



UL 731

STANDARD FOR SAFETY

Oil-Fired Unit Heaters

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UL Standard for Safety for Oil-Fired Unit Heaters, UL 731

Fifth Edition, Dated September 25, 1995

Summary of Topics

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

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INTRODUCTION

1 Scope

1.1 These requirements apply to oil-fired unit heaters as defined herein. Unit heaters designed to supply heated air through ducts are covered in the Standard for Oil-Fired Central Furnaces, UL 727.

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 and the BOCA National Mechanical Code.

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

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

2 Glossary

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

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

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

2.4 APPLIANCE FLUE – The flue passages within the appliance.

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

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

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

2.8 BURNER – A device for the final conveyance of fuel or a mixture of fuel and air to the combustion zone.

2.9 BURNER, AUTOMATICALLY LIGHTED – One where fuel to the main burner is normally turned on and ignited automatically.

2.10 BURNER, MANUALLY LIGHTED – One where fuel to the main burner is turned on only by hand and ignited under supervision.

2.11 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.

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

2.13 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.

2.14 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 is used to vaporize the fuel, with provision for admitting air and mixing it with the oil vapor in combustible proportions.

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

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

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

2.18 COMBUSTIBLE MATERIAL – Combustible material as pertaining to materials adjacent to or in contact with heat-producing appliances, chimney connectors, vent connectors, 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.

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

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

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

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

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

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

2.25 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.

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

2.27 CONTROL, SAFETY COMBUSTION – A primary safety control responsive directly to flame properties. It senses the presence of flame and causes fuel to be shut off in event of flame failure.

2.28 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.

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

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

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

2.32 ELECTRICAL CIRCUITS:

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

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

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

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

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

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

2.36 FLUE GASES – Combustion products and excess air.

2.37 FUEL OIL – Any hydrocarbon oil as defined by Specification for Fuel Oils, ASTM D396-1992.

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

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

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

2.41 INDIRECT-FIRED APPLIANCE – An appliance designed so that combustion products or flue gases are not mixed in the appliance with the medium to be heated and provided with a flue collar.

2.42 LINER – See Radiation Shield.

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

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

- a) Cleaning or replacing nozzles, atomizers, and pilots.
- b) Setting ignition electrodes.
- c) Cleaning strainers or replacing strainer or filter element.
- d) Resetting safety control.
- e) Replacing igniter cable.

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

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

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

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

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

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

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

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

2.53 UNIT HEATER – A self-contained, automatically controlled, indirect-fired air heating appliance which may be floor mounted or of the suspended type. It is equipped with an integral fan or blower for circulation of air and is to be used for the heating of a nonresidential space. It may be equipped with louvers or face extensions by the manufacturer.

2.54 VALVE, MANUAL OIL SHUT-OFF – A manual operated valve in the oil line for the purpose of completely turning on or off the oil supply to the burner.

2.55 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 an emergency device.

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

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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

CONSTRUCTION

4 Assembly

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

4.2 A unit 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 4.3, threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the proper and safe installation or operation of the unit heater, shall be arranged and constructed to permit them to be incorporated into the complete assembly, without need for alteration or alignment, only in the correct relationship with each other. Otherwise, such subassemblies shall be assembled, tested, and shipped from the factory as one element.

4.3 To comply with 4.2, major subassemblies of a unit heater are deemed to be the burner; the heat exchanger, including its base, combustion chamber, casing, and safety controls; the fan or blower assembly, including the base, filters, and casing; and the fan or blower motor if not included as part of the assembly. A wiring harness may be packaged with one of the major subassemblies.

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

4.5 A unit heater shall be such that, for any normal installation, the alteration or removal of a baffle, insulation, or radiation shield needed to prevent unsafe temperatures is not required.

4.6 A unit heater intended for suspended installation shall be provided with suitable brackets or hangers to support the heater from its basic frame or structure.

4.7 A unit heater shall afford convenient operation by the user of those parts requiring attention or manipulation by him in normal usage.

4.8 Adjustable or movable parts shall be provided with locking devices to prevent accidental shifting.

4.9 Screws or bolts used to attach parts which are detached for normal care or servicing of the appliance shall be capable of holding upon the application of the torques indicated in Table 4.1 after removal and replacement.

Table 4.1
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)

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

4.11 The burner and combustion chamber of a unit heater shall be enclosed to the extent necessary to prevent incandescent particles from dropping from the heater.

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

5 Burners

5.1 Oil burners and the oil portion of combination gas-oil burners that are intended for use with the unit heater shall comply with the Standard for Oil Burners, UL 296.

6 Accessibility for Servicing

6.1 A unit heater shall be built to allow cleaning of parts such as heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers without major dismantling of the unit heater or removal of parts required by 4.2 to be factory-assembled.

6.2 The removal of access panels, burners, blowers, caps, plugs, and the like, intended to permit ready removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 6.1.

6.3 Accessibility shall be afforded for intended cleaning, inspection, repair, and replacement of all burners, operating controls, and safety controls when the unit heater is installed as recommended by the manufacturer. 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.

7 Disposal of Combustion Products

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

8 Base

8.1 The base of a unit heater shall be constructed of metal or other noncombustible material to provide support of the heater.

9 Casing

9.1 The outer casing or jacket shall be made of steel or equivalent material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, or use. Sheet metal casing shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) (No. 24 MSG) if uncoated, or 0.023 inch (0.58 mm) (No. 24 GSG) if galvanized or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

9.2 Access panels intended to be removed for service and accessibility shall be capable of repeated removal and replacement without evidence of damage or impairment of any required insulating value.

9.3 A removable panel through which combustion air is drawn shall be capable of repeated removal and replacement without causing a risk of fire, electric shock, or injury to persons.

9.4 A removable panel shall not be interchangeable with other panels on the same heater when interchange may cause a risk of fire, electric shock, or injury to persons.

9.5 The casing of a floor-mounted heater for installation on combustible flooring shall completely close the bottom or be constructed to provide a radiation barrier between the heat exchanger and the floor.

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

10 Radiation Shields and Materials in Air-Handling Compartments

10.1 A radiation shield or liner shall remain in its intended position during intended service without distortion or sagging. A shield or liner shall be protected against corrosion if its deterioration may result in temperature rises greater than those specified in Table 45.1. Any finish used to obtain the required resistance to corrosion shall not be damaged by heat when the heater is tested under these requirements.

10.2 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.

10.3 Thermal or acoustic insulation shall not have a flame spread rating over 25 nor a smoke rating over 50 when tested in accordance with the Tests for Surface Burning Characteristics of Building Materials, UL 723.

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

10.5 With reference to the requirements specified in 10.4, a mechanical fastener for each square foot of exposed surface is considered to securely position insulating liners. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Rigid or semirigid sheets of insulating material may not require fastening to the extent needed for less rigid material or protection of leading edges if the material possesses inherent resistance to damage.

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

11 Air Filter

11.1 A filter shall be accessible for inspection or replacement without the use of special tools and without dismantling the heater.

12 Combustion Chamber

12.1 A combustion chamber and flueway shall be constructed of cast iron, sheet steel, or other suitable material. Sheet steel 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).

12.2 Combustion chamber or fire box lining material shall be durable, securely held in place, and accessible for replacement with equivalent material.

13 Radiator

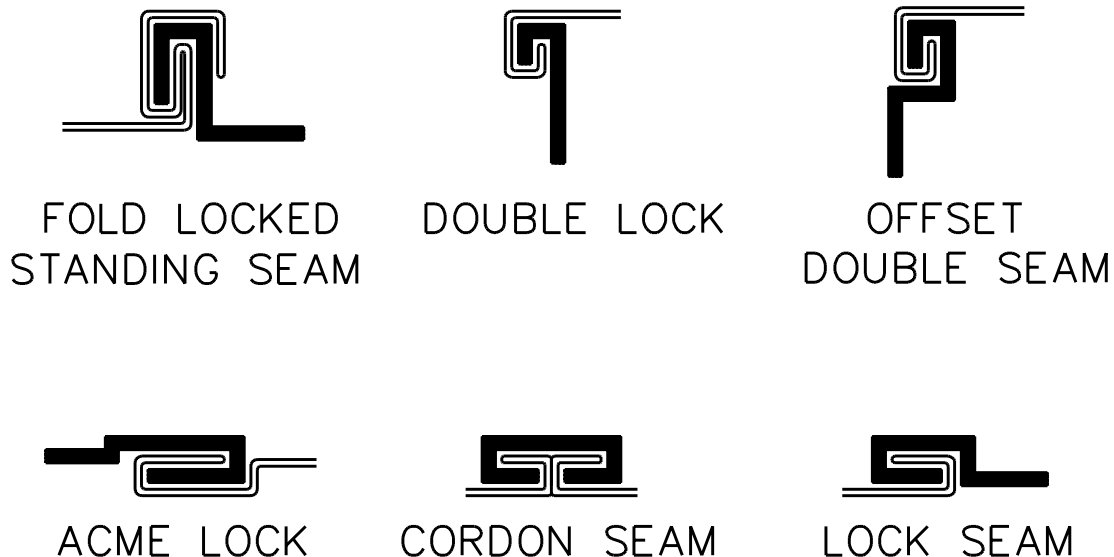
13.1 A radiator shall be made of material not lighter than that designated in 12.1 for a combustion chamber and shall be accessible for cleaning.

14 Heating Surface Joints

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

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

Figure 14.1
Types of acceptable lock-seams



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15 Baffles

15.1 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), unless its deterioration will not cause excessive temperatures or deleterious performance characteristics when the heater is tested in accordance with these requirements.

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

16 Flue Collar

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

16.2 A flue collar or flue collector parts shall have the rigidity and heat and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.042 inches (1.07 mm).

17 Damper and Draft Regulator

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

17.2 An automatically operated damper shall maintain 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.

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

18 Controls

18.1 Application

18.1.1 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.

18.1.2 It is the intent of the requirement in 18.1.1 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 18.1.1 may be considered if they accomplish the intent of this requirement.

18.1.3 The requirement in 18.1.1 does not apply to a circuit within a safety control or to the extension of a circuit to a separate element of the control, such as a flame-sensing device.

18.1.4 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.

18.1.5 All safety controls shall be accessible.

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

18.1.7 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.

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

18.2 Limit control

18.2.1 A heater shall be provided with a suitable integral limit control to prevent excessive temperature. The limit control shall be a recycling type.

18.2.2 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.

18.2.3 The requirement in 18.2.2 is intended to avoid interposing in the limit control circuit other controls, the failure of which may create an unsafe condition the limit control is intended to prevent.

19 Field Wiring

19.1 General

19.1.1 Provision shall be made for connection of a wiring system that would be suitable for power supply in accordance with the National Electrical Code, NFPA 70-1993.

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

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

19.1.4 The size of a junction box in which field installed conductors are to be connected by splicing shall be not less than that indicated in Table 19.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm²).

19.1.4 revised April 22, 2010

19.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 19.2.

Table 19.1
Size of junction boxes

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

Table 19.2
Trade size of conduit in inches

Wire Size		Number of Wires				
AWG	(mm ²)	2	3	4	5	6
14	2.1	1/2	1/2	1/2	1/2	1/2
12	3.3	1/2	1/2	1/2	3/4	3/4
10	5.3	1/2	1/2	1/2	3/4	3/4
8	8.4	3/4	3/4	1	1	1-1/4
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
4/0	107.2	1-1/2	2	2	2-1/2	2-1/2
MCM						
250	127	2	2-1/2	2-1/2	3	3
300	152	2	2-1/2	3	3	3-1/2
350	177	2-1/2	2-1/2	3	3-1/2	3-1/2
400	203	2-1/2	3	3	3-1/2	4
500	253	3	3	3-1/2	4	4

NOTES

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

2 Conversion factors: 1/4 inch = 6.4 mm, 1 inch = 25.4 mm.

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19.1.6 Wiring exterior to a unit heater between the burner assembly and a limit control, a safety combustion control, or a motor controller, that can be done readily with Type T wire enclosed in conduit or with metal-clad cable in accordance with these requirements, need not be furnished by the manufacturer as part of the unit heater if adequate instructions for installing such wiring are furnished with each heater. See 20.1.4.

19.1.7 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 normal care of the unit. This requirement does not apply to separate limit controls and stack switches, where permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

19.1.8 A box or enclosure in which field installed conductors are to be connected as indicated in 19.1.6, 19.1.7, and 19.1.9 shall be so located that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the heater is tested in accordance with these requirements.

19.1.9 Except as specified in 20.1.4, wiring to be done in the field between the heater and devices not attached to the heater or between separate devices which are field installed and located shall conform to these requirements if done with Type T wire enclosed in suitable conduit or with suitable metal-clad cable.

19.1.10 The wiring of the product may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 19.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, NFPA 70-1993, shall be included unless:

- a) The total length of flexible metal conduit of any ground return path in the burner is not more than 6 feet (1.83 m);
- b) No circuit conductor protected by an overcurrent-protective device rated at more than 20 amperes is included; and
- c) The conduit is no larger than 3/4-inch trade size, or the fittings for the conduit are identified as providing grounding.

19.2 Leads and terminals

19.2.1 Wiring terminals or leads not less than 6 inches (152 mm) long for connection of field wiring conductors of at least the size required by the National Electrical Code, NFPA 70-1993, corresponding to the marked rating of the assembly, shall be provided.

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

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

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

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

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

19.2.6 revised April 22, 2010

19.2.7 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 are designed to prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing or the equivalent. If the required spacings may be reduced as a result of loosening of the clamping means, the thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

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

19.2.9 Terminal parts by which field wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 19.2.5 except that for 10 AWG (5.3 mm²) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

19.2.9 revised April 22, 2010

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

Exception No. 1: A No. 8 screw (4.2 mm major diameter) may be used for the connection of a conductor not larger than 14 AWG (2.1 mm²).

Exception No. 2: A No. 6 screw (3.5 mm major diameter) may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm²) control-circuit conductor.

19.2.10 revised April 22, 2010

19.2.11 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 mm²) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm²). In either case there shall be not less than two full threads in the metal.

19.2.11 revised April 22, 2010

19.2.12 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.

19.2.13 A wire binding screw shall thread into metal.

20 Internal Wiring

20.1 General

20.1.1 The wiring of high-voltage and safety control circuits shall conform to the requirements in this section.

20.1.2 Wiring shall be done with insulated conductors having current carrying capacity, voltage, and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be not smaller than 18 AWG (0.82 mm²).

20.1.2 revised April 22, 2010

20.1.3 Except as indicated in 19.1.6, the wiring for all heater circuits shall be furnished by the manufacturer as part of the heater. If the heater is not 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.

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

20.2 Methods

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

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

20.2.3 Group A of Table 20.1 includes some wiring materials rated for use if enclosed as indicated in 21.6.

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

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

Table 20.1
Typical wiring materials

Table 20.1 revised April 22, 2010

Group	Type of wire, cord, cable, or appliance wiring material with insulation thicknesses shown at the right corresponding to wire sizes indicated	Wire size		Insulation thickness	
		AWG	mm ²	Inch	mm
A	FFH-2, TF, TFF, TFFN, SF-2, SFF-2, RH, RHH, RHW, T, THW, XHHW, MTW, THW-MTW, THWN, TW, PF, PFF, PCF, PGFF, RFH-3 or thermoplastic appliance wiring material.	10 and smaller	5.3	2/64	0.8
		8	8.4	3/64	1.2
		6	13.3	4/64	1.6
		4	21.2	4/64	1.6
		3	26.7	4/64	1.6
		2	33.6	4.64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.2	5/64	2.0
B	SO, ST, SJO, SJT, S, SE, SJ, SJOO, SJTO, SJTOO, SOO, STO, STOO, or appliance wiring material with thermoplastic or neoprene insulation	18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.4	6/64	2.4
		6	13.3	6/64	3.3
Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm ²) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm ²), are considered equivalent to the wiring material referenced in Group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type suitable for the purpose from the standpoint of dielectric properties, heat resistance, moisture-resistance, and flammability.					

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