UL 733

STANDARD FOR SAFETY

Oil-Fired Air Heaters and Oil-Fired Direct-Fired Heaters

UL Standard for Safety for Oil-Fired Air Heaters and Oil-Fired Direct-Fired Heaters, UL 733

Fifth Edition, Dated May 2, 2019

Summary of Topics

This new edition of UL 733 dated May 2, 2019 includes the following changes:

Change to the title and scope of standard

Update to the glossary terms

Clarify assembly requirements

Clarify construction requirements

Clarify marking requirements

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 21, 2018

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Standard for Oil-Fired Air Heaters and Oil Fired Direct-Fired Heaters

The first through fourth editions were titled Oil-Fired Air Heaters and Direct-Fired Heaters

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Second Edition – May, 1973
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Fourth Edition – August, 1993

Fifth Edition

May 2, 2019

This UL Standard for Safety consists of the Fifth Edition.

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

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INTRODUCTION

1 Scope

1.1 These requirements apply to oil-fired air heaters and oil fired direct-fired heaters.

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

1.3 This standard is not intended for permanently installed heaters.

2 General

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

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

2.3 Except as indicated in 2.4, 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.

2.4 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b) Is superseded by a requirement in this standard.

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

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

4 Undated References

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

5 Glossary

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

5.2 AIR HEATER – An appliance, manufactured for assembly as a complete unit, intended to supply heated air for space heating and other purposes, equipped with one or more oil burners, safety controls, electrical equipment as needed, and related equipment and provided with a flue collar designed so that

combustion products or flue gases are not mixed in the appliance with the medium to be heated. This definition does not include central furnaces, kerosene stoves, oil-burning stoves, or unit heaters..

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

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

5.5 APPLIANCE FLUE – The flue passages with in the appliance.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.23 DIRECT-FIRED HEATER – A heater, equipped with one or more oil burners, safety controls, electrical equipment as needed, and related equipment, manufactured for assembly as a complete unit, in which combustion products or flue gases are mixed with the air being heated, such as a salamander.

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

5.25 ELECTRICAL CIRCUITS:

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

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

1) A Class 2 transformer, or by a battery, by a battery and fixed impedance, or by 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.

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

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

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

5.29 FLUE GASES – Combustion products and excess air.

5.30 FUEL OIL – Any hydrocarbon oil as defined by Commercial Standard CS12 or ASTM D396-1969, ANSI Z11.203-1970.

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

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

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

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

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

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

b) Setting ignition electrodes.

c) Cleaning strainers or replacing strainer or filter elements.

d) Resetting safety control.

e) Replacing igniter cable.

5.36 PILOT – A flame, smaller than the main flame, which is utilized to ignite the fuel at the main burner(s).

5.37 PORTABLE APPLIANCE – A mobile appliance or one intended to be moved from place to place. The term indicates a temporary installation as opposed to a permanent installation.

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

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

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

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

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

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

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

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

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

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

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

6 Instructions

6.1 A copy of the manufacturer's operating and installation instructions is to be furnished with each heater to be used as a guide in the examination and test of the appliance. For this purpose, a printed edition is not required.

6.2 The instructions should include such directions and information as deemed by the manufacturer to be adequate for attaining proper and safe installation, maintenance, and use of the heater.

CONSTRUCTION

7 Assembly

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

7.2 An outdoor-use heater shall conform also to Sections 58 – 64.

7.3 The various parts of a heater shall be constructed and assembled in accordance with these requirements in a manner to ensure strength, rigidity, and durability.

7.4 A heater, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated readily into the final assembly without requiring alteration, cutting, drilling (except to the extent indicated in 7.5) 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 heater shall be arranged and constructed to permit them to be incorporated into the complete assembly, only in the correct relationship with each other; without need for alternation or alignment; or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

7.5 To be in accordance with 7.4 major subassemblies of a heater are deemed to be the burner; the heat exchanger, including its base, combustion chamber, casing, and safety controls; the blower assembly, including the base, filters, and casing; and the blower motor if not included as part of the blower assembly. A wiring harness may be packaged with one of the major subassemblies.

7.6 The base, frame, or housing of a heater shall be constructed to permit movement of the heater without damaging it. Parts of the heater shall not be damaged when any side of the heater is placed as close to a solid vertical wall as the base, frame, or housing will permit.

7.7 The chassis or frame of a mobile heater intended to be hauled by a vehicle shall be constructed of channel-iron framework or of formed-steel members not less than 0.134 inch (3.40 mm), or the equivalent, adequately cross-braced, and of sufficient strength to support safely, with a factor of not less than five, the framework and equipment when in transit. The hitching yoke which extends in front of the assembly and to which the coupling mechanism is attached shall be an integral part of the chassis.

7.8 The chassis should be equipped with springs, wheels, and brakes of a strength and construction to ensure safety while the heater is in transit.

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

7.10 A heater shall afford convenient operation by the user of those parts requiring attention or manipulation in intended usage.

7.11 Parts, when adjustable or movable, shall be provided with locking devices to reduce the risk of unintentional shifting.

7.12 Screws or bolts used to attach parts that are detached for intended care or servicing of the appliance shall be capable of holding upon the application of the torques indicated in Table 7.1 after removal and replacement.

Table 7.1
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)

7.13 Any external door providing access into the combustion chamber of a heater shall be self-closing.

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

7.15 A heater equipped with an antiflooding device shall be constructed so that, when the heater is level, the minimum distance between the intended maximum oil level maintained by the oil control device and the level of the lowest point at which overflow may occur is not less than 3/4 inch (19.1 mm).

8 Accessibility for Servicing

8.1 A heater shall be built to allow cleaning of parts such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers, without major dismantling of the heater or removal of parts required by 7.3 to be factory-assembled.

8.2 The removal of access panels, burners, blowers, caps, plugs, and the like, specifically constructed to permit ready removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 8.1.

8.3 Accessibility shall be afforded for intended cleaning, inspection, repair, and replacement of all burners, operating controls, and safety controls. The disposition of parts in the assembly removed for intended care shall be such that their restoration following removal will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special tools or parts required for intended care to be done by the operator shall accompany the heater to the user.

9 Disposal of Combustion Products

9.1 The construction of a heater shall not allow the products of combustion to become mixed with the circulating air.

10 Casing

10.1 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 0.032 inch (0.81 mm) (No. 20 MSG).

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

10.3 A removable panel through which air is drawn for combustion shall be so constructed as to reduce the risk of its being attached in a manner that may result in a risk of fire, electric shock, or injury to persons.

10.4 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same heater when interchange may result in a risk of fire, electric shock, or injury to persons.

10.5 The casing or base of a heater shall completely close the bottom or be constructed to provide an effective partition between the heat exchanger and the floor or ground.

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

11 Radiation Shields or Liners and Materials in Air Handling Compartments

11.1 A radiation shield or liner shall be so constructed, formed, and supported so that it cannot be improperly positioned and so that distortion or sagging in service cannot occur. A shield or liner shall be protected against corrosion if its deterioration may cause temperatures in excess of those specified in Table 44.1 when the heater is tested in accordance with these requirements. Any finish intended to obtain the required resistance to corrosion shall not be damaged by heat when the heater is tested under these requirements.

11.2 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.

11.3 Insulating material that is not self-supporting, employed as a radiation shield, shall be applied to solid surfaces in a manner to prevent sagging. The insulating material shall not have a flame spread rating over 25 nor a smoke developed rating over 50 when tested in accordance with the tests for surface burning characteristics of building materials, UL 723, and its insulating value shall be unimpaired by heat

when the heater is tested under these requirements. An adhesive for attaching insulating material shall retain its adhesive qualities at any temperature it may attain when the heater is tested under these requirements and at 0°F (minus 17.8°C) or minus 20°F (minus 29°C) for outdoor use equipment.

11.4 Insulating material shall be securely positioned if:

a) Loosening may reduce or block air flow to cause temperature or pressures in excess of those acceptable in the temperature tests, or

b) 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.

11.5 A mechanical fastener for each square foot (m^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 normally provides 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.

12 Air Filter

12.1 A filter supplied as a part of the heater shall be accessible for inspection or replacement without the use of special tools and without dismantling the heater.

13 Integral Oil Tanks

13.1 A heater may be equipped with an integral oil supply tank having a capacity of not more than 20 gallons (76 liters) from which the fuel may be delivered to the burner by gravity or suction feed.

13.2 A tank shall be constructed of material equivalent to that described in 13.3 – 13.7.

13.3 Uncoated sheet steel shall have a minimum thickness of 0.053 inch (1.35 mm) (No. 16 MSG). A preservative shall be applied to uncoated surfaces of tanks to prevent rusting.

13.4 The thickness of aluminum-coated steel, galvanized sheet steel, terne sheet, and noncorrodible sheet metal shall be not less than that of No. 20 gage steel. Coated sheet shall be of prime finish, that is, free from blisters, flux, and uncoated spots visible to the unaided eye.

13.5 Galvanized steel shall have a coating of zinc conforming with the coating Designation G90 in Table I of ASTM Designation A653, 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 be determined by any suitable method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM Designation A90-69.

13.6 The coating of terne sheet shall be not less than 8 – 12 pounds (3.6 – 5.4 kg) per double base box, 112 sheets, 20 by 28 inches (508 by 711 mm).

13.7 The coating of aluminum-coated steel shall be adequate for the purpose as determined by test.

13.8 Tanks made of uncoated sheet steel, aluminum-coated steel, and terne sheet shall be of "full-drain" construction.

13.9 Full-drain construction is obtained by building a tank so that it is emptied through the fuel feed outlet at the bottom of the tank.

13.10 A tank not required to be full-drain construction shall allow the ready removal of any accumulation of water or sludge. For a tank not over 18 inches (457 mm) deep, this may be accomplished by providing an accessible fill opening large enough to permit entrance of the average adult hand.

13.11 Joints of all fuel tanks shall be lock-seamed (see 16.2), brazed, welded, or otherwise made mechanically secure. All joints not continuously brazed or welded shall be thoroughly sweated with solder. The brazing or welding of coated sheets less than 0.045 inch (1.14 mm) (No. 18 GSG) shall not damage the coating of the surfaces in contact with oil when the tank is full. All connections shall be made through solid threaded bosses or fittings mechanically secured to the tank.

13.12 A tank shall be constructed for permanent attachment to the heater and be supported securely in its proper position on the heater.

13.13 An integral tank shall be provided with a liquid-level indicator readily observable when the tank is being filled unless the fill opening is of a shape and size permitting ready observation of the liquid level within the upper 2 inches (50.8 mm) below the lowest point of overflow while the tank is being filled.

13.14 A gauge glass or sight feed, the breakage of which will allow the escape of fuel, shall not be used.

13.15 The top of the fill opening of a tank shall not be above the level at which oil will overflow the tank.

13.16 A tank shall permit filling by the operator from the floor level in a manner to avoid oil spillage without requiring the operator to reach over the heater.

13.17 A tank shall be equipped with a securely attached fill cap that is oil-tight when in place, except for the vent hole which shall be splash-proof.

14 Combustion Chamber

14.1 A combustion chamber shall be constructed of cast iron, sheet steel, or equivalent material. Sheet steel, if used, shall be such as to assure strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a minimum thickness of 0.042 inch (1.07 mm) (No. 18 MSG).

14.2 For outdoor-use heaters, the combustion chamber shall be constructed of material equivalent to sheet steel having a minimum thickness of 0.053 inch (1.35 mm) (No. 16 MSG).

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

15 Radiator

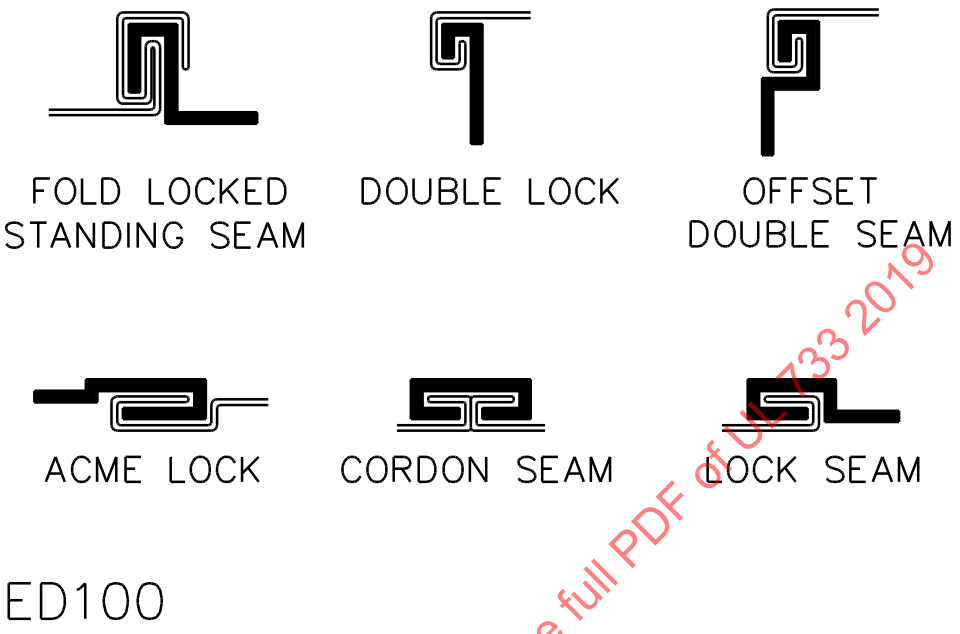
15.1 A radiator shall be made of material not lighter than that designated in 14.1 for a combustion chamber and shall be readily cleanable.

16 Heating Surface Joints

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

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

Figure 16.1
Types of acceptable lock-seams



17 Baffles

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

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

18 Flue Collar

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

18.2 A flue outlet of a heater shall be vertical and so located that when a vertical flue pipe is connected, the flue pipe will be not less than 9 inches (229 mm) from a vertical wall when any side of the heater is placed as close to the wall as the base, frame, or housing of the heater will permit.

18.3 A flue collar or flue collector parts within the air handling compartment shall have the rigidity, heat resistance, and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.042 inches (1.07 mm) (No.18 MSG).

19 Damper and Draft Regulator

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

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

20 Ducts

20.1 An outlet duct for a direct-fired heater shall be of material equivalent to metal having a melting point of not less than 950°F (510°C). A duct provided as part of an air heater shall conform to the following:

a) It shall be made from metal or mineral base material.

b) It shall not be subject to deterioration from mildew or moisture.

c) It shall be no more combustible than flame-resistant fabric conforming to the applicable requirements in Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, NFPA 701.

21 Controls

21.1 Application

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

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

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

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

21.1.5 All safety controls shall be accessible.

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

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

21.1.8 A burner not equipped to provide automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel interrupted power supply.

21.2 Limit control

21.2.1 A heater shall be provided with an integral limit control to prevent excessive temperature.

21.2.2 The maximum setting of a limit control allowed by a fixed stop shall permit an outlet-air (or air and combustion products) temperature of not more than the temperature for which the heater is intended.

21.2.3 An automatically fired heater shall be provided with a recycling type limit control unless the heater is constructed so that equilibrium output temperature is obtained during the Limit Control Cutout Test, Section 42, at a value lower than the appropriate value specified in 41.1.

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

21.2.5 The purpose of the above requirement is to avoid interposing in the limit-control circuit other controls, the malfunction of which may result in the limit control's not operating as intended.

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

21.3 Primary safety control

21.3.1 An automatically lighted heater and one intended for use where a competent attendant will not be on duty constantly in the room where the heater is located, while it is in operation, shall be equipped with a suitable primary safety control.

21.3.2 A constant-level valve shall be capable of maintaining the oil level to within ±1/32 inch (0.8 mm) of the intended oil level during operation of the heater.

21.3.3 A heater equipped with an antiflooding device shall be constructed so that when the heater is level, the minimum distance between the intended maximum oil level maintained by the oil-control device and the level of the lowest point at which overflow may occur is not less than 3/4 inch (19.1 mm).

22 Field Wiring

22.1 General

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

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

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

22.1.4 A cord furnished for connecting a heater to the electrical supply shall be Type SO or the equivalent, and facilities shall be provided for stowing the cord when not in use. An attachment-plug cap shall be of an acceptable type.

22.1.5 The size of a junction box in which field-installed conductors are to be connected by splicing shall not be less than that specified in Table 22.1. A conductor passing through the box is to be counted as one conductor, and each conductor terminating in the box is also to be 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 22.1
Size of junction boxes

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

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

Table 22.2
Trade size of conduit in inches[a]

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

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

22.1.7 A box or enclosure included as part of the assembly and in which a branch circuit supplying power to the heater is to be connected shall not require that it be moved for intended 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.

22.1.8 A box or enclosure in which field-installed conductors are to be connected as indicated in 22.1.7 and 22.1.9 shall be located so that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the heater is tested in accordance with these requirements.

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

22.2 Leads and terminals

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

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

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

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

22.2.5 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead-metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. Open slot-type connectors shall not be used unless they 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).

22.2.6 Field wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required. This may be accomplished:

a) By two screws or rivets;

b) By square shoulders or mortices;

c) By a dowel pin, lug, or offset;

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

e) By some other equivalent method.

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

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

22.2.9 Terminal parts by which field wiring connections are made shall consist of soldering lugs or pressure terminal connectors, secured in place in accordance with 22.2.6, except that for 10 AWG (5.3 mm^2 and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

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

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

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

22.2.13 A wire-binding screw shall thread into metal.

23 Internal Wiring

23.1 General

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

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

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

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

23.2 Methods

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

23.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 23.2.15 and 23.2.16.

23.2.3 Group A of Table 23.1 includes some wiring materials acceptable for use if enclosed as indicated in 23.2.2.

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

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

Table 23.1
Typical wiring materials

Group	Type of wire, cord or cable	Wire size		Insulation thickness	
		AWG	mm^2	in.	mm
A	RF-2, FF-2, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, T, THW, XHHW, MTW, THW-MTW, THWN, TW, or thermoplastic appliance wiring material, with insulation thicknesses shown at the right corresponding to the wire sizes indicated.	10 & Smaller	5.3	2/64	0.8
		8	8.3	3/64	1.2
		6	13.3	4/64	1.6
		4	21.2	4/64	1.6
		3	25.7	4/64	1.6
		2	33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.0	5/64	2.0
B	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	8.3	6/64	2.4
		6	13.3	8/64	3.2
Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, 8.3 mm^2), are considered equivalent to the wiring material referenced in Group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type suitable for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, flammability and the like.				

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

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

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

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

23.2.10 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which high-voltage wiring materials, as specified in Group A of Table 23.1, may be employed. Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

23.2.11 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 such that the insulating bushing or its equivalent will be visible for inspection.

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

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

23.2.14 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 23.2.12.

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

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

23.2.15 Cords or appliance wiring material as referenced in Group B of Table 23.1 may be employed if the wiring is enclosed by a heater casing conforming to all of the following:

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

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

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

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

23.2.16 With reference to 23.2.15(d), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements for flammability of plastic materials for parts in devices and appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

23.2.17 Cords and other wiring material permitted in accordance with 23.2.15 shall be arranged to avoid being mechanically damaged, such as by closely following surfaces, and shall be adequately supported. Strain relief, where required, shall be provided.

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

23.2.19 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 greater than 90°C (194°F) under intended operating conditions.

23.2.20 To provide an acceptable opening in sheet metal not requiring a bushing usually requires rolling, extrusion, or both, of the metal around the opening or the insertion of a grommet conforming to 23.2.18.

23.3 Short circuit protection

23.3.1 Except as indicated in 23.3.2, conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected and wired for connection to one supply line shall withstand the conditions of a short-circuit test without creating a risk of fire of electric shock. See Short Circuit Test, Section 51.

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

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

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

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

24 Separation of Circuits

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

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

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

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

b) Uninsulated live parts of any other circuit.

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

24.4 Segregation between field installed conductors and from uninsulated live parts connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits. If the number of openings in the enclosure does not exceed the minimum required for proper wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 24.3 that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit is to be investigated. To determine if a device complies with the requirements of 24.3, it is to be wired as it would be in service and in doing so a

reasonable amount of slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

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

24.6 A metal barrier shall have a thickness at least as great as that required by Table 28.1, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

25 Bonding for Grounding

25.1 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 likely to be performed when the equipment is energized shall be electrically connected to the point of connection of an equipment ground.

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

25.3 Metal parts as described below need not be grounded:

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

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

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

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.

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

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

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

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

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

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

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

25.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 25.11 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.

25.10 Where the bonding means depend upon screw threads, two or more screws, or two full threads of a single screw engaging metal, is considered in compliance with 25.8.

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

a) When carrying for the time indicated in Table 25.1 twice the current equal to the rating of the branch-circuit overcurrent device required to protect the equipment, and

d) During a short-circuit test in series with a fuse of proper rating. See Short-Circuit Test.

Table 25.1
Duration of current flow, bonding-conductor test

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

25.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 25.11, the size of the conductor or strap shall be in accordance with Table 25.2.

Table 25.2
Bonding wire conductor size

Rating of Overcurrent Device, Amperes	Size of Bonding Conductor[a]			
	Copper Wire		Aluminum Wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.3)
40	10	(5.3)	8	(8.3)
60	10	(5.3)	8	(8.3)
100	8	(8.3)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

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

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

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

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

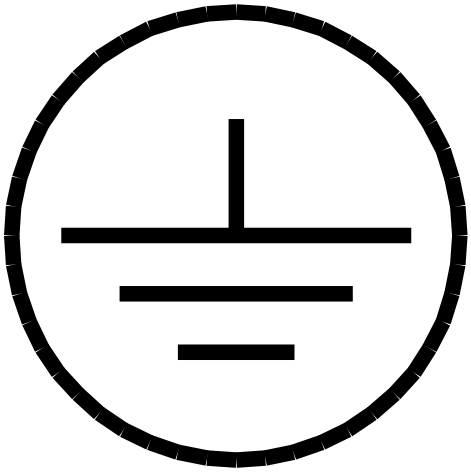
b) In equipment intended to be connected by a nonmetal enclosed wiring system, e.g., metal clad cable – An equipment grounding terminal or lead.

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

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

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

Figure 25.1
Grounding symbol



25.19 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.

ELECTRICAL COMPONENTS

26 General

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

26.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may allow operation of the equipment that results in risk of fire, electric shock, or injury to persons.

27 Mounting of Electrical Components

27.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 27.2 and 27.3.

27.2 The requirement that a switch 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 normal operation of the switch.

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

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

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

27.3 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.

27.4 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.

27.5 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 Electrical Enclosures

28.1 General

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

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

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

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

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

28.1.3 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.

28.1.4 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.

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

28.1.6 Sheet metal complying with Table 28.1 and Table 28.2 whichever applies, is acceptable for the individual enclosure of electrical components.

28.1.7 Where the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 28.1 or Table 28.2 whichever applies, may be employed.

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

28.1.9 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 28.1.3.

Table 28.1
Minimum thickness of sheet metal for enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b] in		Maximum length[c] in		Maximum width[b] in		Maximum length in					
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	Uncoated (MSG)		Metal coated (GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d]	(0.51)	0.023[d]	(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[d]	(0.66)	0.029[d]	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.34)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.53)	0.063	(1.61)
25.0	(63.5)	31.0	(78.7)	35.0	(89.0)	43.0	(109.2)	(15)		(15)	
25.0	(63.4)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.04)	0.084	(2.13)
35.0	(89.0)	47.0	(119.4)	54.0	(137.1)	66.0	(167.6)	(13)		(13)	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.80)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)		(11)	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)		(10)	

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

Table 28.1 Continued on Next Page

Table 28.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)	
Maximum width[b] in		Maximum length[c] in		Maximum width[b] in		Maximum length in			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	Uncoated (MSG)	Metal coated (GSG)

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

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

c) 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.

[d] Sheet metal for an enclosure intended for outdoor use shall comply with 59.1.6 and 59.1.7.

Table 28.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

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

Table 28.2 Continued on Next Page

Table 28.2 Continued

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

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

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

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

c) 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.

[d] Sheet metal for an enclosure intended for outdoor use shall comply with 59.1.6 and 59.1.7.

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

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

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.

28.1.11 The criteria for judging an opening in an electrical enclosure are given in the following items and the related figures:

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

1) A probe as illustrated in Figure 28.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 28.2 cannot be made to touch enamel-insulated wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 28.3.

28.1.12 During the examination for conformance with the requirements of 28.1.11, any part of the enclosure (including air filters) which may be removed without the use of tools is to be removed.

Figure 28.1
Probe

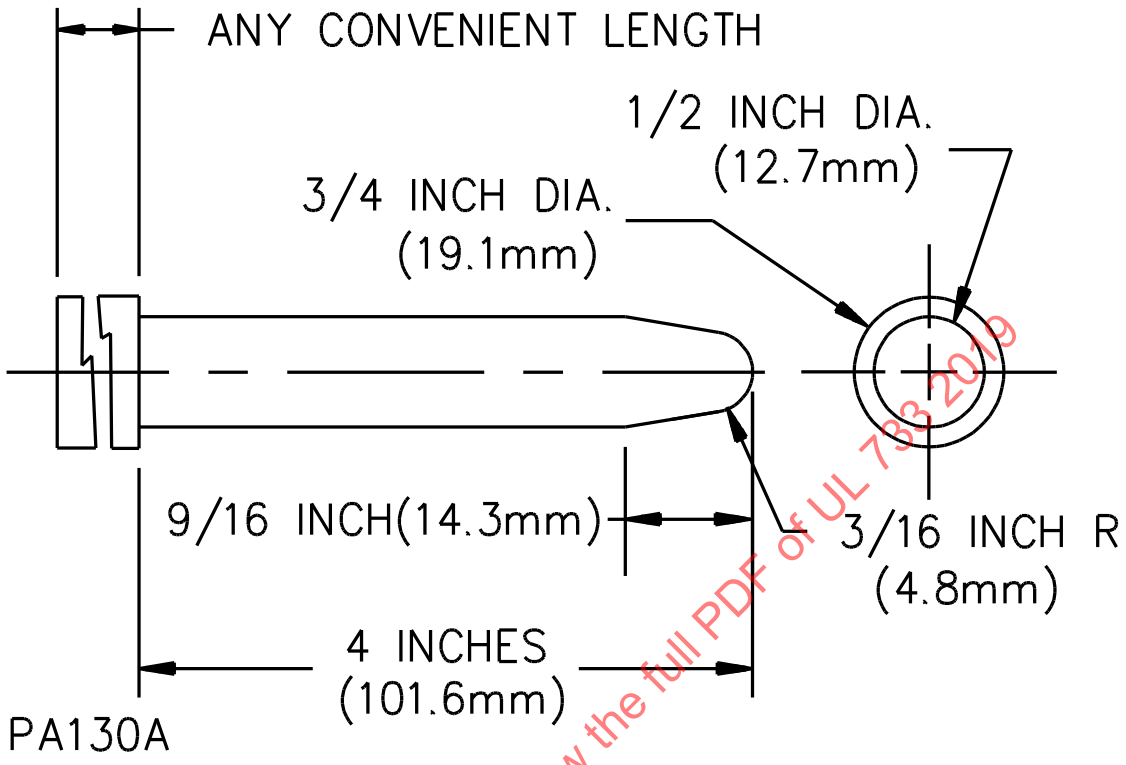


Figure 28.2
Probe

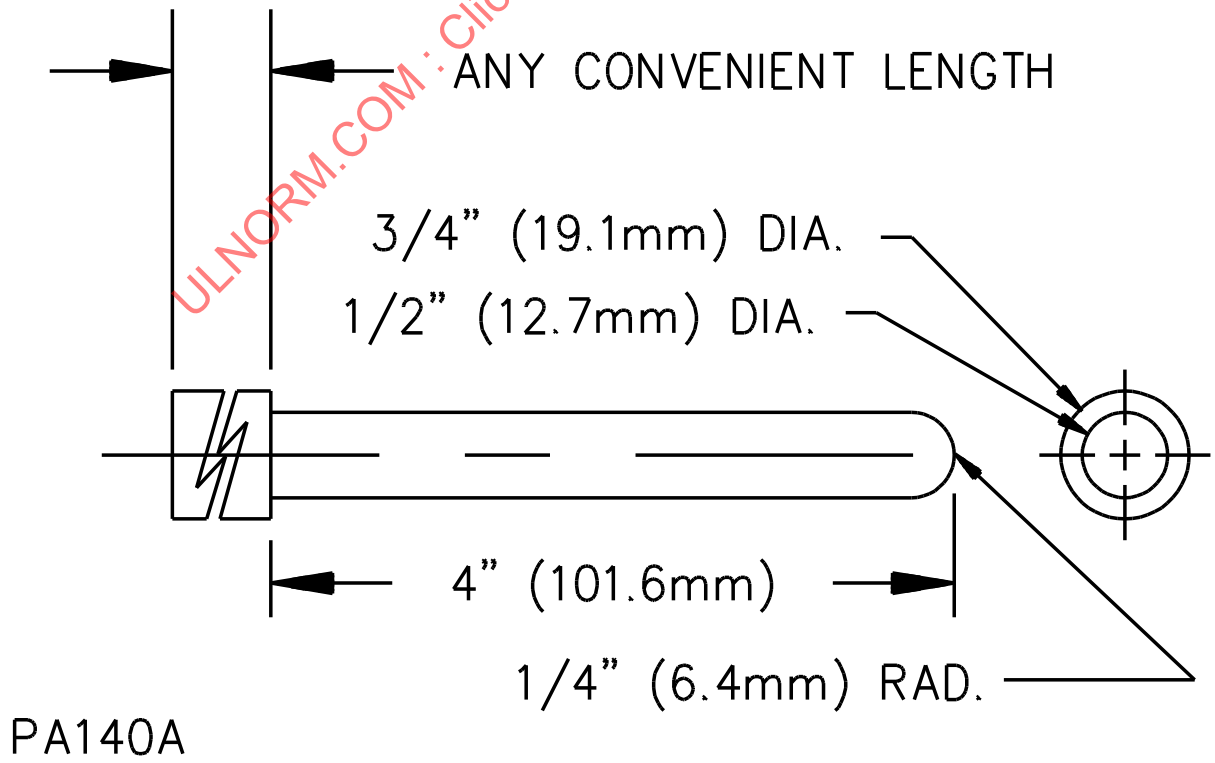
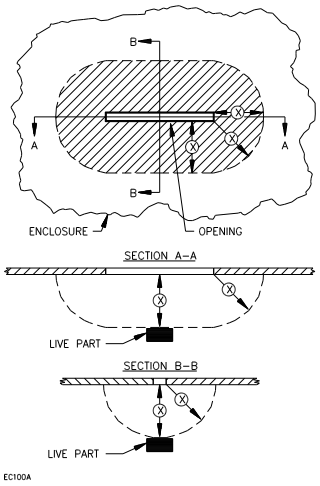


Figure 28.3
Opening in enclosure



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

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

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

28.2 Doors and covers

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

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

28.2.3 The assembly shall be so arranged that an overcurrent protective device such as a fuse, whose normal functioning requires renewal can be replaced, and manual-reset devices can be reset without removing parts other than a service cover or panel and a cover or door enclosing the device. See 28.2.7.

28.2.4 A required protective device shall be wholly inaccessible from outside the appliance without opening a door or cover, except that the operating handle or 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.

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

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

28.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manual reset overload protective device, except as indicated in 28.2.8.

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

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

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

c) Fuses in low-voltage circuits.

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

28.2.10 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open, is considered to be an acceptable means for holding the door in place as required in 28.2.9.

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

28.2.12 Strips used to provide rabbets or angle strips fastened to the edges of a door shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip, and at points between these end fastenings not more than 6 inches (152 mm) apart.

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

28.3 Field wiring system connection

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

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

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

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

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

28.3.6 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) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum 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 Motors and Motor Overload Protection

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

29.2 "Overcurrent protective devices" as referred to in 28.1, mean those which conform to the requirements of the National Electrical Code, ANSI/NFPA 70 as follows:

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

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

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

3) All other motors – 115 percent

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

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

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

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

3) All other motors – 130 percent

29.3 An integral thermal protective device is to comply with the Standard for Overheating Protection for Motors, UL 2111.

29.4 Separate overcurrent devices, except when included as part of a magnetic motor controller, are to be assembled as part of the equipment and be readily 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 allow operation of the equipment that results in risk of fire, electric shock, or injury to persons.

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

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

b) Thermal protectors, combinations of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide protection under primary single-phase failure conditions when supplied from transformers connected Wye-Delta or Delta-Wye. Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phase conditions. This marking may be a paper sticker, decal, or an attached wiring diagram.

29.6 If the assembly is of such construction that it is not intended to be installed in isolated, inaccessible, or unattended locations, two properly rated overcurrent devices or equivalent thermal protection may be employed provided the assembly is marked to indicate it is for operation only in the presence of a competent attendant.

29.7 "Unattended," as used in 29.6, is defined as lacking the presence of a person, not necessarily an electrician, capable of exercising responsible control of the motor under consideration. Such a person need not be in sight of the motor at all times but must be available for opening the motor circuit in the event of motor overheating.

29.8 A motor included in a heater shall be of the totally enclosed construction if not wholly enclosed within the heater casing.

29.9 In determining compliance with 29.8, when a totally enclosed motor is to be provided, no openings are permitted in portions of the motor frame exterior to the appliance, i.e., openings may be in the shaft end of face-mounted oil-burner motors bolted flush to the blower housing of a gun-type burner but not in other portions of the motor frame.

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

29.11 Impedance protection may be accepted for motors which are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under the performance requirements of this Standard; except that such protective means is not acceptable where the motors are installed in compartments handling air for circulation to the conditioned space through a duct unless no smoke is generated under any required test condition with the rotor of the motor locked.

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

29.13 Motors shall not exceed the temperature rises indicated in Table 44.1 when tested as described herein.

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

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

29.16 Automatic-reset type protective devices shall not be if the automatic reclosing of the circuit to the motor by the device may result in unsafe operation of the equipment.

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

29.18 Conformance to 29.17 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

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

29.20 The requirement in 29.19 will necessitate the use of a barrier on nonflammable material under an open type motor unless:

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

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

1) Open main winding,

2) Open starting winding,

3) Starting switch short-circuited, and

4) Capacitor shorted, permanent split capacitor type, or

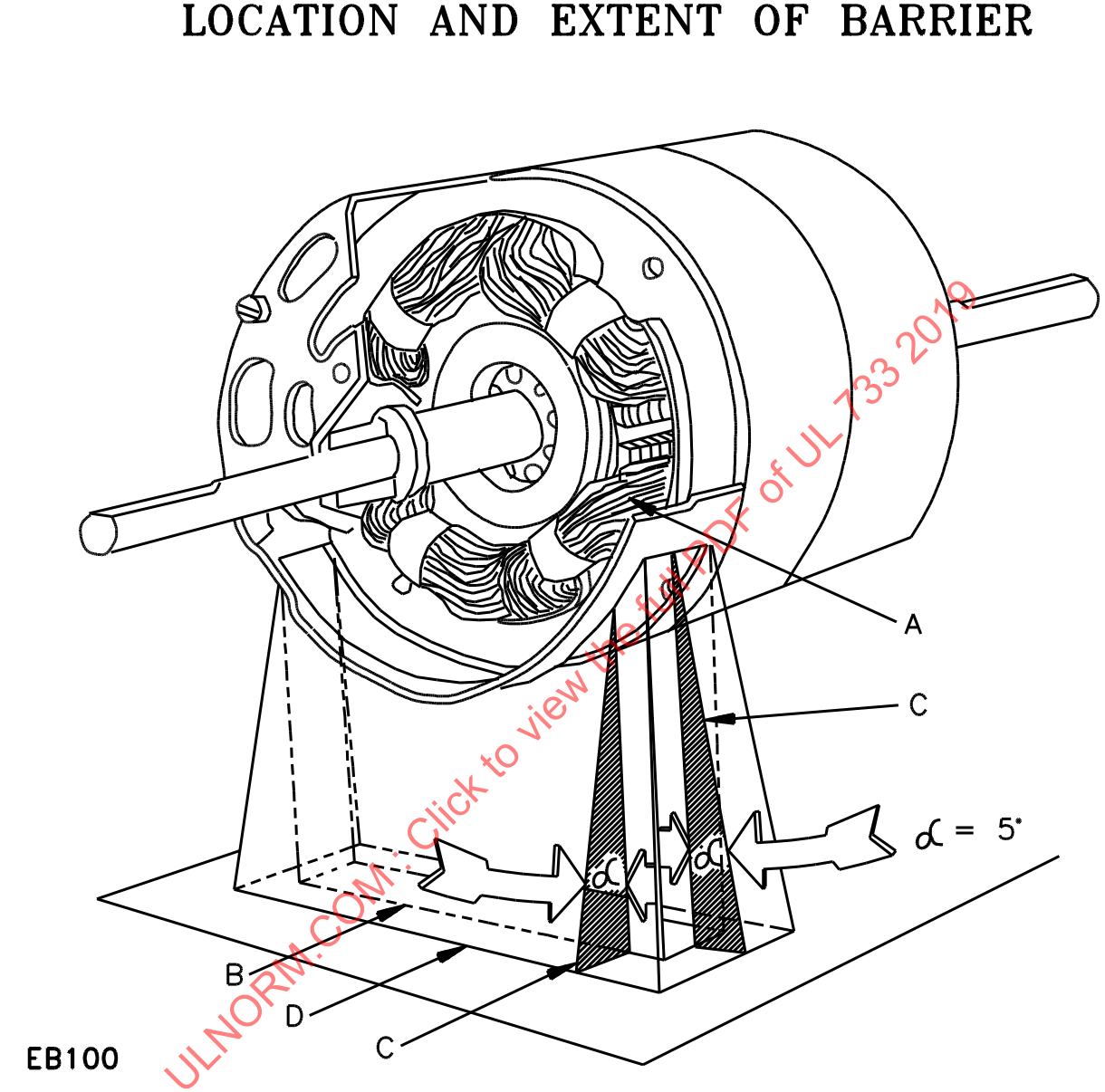
c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load below which the motor will run without causing the protector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

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

29.21 The barrier mentioned in 29.20 shall be horizontal, located as indicated in Figure 29.1, and have an area not less than that described in that illustration. Openings for drainage, ventilation, etc. may be employed in the barrier provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

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

Figure 29.1
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:

a) Tangent to the motor winding;

b) Five degrees from the vertical; and

c) 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 Switches and Controllers

30.1 Except as indicated in 30.2, 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.

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

30.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 57.7 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

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

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

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

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

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

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

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

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 which 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 material other than metal if the capacitor is mounted in an enclosure that houses other parts of the burner and provided that such a box, case, or the like, is acceptable for the enclosure of current-carrying parts.

31.3 Where 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 27.4. Otherwise, it shall be separated from dead-metal parts by spacings in accordance with Table 33.1.

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 51.

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

32 Insulating Material

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

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

SPACINGS

33 High-Voltage Circuits

33.1 Except as noted in 33.2 – 33.4, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead-metal part shall be not less than the values indicated in Table 33.1.

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

Table 33.1
Minimum spacings

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

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient, shall be not less than 0.028 inch (0.17 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

Table 33.1 Continued on Next Page

Table 33.1 Continued

Ratings		Minimum spacings[a,e],inch (mm)		
Volt-amperes	Volts	Through air	Over surface	To enclosure[d]
spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be damaged by arcing. Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.				
[b] If over 300 volts, spacings in last line of table apply.				
[c] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and grounded metal, shall be not less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greater than that given in the above table. Wiring terminals are those connected in the field and not factory wired. Measurements are to be made with solid wire of adequate ampacity for the load connected to each terminal.				
[d] Includes fittings for conduit or metal-clad cable.				
[e] The spacings at wiring terminals of a motor shall be 1/4 inch (6.4 mm) for a motor rated 250 volts or less and 3/8 inch (9.5 mm) for a motor rated more than 250 volts.				

33.3 The spacing requirements in Table 33.1 do not apply to the inherent spacings of a component that is to be judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead-metal or enclosures, shall be those indicated.

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

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

34 Low-Voltage Circuits

34.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor protective device or other protective device shall comply with 34.2 – 34.5 if a short or grounded circuit may result in risk of fire, electric shock, or injury to persons when the heater is operated.

34.2 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 33.4.

34.3 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).

34.4 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 permit spacings to be maintained.

34.5 The spacings in low-voltage circuits that do not contain devices, such as those indicated in 34.2 are not specified.

PROTECTION OF USERS AND SERVICE PERSONNEL

35 General

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

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

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

b) Resetting the control trip mechanism;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

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

35.3 The requirements of 35.1 are not applicable to mechanical service functions that are not intended to be performed with the equipment energized.

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

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

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

35.5 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 grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to the likelihood of shock hazard from adjacent uninsulated live parts or to accident hazard from adjacent moving parts.

35.6 Accessibility and protection from shock and accident hazard may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 35.1.

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

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

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

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

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

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

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

35.7 Components in a low-voltage circuit are to comply with the requirements of 35.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

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

a) Coils of controllers;

b) Relays and solenoids;

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

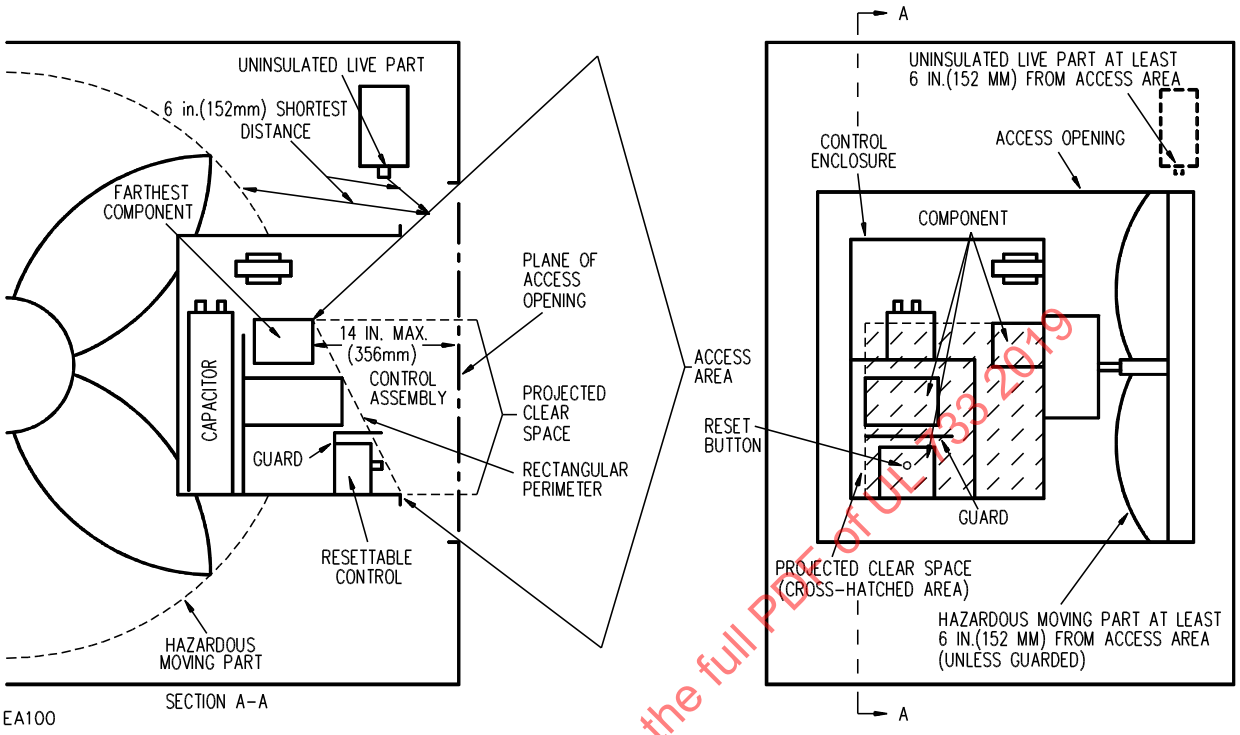
d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wires.

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

Figure 35.1
Accessibility and protection



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

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

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

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

DANGER – TO AVOID INJURY FROM MOVING PARTS, SHUT OFF THE (EQUIPMENT) BEFORE (REMOVING-OPENING) THIS (COVER-DOOR).

35.11 The distance from an opening in a required guard or enclosure to the moving part mentioned in 35.9 shall be in accordance with Table 35.1 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 35.1
Dimensions of openings

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

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

35.12 A moving part is not to be considered when judging compliance with 35.1 and 35.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

PERFORMANCE

36 General

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

36.2 A heater shall be tested normally for installation on combustible floors, with a clearance from the warm air discharge to combustible walls as specified by the manufacturer.

36.3 Additional performance requirements are specified in 11.1, 11.3, and 30.7.

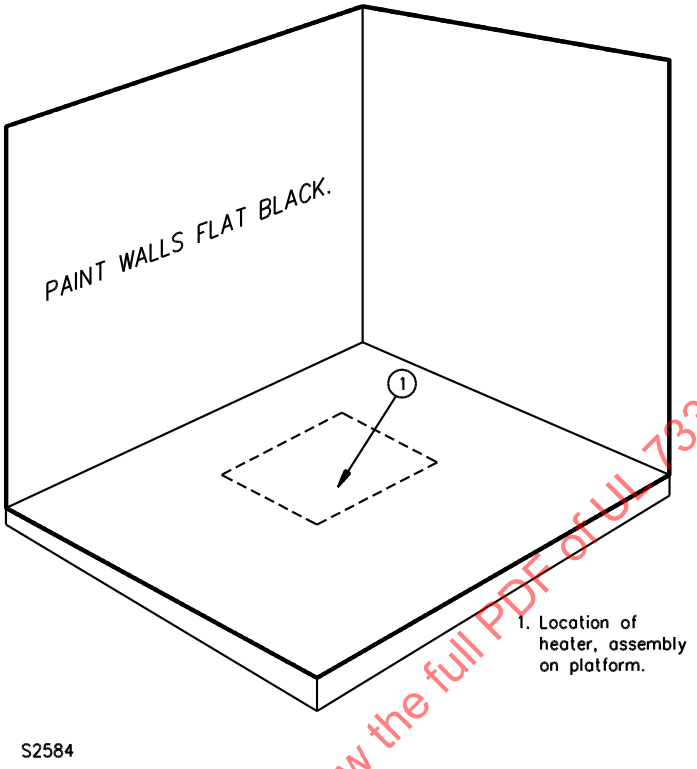
37 Test Installation

37.1 For all tests except the Maximum Wall Temperature Test, the heater (in the as-received condition) is to be placed on a floor constructed of 1 inch (25.4 mm) soft-wood flooring covered with one thickness of building paper and then with 3/4 inch (19.1 mm) thick plywood, and unpainted or finished with a clear sealer.

37.2 For tests as described in 50.1 – 50.4, a direct-fired heater is to be placed in a partial enclosure as detailed below. The warm air discharge of the heater is to be directed toward one wall of the enclosure, at a distance from the wall recommended by the manufacturer, but not exceeding 36 inches (0.91 m). The side of the heater is to be located 24 inches (610 mm) from the adjacent wall of the partial enclosure.

37.3 The partial enclosure is to be formed by two walls of 1 inch nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. See Figure 37.1. The height of the walls is to be such as to extend a minimum of 3 feet (0.91 m) above the center line of the warm air discharge. The walls of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the heater. All joints in the test enclosure are to be tight or sealed.

Figure 37.1
Test enclosure for standard clearances



37.4 If the heater is provided with a flue outlet, a flue pipe is to be installed in accordance with the instructions furnished by the manufacturer with the heater. The flue pipe is to be of:

a) The minimum height recommended in the instructions; and

b) The same nominal size as the flue collar or outlet of the heater.

Galvanized stovepipe not heavier than 0.023 inch (0.58 mm) (No. 24 GSG) is to be used.

37.5 The heater is to be level, but leveling means are to be adjusted to place the heater the minimum allowable distance above the floor.

37.6 Each output opening of the heater is to be fitted with a straight duct extending 36 inches (0.91 m) from the plane of the opening and of the same cross-sectional area and shape as the output opening. This duct, for testing purposes only, is to be furnished by the manufacturer. An adjustable means to symmetrically restrict the outlet end of the duct is to be provided. The restrictor is to form a diamond-shaped opening at the outlet of the test duct.

37.7 The inlet-air temperature is to be measured by a thermocouple, not heavier than 24 AWG (0.21 mm^2) suitably shielded from direct radiation and located centrally 24 inches (610 mm) opposite the side or end of the heater in which the inlet-air opening is located and 24 inches (610 mm) above the test floor.

37.8 The output temperature is to be measured by a thermocouple, not heavier than 24 AWG (0.21 mm^2) suitably shielded from direct radiation and located in the center of the plane of the outlet opening of the test duct.

38 Instrumentation

38.1 Draft

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

38.2 Fuel input

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

38.3 Power measurement

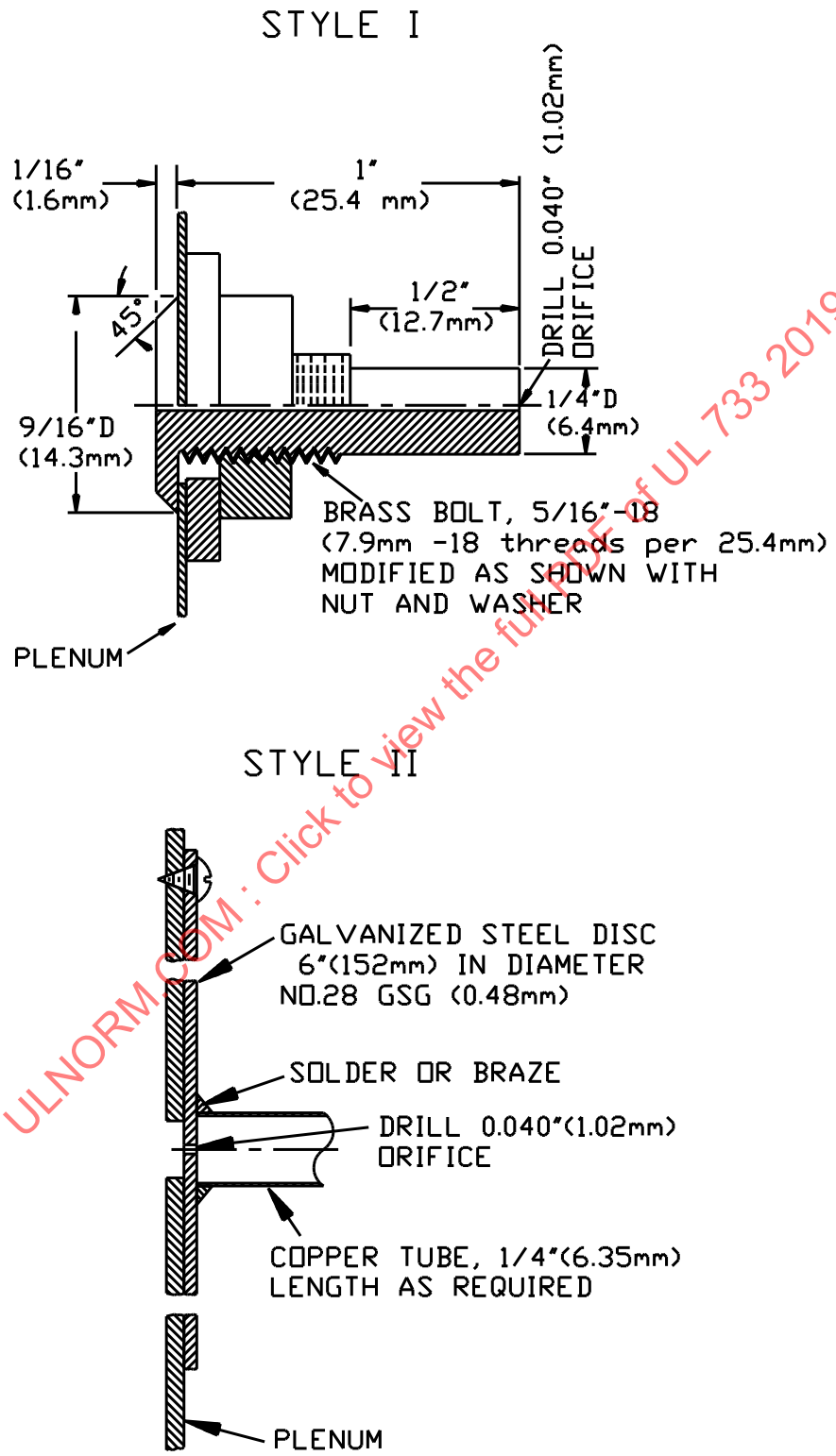
38.3.1 The total electrical input to a heater is to be measured in amperes.

38.3.2 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.

38.4 Speed measurement

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

Figure 38.1
Static pressure pickup arrangements



38.5 Static pressure

38.5.1 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).

38.5.2 The static pressure connection is to consist of one of the arrangements shown in Figure 38.1.

38.6 Temperature measurement

38.6.1 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).

38.6.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during test.

38.6.3 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material whose temperature is being measured. In most cases, thermal contact will result from 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.

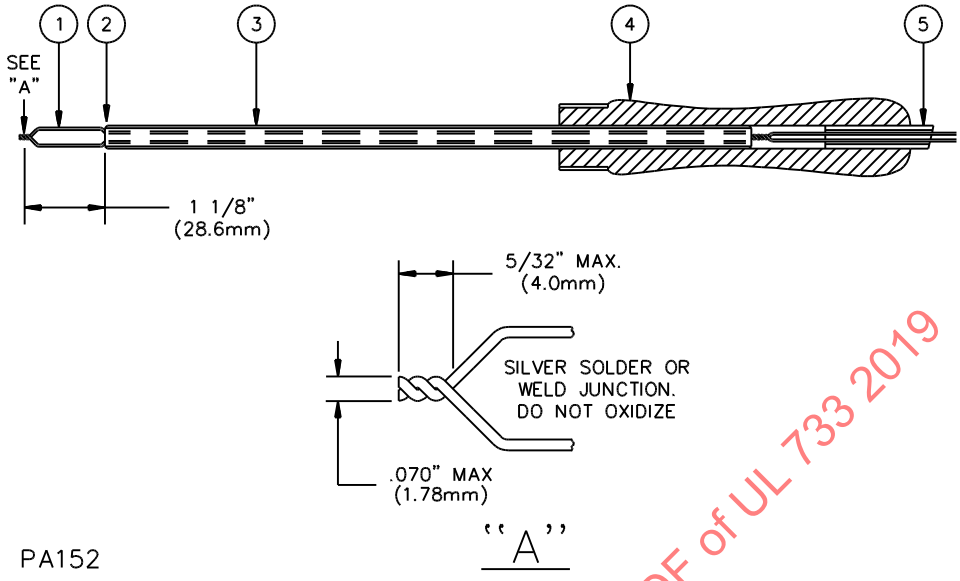
38.6.4 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with the tip held in thermal contact with the surface by pressure-sensitive tape.

38.6.5 Thermocouples are to be attached to surfaces other than as described above by being cemented or taped to the surface in a manner to provide thermal contact with the surface.

38.6.6 The temperatures at points on external surfaces of the heater are to be determined by a thermocouple attached to the surface under a flexible pad of fire and heat resistive insulating material 6 inches (152 mm) square, 0.4 inch (10.2 mm) thick and weighing 1.0 – 1.4 pound per square foot (4.9 – 6.8 kg/m^2).

38.6.7 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 38.2, inserted into the chimney connector as shown in Figure 38.3. There is to be no draft control between the heater and the point where the flue-gas temperature is measured. If a draft control is incorporated in the heater, it shall be sealed dependably in the position allowing maximum draft during all tests.

Figure 38.2
Standard thermocouple for flue-gas temperature



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

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

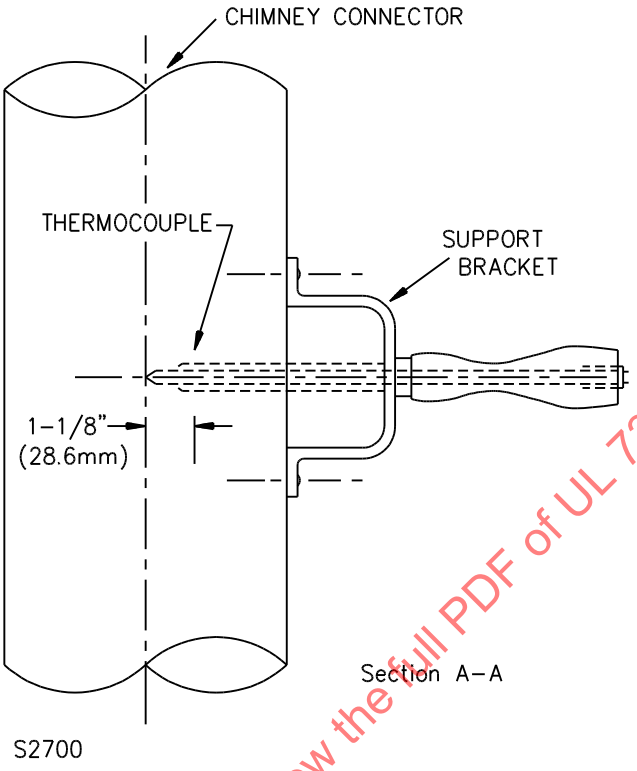
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

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

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

Figure 38.3
Flue-gas thermocouple and support bracket



39 Initial Test Conditions

39.1 General

39.1.1 The heater is to be set up for test in the appropriate enclosure and manner described in a preceding section of these requirements.

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

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

39.1.4 Unless otherwise specified in the describing the tests, heaters are to be tested at the potentials indicated in Table 39.1.

Table 39.1
Test voltages

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

39.1.5 When a heater is equipped with air filters, they are to be in place. Disposable filters, if used, are to be 2 inches (50.8 mm) thick, except that filters 1 inch (25.4 mm) thick may be used if the heater is built to accommodate only filters no thicker than 1 inch (25.4 mm).

39.2 Heater equipped with mechanical atomizing burner

39.2.1 The heater is to be fired at its rated Btu per hour (watt) input, ±2 percent, with a grade of fuel for which the burner is rated. The draft at the flue collar is to be as recommended by the manufacturer but not more than 0.06 inch (1.5 mm) water column for burners fired at 5 gallons per hour (0.0005 liters per second) or less and not more than 0.09 inch (2.3 mm) for burners fired at rates from 5 to 16 gallons per hour (0.0005 to 0.0017 liters per second).

39.3 Heater equipped with vaporizing burner

39.3.1 The heater is to be fired at its rated Btu per hour (watt) input, ±2 percent.

39.3.2 Number 1 fuel oil having a viscosity conforming to the following is to be used for firing vaporizing burners.

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

39.3.3 The firing rate at high fire is to be equivalent to the rated input of the heater.

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

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

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

39.3.7 The draft at the flue collar is to be as recommended by the manufacturer, that being not less than 0.02 inch (0.5 mm) water column.

40 Combustion Test – Burner and Heater

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

40.2 When the heater is fired at rated input and operated until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established, the smoke in the flue gases is not to exceed that indicated by a number 2 spot for heaters firing a distillate fuel and a number 4 spot for heaters firing a residual type fuel as indicated on the Shell-Bacharach Scale with the Model RDC Smokemeter. When operated as described above, the stack loss for an air heater is not to exceed 25 percent.

41 Operation Tests

41.1 The limit control when adjusted to its maximum setting allowed by a fixed stop shall prevent an air heater from delivering output air at a temperature in excess of 250°F (121°C), and a direct-fired heater from delivering output air at a temperature in excess of its designed outlet temperature when tested as described herein. See Limit Control Cutout Test.

41.2 A heater fired at rated input and delivering rated output shall be capable of continuous operation without any control functioning to cause reduction in the input when the heater is tested as described herein. See Continuity of Operation Test.

42 Limit Control Cutout Test

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

42.2 A preliminary test is to be made to determine the degree of blocking of the cold-air inlet required to cause the limit control to function.

42.3 The cold-air inlet blocking is then to be relieved sufficiently to permit continuous operation of the heater which is to operate until substantial equilibrium output temperature is obtained.

42.4 The cold-air inlet is then to be gradually blocked over a period of 10 minutes until the limit control acts to shut off the main burner. At the instant the limit control functions, the output temperature (T_L) and the inlet-air temperature (T_O) are to be measured. The temperature thus obtained is not to exceed the appropriate value specified in 41.1. If the output temperature reaches equilibrium at a value less than the value specified in 41.1, the heater is deemed to comply with 41.1.

43 Continuity of Operation Test

43.1 The limit control is to be bypassed to permit continued operation during this test. The heater is to be placed in operation. The circulating fan speed, if variable, is to be adjusted so that approximate rated delivery is obtained.

43.2 Distribution devices or louvers integral with the heater are to be set at the positions allowing maximum output flow.

43.3 The test-duct outlet of a heater intended for use with ducts is to be restricted symmetrically to maintain an external static pressure in the duct of 0.20 inch (5.08 mm) water column.

43.4 Operation of the heater is to be continued until equilibrium output temperature is obtained. The inlet-air temperature (T_1), the output temperature (T_2), and the current input to the heater are to be measured.

43.5 To be in conformance with 41.2,

$$T_2 \text{ minus } T_1 \text{ is to be not more than } T_L \text{ minus } T_O$$

where:

T_1 = inlet-air temperature in this test, degrees F.

T_2 = output temperature in this test, degrees F.

T_L = output temperature at which limit control functioned in the Limit Control Cutout Test, degrees F.

T_O = inlet-air temperature at the time the limit control functioned in the Limit Control Cutout Test, degrees F.

44 Temperature Tests

44.1 When a heater is tested in accordance with these requirements, no part shall attain a temperature sufficient to damage required corrosion protection, to adversely affect operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage when such damage to the material or part may cause the heater to become unsafe for use. The maximum temperatures on external surfaces of a heater, flue outlet excepted, shall be not more than 175°F (79°C) above inlet-air temperature, and the maximum temperature on a floor beneath the heater shall be not more than 90°F (32°C) above inlet-air temperature when tested as described herein. The temperature rises at specific points shall be not greater than those specified in Table 44.1 unless otherwise indicated.

44.2 A heater equipped with a burner incorporating a fire pot or a receptacle to retain or collect oil to prevent its hazardous discharge in the event of ignition or flame failure shall be constructed so that no hazardous seepage of oil will occur.

44.3 When a direct-fired heater is installed in a partial enclosure as described in 37.3 and tested in accordance with these requirements, the maximum temperature on walls adjacent to the heater outlet shall be not more than 350°F (177°C). See Maximum Wall Temperature Test.

Table 44.1
Maximum temperature rises

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
A. Motor[a,b]				
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).				
a. In open motors –				
thermocouple or resistance method	75	135	115	208

Table 44.1 Continued on Next Page

Table 44.1 Continued

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
b. In totally enclosed motors –				
thermocouple or resistance method	80	144	115	208
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current motors and universal motors.				
a. In open motors –				
thermocouple method	65	117	115	208
resistance method	75	135	115	208
b. In totally enclosed motors –				
thermocouple method	70	126	115	208
resistance method	80	144	115	208
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).				
a. In open motors –				
thermocouple or resistance method	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 motors and universal motors.				
a. In open motors –				
thermocouple method	85	153	140	252
resistance method	95	171	140	252
b. In totally enclosed motors –				
thermocouple method	90	162	140	252
resistance method	100	180	140	252
B. Components				
1. Capacitors	40	72		
electrolytic type[c]	65	117	(Not specified)	
other types[d]				
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 (104°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

Table 44.1 Continued on Next Page

Table 44.1 Continued

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
C. Insulated conductors[e,f]				
1. Appliance wiring material				
75°C rating	50	90	65	117
80°C rating	55	99	70	126
90°C rating	65	117	80	144
105°C rating	80	144	95	171
200°C rating	175	315	200	360
250°C rating	225	405	250	450
2. Flexible cord – Types SO, ST, SJO, SJT	35	63	60	108
3. GTO cable	35	63	60	108
4. Wire, code				
Types RF, FF, RUW	35	63	60	108
Types RH, RFH, FFH, RHW, THW, THWN	50	90	75	135
Types T, TF, TFF, TW	35	63	60	108
Type TA	65	117	90	162
5. Other types of insulated wires	See note e			
D. Electrical insulation – general[f]				
1. Class C electrical insulation material	Not specified			
2. Class (180) electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	117	90	162
4. Phenolic composition used as electrical insulation or as parts where failure will result in a hazardous condition.	125	225	150	270
5. Thermoplastic material	25°C (77°F) less than its temperature rating			
6. Varnished cloth insulation	60	108	85	153
E. Metals				
1. Aluminum alloys				
a. 1100	183	330	239	430
b. 3003	239	430	294	530
c. 2014, 2017, 2024, 5052	294	530	350	630
2. Aluminum-coated steel[g]	656	1180	767	1380
3. Carbon steel sheet, cast iron	517	930	683	1230
4. Carbon steel-coated with Type A19 ceramic	572	1030	683	1230
5. Galvanized steel[h]	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
Types 403, 409, 410, 416	572	1030	683	1230

Table 44.1 Continued on Next Page

Table 44.1 Continued

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
Type 430	711	1280	822	1480
Type 442	877	1580	933	1680
Type 446	961	1730	1072	1930
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 at points of zero clearance to test structure	50	90	97	175
5. Surface of floor beneath and within 3 feet (0.91 m) of heater to be classified for installation on combustible floors	50	90	97	175
6. Surfaces of test enclosure (ceiling, walls, etc.)	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, and 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 (e.g., a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point of the surface of a 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 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] 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).

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

[e] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code; 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 rises are specified, and the maximum allowable temperature rise where Column 2 rises are specified is to be based on the heat resistant properties of the insulation.

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

[g] When the reflectivity of aluminum-coated steel is utilized to reduce risk of fire, the maximum allowable temperature use is 830°F (261°C).

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

45 Continuous Operation Temperature Test

45.1 The limit control is to be bypassed to permit continued operation during this test and the heater placed in operation.

45.2 The test duct on the outlet of a heater not intended to be used with ducts is to be removed. Any louvers or other output distributing devices are to be set at any allowable position producing maximum output temperature.

45.3 For a heater intended to be used with ducts, the through put is to be adjusted by gradually restricting the circulating flow to obtain a temperature rise through the heater (output temperature minus inlet-air temperature) equivalent to T_L minus T_O as obtained in the Limit Control Cutout Test maintaining a static pressure in the outlet duct of not more than 0.02 inch (5.08 mm) water column.

45.4 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.

45.5 During this test, the temperature rise above inlet-air temperature for any item shall not exceed the applicable value specified in Column 1 of Table 44.1.

46 Blocked Inlet Test

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

46.2 The heater arranged as described in 45.2 and 45.3 is to be fired and the circulating flow regulated, if necessary, to maintain an output temperature enough below that required to operate the limit control, which will allow continuous operation of the heater, maintaining a static pressure in the outlet duct applied to an air heater intended for use with ducts of not more than 0.02 inch (5.08 mm) water column. After steady state output temperature conditions are attained, the test (in 46.3, 46.4, or 46.5) is to be conducted.

46.3 The heater inlet-air opening or filter is to be gradually restricted until the limit control functions. Then the heater is to be allowed to be cycled by the limit control if of the automatic reset type. If the heater is equipped with a manual reset limit control which functions during the test, the test is to be continued until maximum temperature are attained.

46.4 If the heater is of a type equipped with an automatic reset limit control only, the temperature rises above inlet-air temperature are not to exceed the values specified in Column 2 of Table 44.1 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 44.1, except that a motor may attain a temperature not in excess of 115°C (208°F) above inlet-air temperature during any part of this test. See 44.1.

46.5 If the heater is of a type equipped with an auxiliary manual reset limit control which functions during the test, the temperature rises above inlet-air temperature during the test shall not exceed the values specified in Column 2 of Table 44.1. See 44.1.

47 Fan Failure Test

47.1 The heater is to be operating under the conditions described in 46.1 and 46.2 to begin this test.

47.2 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 heater is then allowed to be cycled by the limit control if of the automatic reset type. If the heater is equipped with a manual reset limit control which functions during the test, the test is to be continued until maximum temperatures are attained.

47.3 If the heater is of a type equipped with an automatic reset limit control only, the temperature rises above inlet-air temperature are not to exceed the values specified in Column 2 of Table 44.1 during the period terminating one 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 44.1, except that a motor may attain a temperature not in excess of 100°C (180°F) above inlet-air temperature during any part of this test. See 44.1.

47.4 If the heater is of a type equipped with an auxiliary manual reset limit control, the temperature rises above inlet-air temperature during the test shall not exceed the values specified in Column 2 of Table 44.1. See 44.1.

48 Stalled Fan Motor Test

48.1 This test shall be conducted only when the impedance of the circulating air fan motor provides the overcurrent protection for that motor. Only the fan motor temperatures need be recorded.

48.2 The heater is to be operated under the conditions described in 46.1 and 46.2 to begins this test.

48.3 The rotor of the fan motor is to be locked while the heater is temporarily de-energized. The heater is to be immediately re-energized 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 inlet-air temperature attained by the motor during the test shall not exceed 225°F (125°C).

49 Blocked Outlet Test

49.1 The heater is to be operated under the conditions described in 46.1 and 46.2 to begin this test.

49.2 The outlets are to be closed and the heater allowed to function. During this test, the temperature rises above inlet-air temperature are not to exceed the values specified in Column 2 of Table 44.1 during the period terminating 1 hour after the first shut off effected by the limit control. Thereafter, the temperature rises shall not exceed the values specified in Column 1 of Table 44.1, except that a motor may attain a temperature not in excess of 100°C (180°F) above inlet-air temperature during any part of this test. See 44.1.

50 Maximum Wall Temperature Test

50.1 A direct-fired heater is to be placed in a partial test enclosure as described in 37.3, and located with respect to the walls of the enclosure as described in 37.2. The test duct on the outlet of a heater not intended to be used with ducts is to be removed. Any louvers or other output distributing devices are to be set to any allowable position producing maximum output temperatures.

50.2 The heater is to be operated under the conditions described in 46.1 and 46.2 to begin this test.

50.3 The heater inlet air opening or filter is to be gradually restricted to obtain an output temperature not less than T_L – 5°F (9°C). Firing of the heater is to be continued until equilibrium temperatures are attained on the walls of the test enclosure as evidenced by no change in temperature rises for three consecutive readings taken 15 minutes apart at observed maximum temperature points. If the limit control cycles

during any part of this test, the heater is to be allowed to cycle by the control of the automatic reset type control. If the heater is equipped with a manual reset type control, it shall not function during any part of this test.

50.4 During this test, the maximum temperatures on wall surfaces of the test enclosure shall not exceed 350°F (117°C).

51 Short Circuit Test

51.1 Inherent overheating-protective devices, bonding conductors or connections when required, and conductors of multiple motor circuits shall withstand short-circuit and ground-fault conditions when protected by:

a) A device that is acceptable for branch-circuit protection and located in the product; or

b) A branch-circuit protective device of the type and maximum rating specified on the product nameplate.

There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line- and low-voltage circuits.

51.2 For the purpose of these tests:

a) Circuit breakers and fuses are not considered to be interchangeable;

b) Fuses of the same rating are considered to be interchangeable;

c) HACR Type circuit breakers of the same rating are considered to be interchangeable; and

d) Other types of circuit breakers are not considered to be interchangeable with each other or with HACR Type circuit breakers.

Table 51.1
Short-circuit test currents

Unit full-load amperes				Circuit capacity, amperes
Single phase				
115 V	208 V	230 – 240 V	277 V	
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	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
Three phase				Circuit capacity, amperes
208 V	220 – 240 V	440 – 480 V	550 – 600 V	
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000
0 – 250 V DC – 0648 V A				200

51.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the heater. See Table 51.1. The heater full-load current is determined by adding the motor full-load current of each other motor, as determined in accordance with the National Electrical Code, ANSI/NFPA 70, 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 51.4.

51.4 Except as indicated in 51.6 and 51.7, an overcurrent protective or a thermal protective device on a heater 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.

51.5 The nearest standard size fuse, rated not higher than the current indicated in 51.4 but not less than 15 amperes, is to be employed for the test. The maximum fuse size marked on the heater is not to exceed this value. See 57.6.

51.6 With reference to 51.4, the protective device may be tested with a fuse having a lower rating than indicated, provided the heater will start and operate without blowing the fuse and is marked to indicate such a maximum limit of fuse protection.

51.7 The test specified in 51.1 may be waived if:

a) A thermally protected motor or a separately enclosed motor-overload protective device is within an outer cabinet of a product or section of a product.

b) The motor or device is intended to be protected by a fuse or HACR Type circuit breaker as specified on the unit nameplate or provided as part of the product and is acceptable for branch-circuit protection,

c) The assembly is constructed so that flame and molten metal will be confined within the cabinet, and

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 23.2.16.

However, if short-circuiting between live parts of different circuits may result, the test shall be waived.

51.8 Short circuit tests are not required for an assembly with more than one motor, each not exceeding 1 horsepower (746 watts) in rating and 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.

51.9 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 51.8, 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 intended service which might be encountered.

51.10 A nonrenewable cartridge fuse is to be connected in series with the device. A new fuse and device are to be used for each test.

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

51.12 Motor circuit conductors shall not become damaged when samples are subjected to the conditions of this test.

51.13 There shall be no ignition of cheesecloth surrounding the enclosure of a positive device when three samples are tested.

52 Dielectric Withstand Test

52.1 A heater shall be capable of withstanding, without breakdown for a period of 1 minute, the application of a 60 hertz (Hz) 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) One thousand volts plus twice rated voltage, except as noted below.

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

52.2 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 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.

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

52.4 The dielectric 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.

52.5 A 500 volt-ampere or larger transformer, the output voltage of which is essentially sinusodial 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 volt-ampere 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.

53 Leakage Current Test

53.1 The leakage current of a cord-connected heater rated for a nominal 120 volt supply employing a standard attachment-plug cap rated 15 or 20 amperes, ANSI C73.11-1966 or ANSI C73.12-1966, when tested in accordance with 53.6 and 53.7 shall be no more than 0.75 milliamperes (mA).

53.2 Leakage current refers to all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of a heater and ground or other exposed conductive surfaces.

53.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively