to be located 1 inch (25.4 mm) from one side of the opening, one at the center, and the other 1 inch (25.4 mm) from the opposite side of the opening.

63.5 The appliance is to be adjusted for firing at rated input, and if a pilot is used it is to be adjusted for minimum normal input. Starting with the appliance at room temperature, the pilot, if used, is to be lighted and allowed to burn for 15 minutes. The appliance is then to be fired and allowed to operate until the blower becomes operative or the limit control functions to shut off the main burner flame.

63.6 The maximum temperature indicated by any of the three thermocouples at the return air opening of the appliance shall not exceed 90°F (50°C) above room temperature prior to or during the first or subsequent cycle of operation effected by the limit control or prior to the functioning of the fan control to circulate air in the intended direction.

64 Seepage and Burnoff Temperature Tests

64.1 An appliance equipped with a burner incorporating a fire pot or a receptacle to retain or collect fuel to prevent its hazardous discharge in the event of ignition or flame failure shall be constructed so that no hazardous seepage of fuel or operation will occur when the appliance is tested as described below.

64.2 Any draft regulator furnished with the appliance by the manufacturer is to be operable during this test. The regulator is to be set to maintain manufacturer's recommended high-fire draft.

64.3 The appliance is to be tilted in any direction to an angle not more than 3 degrees from the horizontal and readied for operation at maximum rated input. Any limit control is to be operable. Drip pans or trays are to be filled with as much fuel as they will retain. An integral fuel tank is to be filled. Paper is to be placed beneath the burner. Any automatic-ignition system is to be rendered inactive.

64.4 The fuel valve is to be opened as required for firing at high-fire rate. The unlighted appliance is to be allowed to stand for 48 hours, during which time no fuel is to drip onto the paper nor accumulate on surfaces of the combustion chamber, flue passages, or chimney connector.

64.5 The paper is to be removed, the appliance lighted and allowed to fire until steady-state combustion and equilibrium temperature conditions are attained. During that time, no flame is to be expelled into the room from the appliance or a draft regulator.

64.6 If an appliance is equipped with a manually controlled air circulating fan, the tests of 64.1– 64.5 are to be conducted with the fan idle until equilibrium temperatures are attained and then are to be continued with the fan operating until equilibrium or continually receding temperatures are attained.

64.7 During this test, the temperature rises above room temperature shall not exceed the values specified in Column 2 of Table 55.1.

64.8 An appliance equipped with an optional draft booster and a natural draft burner is to be tested with and without the power supply connected to the draft booster.

64.9 If the appliance is equipped with a device to avoid pooling of the burner, and the device can be nullified by a malfunction of the device, the appliance is to be tested as specified above, except that the appliance is to be level. The burner is to be pooled to the extent allowed by the fuel level control with the antipooling device not functioning.

65 Direct Vent System Leakage Test

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

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4.0 percent of the products of combustion; and

b) The leakage from the air intake section of the system shall not exceed 8.0 percent of the products of combustion. See 65.2 – 65.5.

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

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

65.4 Clean air is to be permitted to flow through a metering device and into the section of the direct vent system being pressurized through the air supply fitting. The air supply fitting to the section of the system not being pressurized is to be open. The internal air pressure in the section of the system being pressurized is to be adjusted to:

a) 0.1 inch water column (25 Pa) above the normal operating system pressure for forced draft systems operating at positive combustion chamber pressures and

b) 0.1 inch water column for all other systems. The leakage rate is to be noted in cubic feet per hour for both the air intake and combustion chamber-vent sections of the direct vent system.

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

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

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

where:

L_c = *Allowable leakage rate from combustion chamber-vent section of direct vent system, cubic feet per hour.*

L_a = *Allowable leakage rate from air intake section of direct vent system, cubic feet per hour.*

V = 1960 cubic feet of flue products based on the formation of approximately 1276 cubic feet of dry flue products plus 684 cubic feet of excess air, when one gallon of ASTM D396 No. 2 fuel oil (nominal density 7.432 pounds per gallon) is burned.

I = Fuel oil input rating, in gallons per hour.

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

a) The leakage from the combustion chamber-vent section of the system shall not exceed 4.0 percent of the products of combustion, as calculated in 65.5, and

b) The leakage from the total system shall not exceed 8.0 percent of the products of combustion plus the leakage, in percent, determined for the combustion chamber-vent section. See 65.7 – 65.10.

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

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

65.9 Using the test apparatus and method of test outlined in 65.3 and 65.4, the total system is to be pressurized and the leakage rate noted in cubic feet per hour.

65.10 The combustion chamber-vent section of the system is then to be sealed, with the appropriate fittings noted above, at the first joint of the vent portion of the combustion chamber-vent section contained within the air intake section downstream of the combustion chamber. Using the test apparatus and method of test outlined in 65.3 and 65.4, the combustion chamber-vent section is to be pressurized and the leakage rate noted in cubic feet per hour.

66 Short Circuit Test

66.1 Inherent overheating-protective devices, bonding conductors or connections when required, and conductors of multiple motor circuits shall withstand short circuiting when protected by a fuse of the size required by the appliance.

a) Bonding conductors and bonding connections shall not open when samples are subjected to the conditions of this test.

b) Motor-circuit conductor shall not become damaged when samples are subjected to the conditions of this test.

c) There shall be no ignition of cheesecloth surrounding the enclosure of a protective device when three samples are tested.

66.2 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the appliance. See Table 66.1. The appliance full-load current is to be determined by adding the motor full-load current to that of each other motor, as determined in compliance with the National Electrical Code, ANSI/NFPA 70-1993, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current employed as the basis of selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit. See 66.3.

Table 66.1
Short-circuit test currents

Full-load amperes				Circuit capacity amperes
Single phase				
115 volts	208 volts	230 – 240 volts	277 volts	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.1 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	17.1 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
0 to 250 volts, dc – 0 to 648 volt-amperes				200

66.3 Except as specified in 66.5 – 66.8, an overcurrent protective or a thermal protective device on an appliance having more than one motor wired for connection to one supply line shall withstand short circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied. There shall be no ignition of cheesecloth surrounding the enclosure of the protective device when samples are subjected to a short circuit test.

66.4 The nearest standard size fuse, rated not higher than the current specified in 66.3, but not less than 15 amperes, is to be employed for the test. The maximum fuse size marked on the appliance is not to exceed this value.

66.5 With reference to 66.3, the protective device may be tested with a fuse having a lower rating than specified, provided the appliance will start and operate without opening the fuse and is marked to specify such a maximum limit of fuse protection.

66.6 If a thermally protected motor or a separately enclosed overcurrent protective device is located within an outer cabinet, and if the assembly is constructed so that it can be determined that flame and molten metal will be confined within the cabinet, and any flammable material except electrical insulation or an air filter is not located below the motor and will not sustain combustion upon removal of the ignition source, the Short Circuit Test for risk of fire specified in 66.3 may be waived. However, if short circuiting between live parts of different circuits may result, the Short Circuit Test is not to be waived.

66.7 Short circuit tests are not required for an assembly with more than one motor, if the rating of each motor does not exceed 1 horsepower (746 W output), and the assembly is intended to be used on a branch circuit protected at not more than 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, provided the following conditions are met:

a) The marked maximum branch circuit protective device size does not exceed the values specified above, and

b) The full-load current rating of each motor does not exceed 6 amperes.

66.8 Short circuit tests are not required for an assembly with more than one motor if the motor(s) have full-load current or horsepower rating(s) in excess of those specified in 66.7, provided:

a) The marked maximum branch circuit protective device size of the assembly does not exceed the maximum size for protecting the motor of the smallest rating, and

b) It is determined that a fuse of marked size will not open under the most severe conditions of service which might be encountered.

66.9 A nonrenewable cartridge fuse is to be connected in series with the device. A new fuse and device, connection, or conductor are to be used for each test.

67 Dielectric Voltage Withstand Test

67.1 An appliance shall withstand for 1 minute without breakdown, the application of 60 hertz (Hz) alternating potential between high-voltage live parts and dead-metal parts, and between live parts of high- and low-voltage circuits. The test potential shall be:

a) 1000 volts plus twice rated voltage except as specified in (b).

b) 1000 volts for motors rated at not more than 1/2 horsepower-output (373 W-output) and not more than 250 volts.

67.2 Where higher than rated voltage is developed in a motor circuit through the use of capacitors, the rated voltage of the appliance is to be employed in determining the dielectric voltage withstand test potential; unless the developed steady-state capacitor voltage exceeds 500 volts, in which case the test potential for the parts affected is to be 1000 volts plus twice the developed voltage.

67.3 A low-voltage circuit shall be capable of withstanding, for 1 minute without breakdown, a 60 Hz alternating potential of 500 volts applied between low-voltage live parts of opposite polarity and between low-voltage live parts and dead-metal parts.

67.4 The dielectric voltage withstand test between low-voltage parts of opposite polarity may be waived on the complete assembly provided the components have been separately subjected to this test condition and the wiring is with material as tabulated in Table 24.1.

67.5 A 500 VA or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with the foregoing. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute. The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment during the duration of the test.

68 Nonmetallic Dip Tube Tests

68.1 Deformation and weight loss

68.1.1 A nonmetallic dip tube shall be subjected to the tests described in 68.1.2 – 68.1.4. The dip tube shall not have:

a) A linear deformation of more than 1/2 inch (12.7 mm),

b) A total lateral deformation of more than 1-1/2 inches (38.1 mm), and

c) A weight loss.

68.1.2 Twelve 51-inch (1.30-m) long dip tube samples are to be tested. Each sample is to be cut to a length of 49 inches (1.24 m), and the weight of each cut-sample is to be determined using a laboratory grade measuring device with a full scale reading not to exceed three times the weight of the sample.

68.1.3 Linear deformation and change of weight are to be determined by suspending the samples as they would be in service for 48 hours in water maintained at 200°F (93°C). The samples are then to be removed from the water and cooled to room temperature. Any surface water is to be removed, and the length and weight are to be determined and compared to the original results.

68.1.4 Lateral deformation is to be determined by installing one end of each sample in a fixture (as it would be in a tank inlet fixture), and measuring the distance between the position of the centerline of the free end and the extended centerline of the fixture. Following immersion for 48 hours in water maintained at 200°F (93°C), the samples are to be removed from the water and cooled to room temperature. Any surface water is to be removed, and the lateral deformation measured. The total lateral deformation of each sample is acceptable if it is within the limits of a circle having a radius of 1-1/2 inches (38.1 mm) measured from the extended centerline of the fixture.

68.2 Resistance to crushing

68.2.1 When tested as described in 68.2.2 – 68.2.4, a nonmetallic dip tube shall not deform more than 1/4 inch (6.4 mm) as described in 68.2.4.

68.2.2 Ten 2-inch (51-mm) long dip tube samples are to be tested. Each test sample is to be tested as described in 68.2.3. The apparatus for the test is to be as illustrated in Figure 68.1. The samples are to be subjected for 24 hours to transverse loading under a weight of 870 grams while being maintained at a temperature of 225 plus 5 minus 0°F (107 plus 3 minus 0°C).