UL 731

STANDARD FOR SAFETY

Oil-Fired Unit Heaters

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

Sixth Edition, Dated January 31, 2018

Summary of Topics

This revision of ANSI/UL 731 dated November 11, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated September 17, 2021.

No Text on This Page

JANUARY 31, 2018
(Title Page Reprinted: November 11, 2021)

UL 731

Standard for Oil-Fired Unit Heaters

First Edition – August, 1955
Second Edition – April, 1974
Third Edition – May, 1975
Fourth Edition – March, 1988
Fifth Edition – September, 1995

Sixth Edition

January 31, 2018

This ANSI/UL Standard for Safety consists of the Sixth Edition including revisions through November 11, 2021.

The most recent designation of ANSI/UL 731 as a Reaffirmed American National Standard (ANS) occurred on November 4, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements apply to oil-fired 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 The oil-burning equipment covered by these requirements are intended for installation in accordance with the National Fire Protection Association Standard for the Installation of Oil Burning Equipment, NFPA 31, the International Mechanical Code and the Uniform Mechanical Code.

1.3 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)

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 Standard for 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.

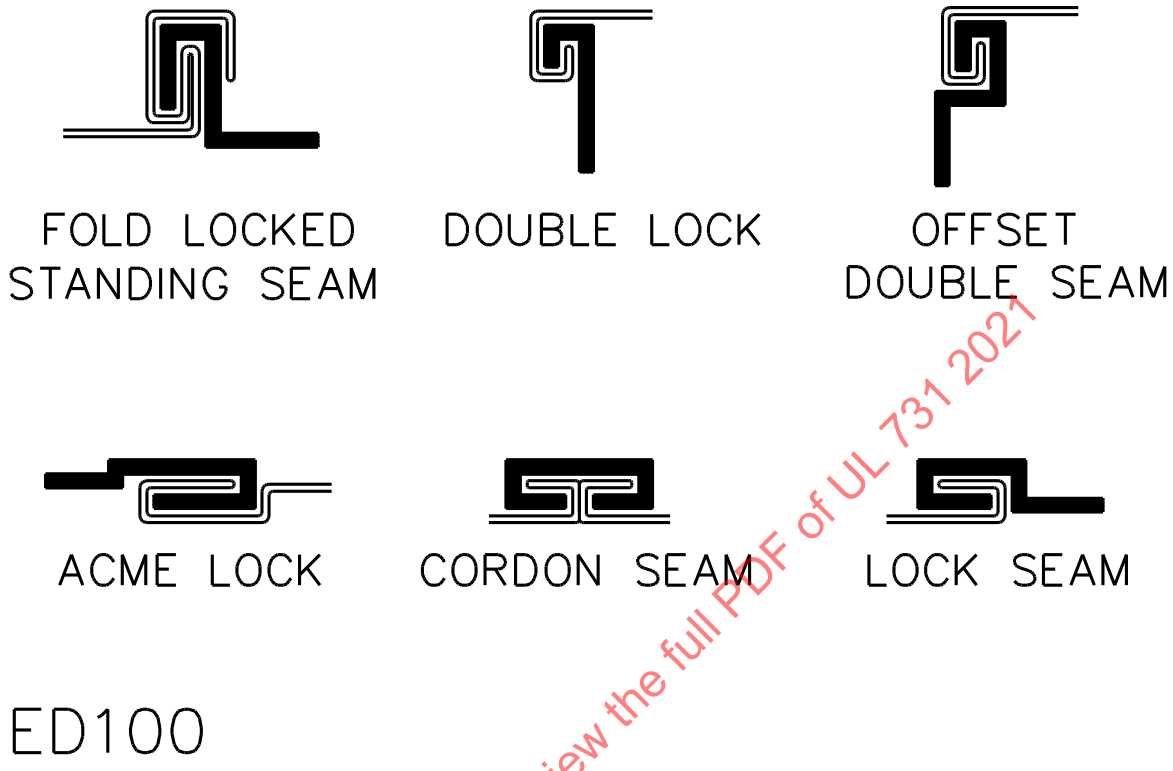
14 Heating Surface Joints

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



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 mm^2).

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

Table 19.2 Continued on Next Page

Table 19.2 Continued

Wire Size		Number of Wires				
AWG	(mm^2)	2	3	4	5	6
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.

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.

19.2.7 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 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.

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 mm^2).

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 mm^2) control-circuit conductor.

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

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 mm^2).

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

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.

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

20.2.8 Splicing devices, such as fixture-type splicing connectors, pressure wire connectors, and the like, may be employed if they have insulation suitable for the voltage to which they are subjected. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat resistant and

moisture resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

20.2.9 A splice is to be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials may be employed.

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

20.2.11 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 20.1, 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.

20.2.12 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.

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

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

20.2.15 Internal 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 20.2.3.

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.

20.2.16 Cords or appliance wiring material as referenced in Group B, Table 20.1 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) If the appliance is for installation only on noncombustible flooring, the bottom of such compartment may be open provided all sides of the compartment extend to the floor level.

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

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

e) Where combustible material other than electrical insulation is located within the compartment, the wiring is separated from such material, and the material has self-extinguishing characteristics. An air filter may be employed within the enclosure.

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

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

20.2.19 To provide an acceptable unbushed opening in sheet metal usually requires rolling, extrusion of the metal around the opening, or both, or the insertion of a grommet conforming to 20.2.17.

20.3 Short circuit protection

20.3.1 Except as indicated in 20.3.2, conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected, wired for connection to one supply line shall withstand the conditions of a Short Circuit Test without creating a risk of fire or electric shock. See Short Circuit Test, Section 48.

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

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

b) Conductors which are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.22 m) in length, provided 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 which serve as jumper leads between controls, providing the length of the leads does not exceed 3 inches (76.2 mm) or the conductors are located in a control panel.

21 Separation of Circuits

21.1 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.

21.2 Segregation of insulated conductors as stated in 21.1 may be accomplished by clamping, routing, or equivalent means which provides permanent separation from insulated or uninsulated live parts of a different circuit.

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

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

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting may affect the intended ignition, control, and operation of the appliance, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, when Type T or equivalent conductors are or will be installed when wired in accordance with the National Electrical Code, NFPA 70-1993.

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

a) If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the heater and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 21.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

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

21.5 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.

21.6 A metal barrier shall have a thickness at least as great as that required by Table 25.1, 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.

21.7 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. The area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

22 Bonding for Grounding

22.1 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 which are likely to be performed when the equipment is energized, shall be electrically connected to the point of connection of an equipment ground.

22.2 Except as indicated in 22.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like, shall be bonded for grounding if they may be contacted by the user or serviceman.

22.3 Metal parts as described below need not be grounded.

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

b) Isolated metal parts, such as magnet frames and armatures, small assembly screws, and the like, 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.

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

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

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

22.7 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.

22.8 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.

22.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 22.11 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.

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

22.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 22.12 – 22.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in the following table twice the current equal to the rating of the branch circuit overcurrent device required to protect the equipment; and

b) During a short circuit test in series with a fuse of proper rating. See Short Circuit Test, Section 49.

Fuse rating, amperes	Maximum carrying time, minutes
30 or less	2
31 – 60	4
61 –100	6

22.12 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 22.11, the size of the conductor or strap shall be in accordance with Table 22.1.

Table 22.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.3)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

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

22.14 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.

22.15 All exposed dead metal parts that are liable to become energized shall be electrically connected to an equipment grounding terminal(s) or lead(s).

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

22.17 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.

22.18 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked G, GR, GROUND, GROUNDING, or by a marking on a wiring diagram provided on the equipment. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be so located that it is unlikely to be removed during normal servicing. At a wire binding screw, upturned lugs or the equivalent shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply, a marking shall be additionally provided indicating EQUIPMENT GROUND and/or identifying the connector by a green color.

22.19 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.

23 Electrical Components – General

23.1 Electrical equipment and wiring shall be arranged so that oil or water will not drip or run on them during normal usage or from a connection required to be uncoupled for servicing the appliance.

23.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may allow unsafe operation of the equipment.

24 Mounting of Electrical Components

24.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 24.2 and 24.3.

24.2 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 normal operation of the switch is by mechanical means rather than by direct contact by persons.

24.3 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.

24.4 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.

24.5 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.

25 Electrical Enclosures

25.1 General

25.1.1 Uninsulated live high-voltage parts shall be enclosed or guarded to prevent accidental contact by persons during normal 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.

25.1.2 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 of these factors are considered with respect to thermal and chemical aging.

25.1.3 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.

25.1.4 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, NFPA 70-1993.

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

25.1.6 Sheet metal complying with Table 25.1 and Table 25.2 whichever applies, is acceptable for the individual enclosure of electrical components.

25.1.7 Where the design 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 25.1 or Table 25.2 whichever applies, may be employed.

Table 25.1
Minimum thickness of sheet metal for enclosures carbon steel of stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.34)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	

Table 25.1 Continued on Next Page

Table 25.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated (MSG)		Metal coated (GSG)	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)				
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	(88.9)	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 which 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. Constructions considered to be without supporting frame includes:

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

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

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

Table 25.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

Without supporting frame[c]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches (mm)	(AWG)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	

Table 25.2 Continued on Next Page

Table 25.2 Continued

Without supporting frame[c]				With supporting frame or equivalent reinforcing[a]				Minimum thickness,	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches (mm)	(AWG)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
42.0	(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)	

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

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

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

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

[b] The width is the smaller dimensions of a rectangular sheet metal 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, such as side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in questions is provided with a flange at least 1/2 inch (12.7 mm) wide.

25.1.8 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.

25.1.9 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 25.1.3.

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

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

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

25.1.11 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 25.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 25.2 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 25.3.

25.1.12 During the examination for conformance with the requirements of 25.1.11, a part of the enclosure (including air filters) which may be removed without the use of tools is to be removed.

Figure 25.1

Probe for uninsulated live metal parts

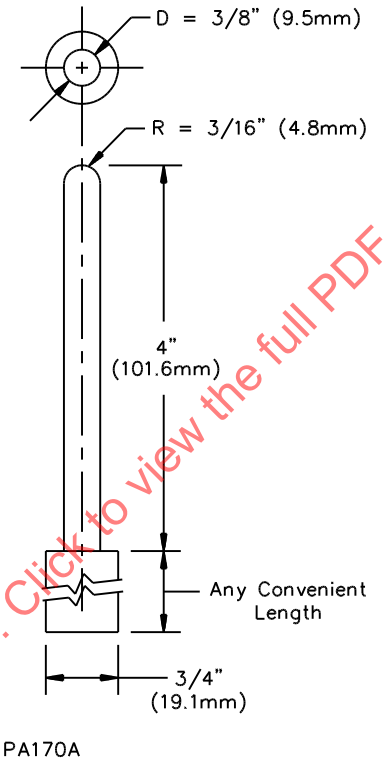


Figure 25.2

Probe for enamel-insulated wire

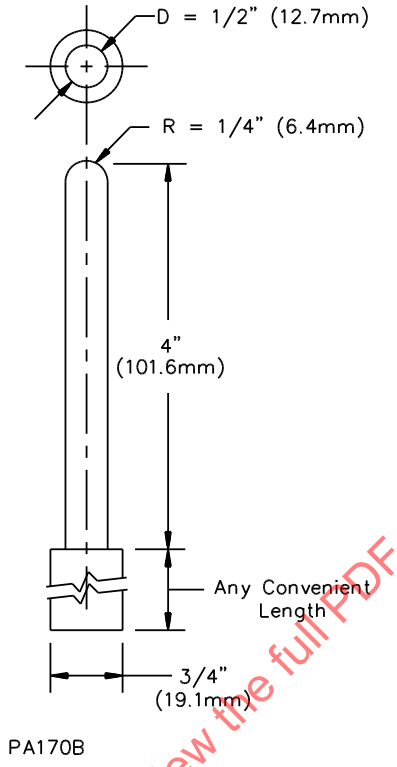
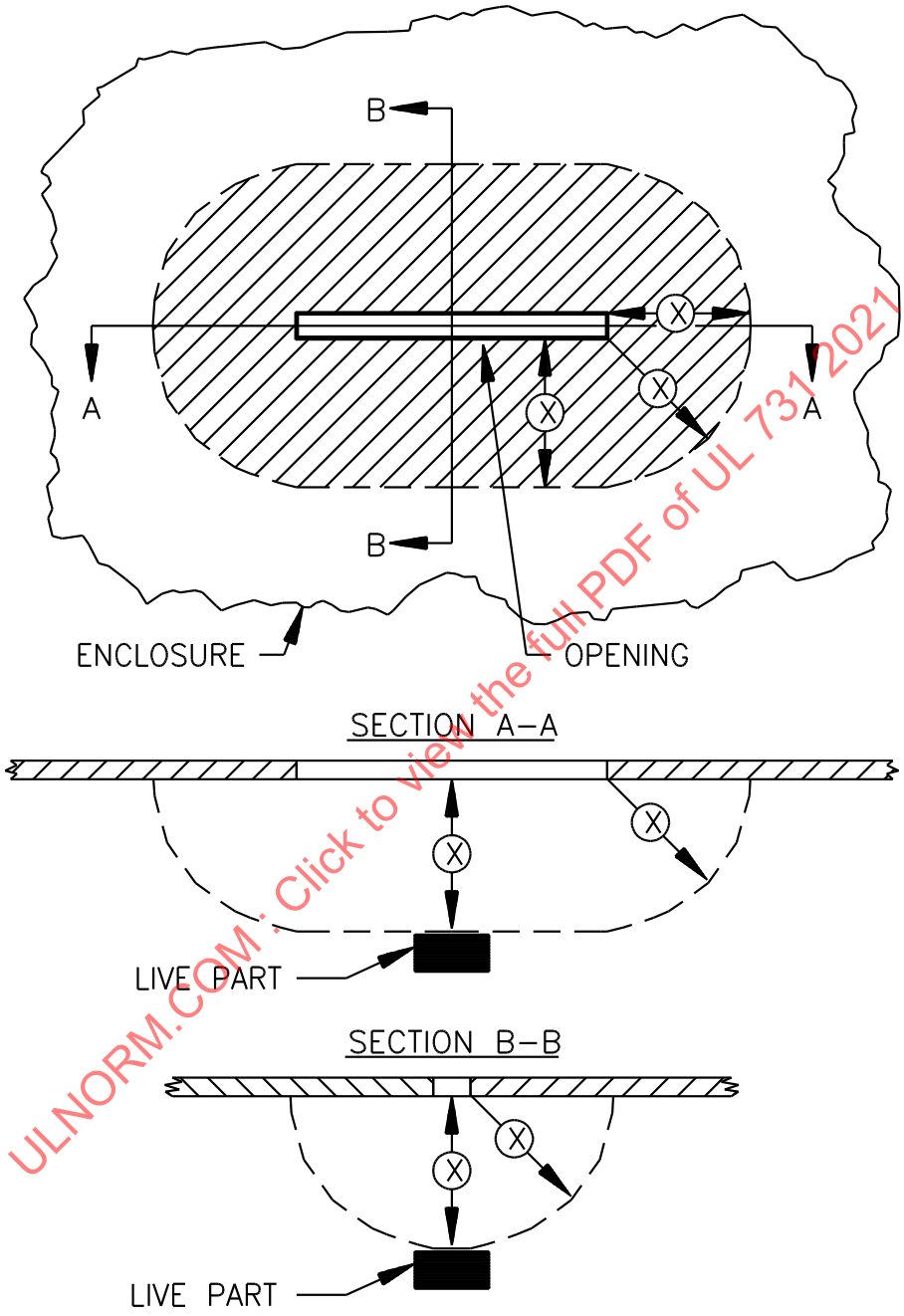


Figure 25.3

Opening in enclosure



EC100A

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 that can be inserted through the opening, but not less than 4 inches (102 mm).

25.2 Doors and covers

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

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

25.2.3 The assembly shall be so arranged that an overcurrent protective device such as a fuse, whose normal functioning requires renewal, can be replaced, and manually-reset device can be reset without removing parts other than a service cover or panel and a cover or door enclosing the device. See 25.2.7.

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

25.2.5 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, and the like.

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

25.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device, such as resetting a manually reset overload protective device, except as indicated in 25.2.8.

25.2.8 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 a pilot lamp, are within the same enclosure; or

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

c) Fuses in low-voltage circuits.

25.2.9 Hinged covers 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.

25.2.10 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 it is considered to be an acceptable means for holding the door in place as required in 25.2.9.

25.2.11 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.

25.2.12 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.

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

25.3 Field wiring system connection

25.3.1 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.

25.3.2 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.

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

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

25.3.5 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.

25.3.6 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.

26 Motors and Motor Overload Protection

26.1 All motors shall be protected by an integral thermal protector, overcurrent-protective device, or combination thereof.

26.2 An overcurrent-protective device as referred to in 26.1 means overcurrent protective devices conforming to the requirements of the National Electrical Code, NFPA 70-1993, as follows:

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

Motors with a marked service factor not less than 1.15	125 percent
Motors with a marked temperature rise not over 40°C (72°F)	125 percent
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:

Motors with a marked service factor not less than 1.15	140 percent
Motors with a marked temperature rise not over 40°C (72°F)	140 percent
All other motors	130 percent

26.3 An integral thermal protective device is to comply with the requirements of the Standard for Overheating Protection for Motors, UL 2111, except as covered by 26.8.

26.4 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 unsafe operation of the equipment.

26.5 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 proper 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-phasing conditions. This marking may be a paper sticker or decal, or may be on an attached wiring diagram.

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

26.7 In determining compliance with 26.6, when a totally enclosed motor is to be provided, no openings are permitted in portions of the motor frame exterior to the appliance, that is, 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.

26.8 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 acceptable under this requirement provided it is determined that the motor will not overheat under actual conditions of use.

26.9 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 actual conditions of use, except that impedance protection is not to be accepted where the motors are installed in compartments handling air for circulation to the conditioned space.

26.10 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.

26.11 Motors shall not exceed the temperature rises indicated in Table 45.1 when tested as described herein.

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

26.13 In no case shall interruption of the circuit to a motor by the overcurrent or overtemperature 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.

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

26.15 A motor shall have no openings permitting a drop of liquid or a particle falling vertically onto the motor to enter the motor as applied to the assembly.

26.16 Conformance to 26.15 may be provided by the motor frame or by another enclosure, structure, or shield, or by another combination of two or more such items and is to be determined with the motor applied to the assembly.

26.17 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.

26.18 The requirement in 26.17 will necessitate the use of a barrier of noncombustible material under an open type motor unless:

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

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

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

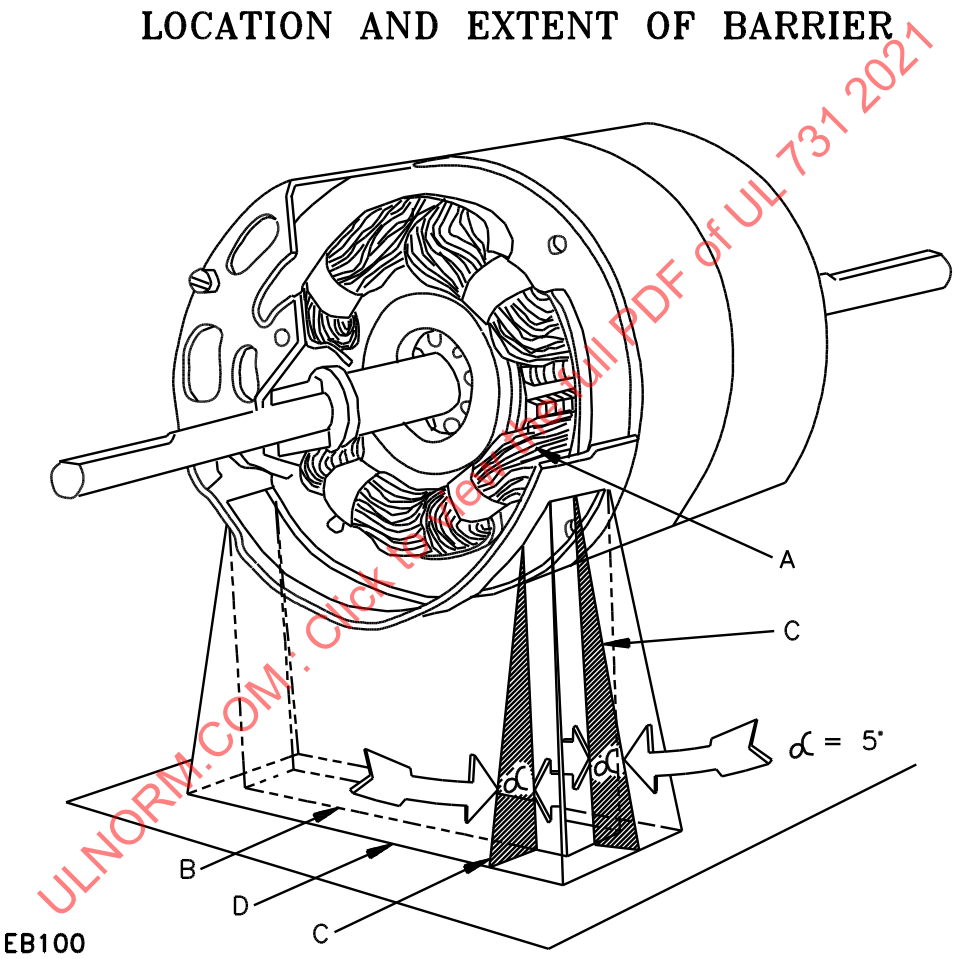
c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from becoming 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle,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

26.19 The barrier mentioned in 26.18 shall be horizontal, shall be located as indicated in Figure 26.1, and shall have an area not less than described in that illustration. Openings for drainage, ventilation, and the like, 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.

26.20 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short Circuit Test, Section 49.

Figure 26.1

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 that is partially shielded by the motor enclosure or equivalent.

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

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

1) Tangent to the motor winding;

2) Five degrees from the vertical; and

3) Oriented so 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.

27 Overcurrent Protection of High-Voltage Control-Circuit Conductors

27.1 General

27.1.1 For the purpose of these requirements, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 28, for additional requirements.

27.2 Direct-connected high-voltage control circuit

27.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 54.14.

27.3 Tapped high-voltage control circuits

27.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the product from the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 27.3.3 – 27.4.2.

27.3.2 A high-voltage control circuit that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, NFPA 70-1993.

27.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 27.1.

Exception No. 1: A 18, 16, or 14 AWG (0.82, 1.3, or 2.1 mm^2) conductor that is not more than 4 feet (1.2 m) long between points of opposite polarity may be protected by a fuse or an HACR Type circuit breaker rated 60 amperes or less.

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 49.14.

Exception No. 3: A lead that is not more than 12 inches (305 mm) long need not be provided with overcurrent protection.

Exception No. 4: A control-circuit conductor, supplied from the secondary of a single-phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device located in the primary side of the transformer if:

a) This protection is in accordance with requirements specified in Overcurrent Protection of Transformers, Section 28; and

b) The rating of the device does not exceed the applicable value specified in Table 27.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 27.1
Overcurrent protective device ratings for control circuit conductors

Tapped control-circuit conductor size, AWG (mm^2)	Maximum rating of overcurrent protective device, amperes			
	Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
	Copper	Aluminum[a]	Copper	Aluminum[a]
18 (0.82)	25	–	7	–
16 (1.3)	40	–	10	–
14 (2.1)	100	–	45	–
12 (3.3)	120	100	60	45
10 (5.3)	160	140	90	75
Larger than 10	b	b	c	c

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of National Electrical Code, NFPA 70-1993.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, NFPA 70-1993.

27.4 Overcurrent-protective devices

27.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 27.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 54.12.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 27.1.

27.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 27.3.3; and

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker or a fuse that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, R, or T cartridge fuse or a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 49.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 54.13.

28 Overcurrent Protection of Transformers

28.1 High-voltage transformers

28.1.1 A transformer, other than as described in 28.2.1 and 28.2.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 28.1.2; or

b) Be protected by an overcurrent device, or devices, in accordance with the requirements in 28.1.4; or

c) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 51.

28.1.2 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High-Voltage Transformers, Section 50.

Exception: If the thermal-overload-protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test, High-Voltage Transformers, Section 51.

28.1.3 A thermal cutoff shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manually or automatically reset thermal protector shall have an endurance rating of not less than 6000 cycles and shall comply with the requirements for calibration of temperature-limiting controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

28.1.4 If a high-voltage transformer is protected by an overcurrent device or devices, such protection shall comply with the requirements specified in 28.1.5, 28.1.6, and 28.3.1 – 28.3.3.

28.1.5 A high-voltage transformer shall be protected by an overcurrent device or devices, that is located in the primary circuit and that is rated or set as indicated in Table 28.1 for the primary. See 28.1.6 and 28.3.1.

28.1.6 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device rated or set as indicated in Table 28.1 for the secondary.

Table 28.1
Ratings of transformer overcurrent protective devices

Rated primary or secondary current, amperes	Maximum rating of overcurrent device, percent of transformer current rating, when in:	
	Primary	Secondary
Less than 2	300[a]	167
2 or more, less than 9	167	167
9 or more	125[b]	125[b]

[a] Does not apply to an autotransformer; may be increased to 500 percent if transformer supplies a motor control circuit.

[b] If 125 percent of the current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating may be used. For the purpose of this requirement, standard ratings are 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60 amperes.

28.2 Low-voltage transformers

28.2.1 Except as specified in 28.2.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 28.3.1.

28.2.2 A transformer that directly supplies a Class 2 circuit (see 2.32(b)) shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

28.3 Overcurrent protective devices

28.3.1 Overcurrent protection in the primary circuit of a transformer, as described in 28.1.5 and 28.2.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 28.1.5 or 28.2.1, as applicable.

28.3.2 Overcurrent protection in the secondary circuit of a transformer, as required by 28.1.6 shall be provided as part of the product. If a fuse is used the product shall be marked in accordance with 54.12.

28.3.3 A required transformer overcurrent-protective device provided as part of the product shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 28.1.5 – 28.2.1, as applicable; and

c) Have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker, or a fuse, that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, R, or T cartridge fuse or a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 49.1. The product shall be marked in accordance with 54.11.

29 Switches and Controllers

29.1 Except as noted in 29.2, 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.

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

29.3 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 54.7 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

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

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

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

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

29.8 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 if direct current.

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

30 Capacitors

30.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 30.2 and 30.3, 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) (No. 24 MSG).

30.2 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 box, case, or the like, is acceptable for the enclosure of current carrying parts.

30.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts by moisture-resistant insulation not less than 0.028 inch (0.71 mm) thick, except as indicated in note a of Table 32.1. Otherwise, it shall be separated from dead metal parts by spacings in accordance with the table.

30.4 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 49.

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

31 Electrical Insulating Material

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

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

32 High-Voltage Circuits Spacings

32.1 Except as noted in paragraphs below, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 32.1.

Table 32.1
Minimum spacings

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

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

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

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

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

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

32.3 The spacing requirements in Table 32.1 do not apply to the inherent spacings of a component which is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, are to be those indicated in the table.

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

33 Low-Voltage Circuits Spacings

33.1 The spacings for low-voltage electrical components which are installed in a circuit which includes a motor overload protective device where a short or grounded circuit may result in unsafe operation of the appliance shall comply with 33.2– 33.5.

33.2 The spacing between an uninsulated live part and the wall of a metal enclosure, including fittings of the connection of conduit or metal-clad cable, shall be not less than 1/8 inch (3.2 mm). See 32.4.

33.3 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).

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

33.5 The spacings in low-voltage circuits which do not contain devices such as indicated in 33.2 are not specified.

PROTECTION OF USERS AND SERVICE PERSONNEL

34 General

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

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

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

b) Resetting control trip mechanisms;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

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

34.3 The requirements of 34.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

34.4 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.

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

34.6 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 34.1.

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.

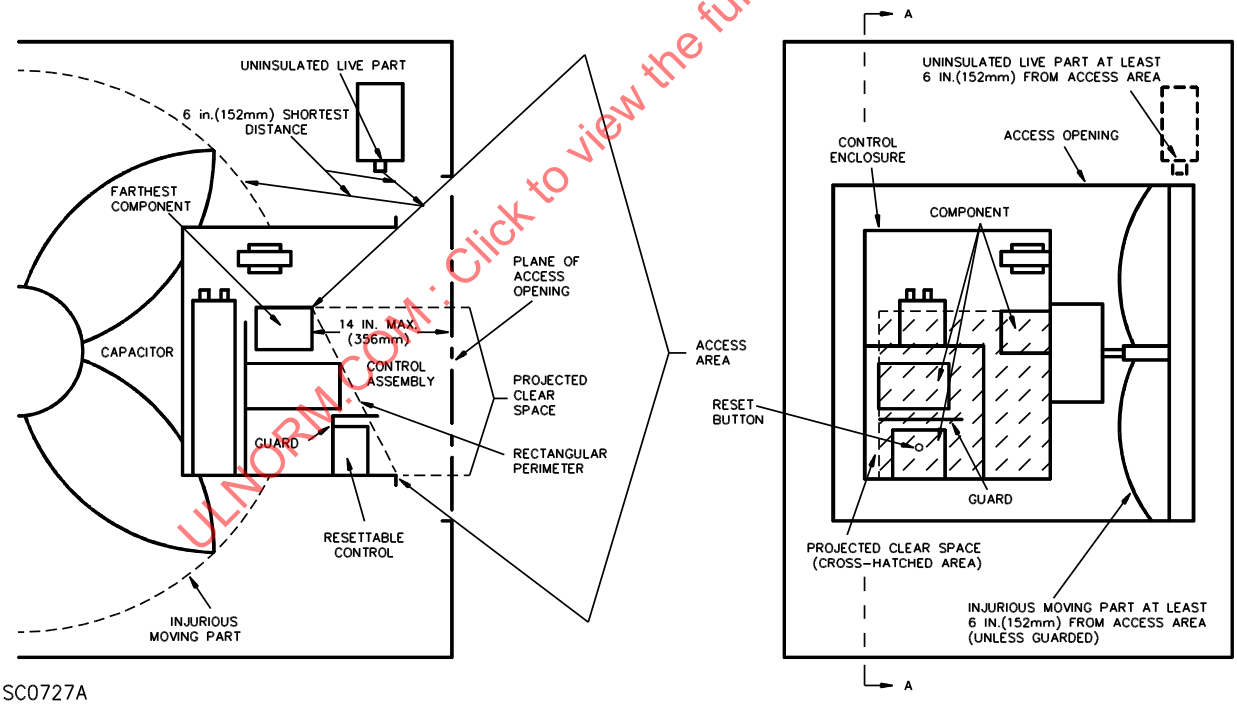
c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet (within the access area) is completely free of obstructions, including wiring.

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 there is unimpeded access to these components through the access opening in the outer cabinet and so that they are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Figure 34.1

Accessibility and protection



34.7 Components in a low-voltage circuit are to comply with the requirements of 34.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

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

a) Coils of controllers;

b) Relays and solenoids;

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

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wire.

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

34.10 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).

34.11 The distance from an opening in a required guard or enclosure to the moving part mentioned in 34.9 shall be in accordance with Table 34.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76 mm). For an opening having a minor dimension intermediate between two of the values specified in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of Table 34.1. 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 34.1
Locations of openings

Minor dimensions of opening[a]		Minimum distance from opening to moving part	
Inches	(mm)	Inches	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114.0)
1	(25.4)	6-1/2	(165.0)
1-1/2	(38.1)	10-1/2	(267.0)
2	(50.8)	14-1/2	(368.0)
Over 2	(over 50.8)	30	(762.0)

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

34.12 A moving part is not to be considered when judging compliance with 34.1 and 34.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

PERFORMANCE

35 General

35.1 A unit 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.

35.2 A floor-mounted unit heater is tested normally for installation on noncombustible floors and with clearances to combustible walls and ceilings as indicated in Table 35.1. Such a heater is classified under Form I or Form III, depending on its physical size as noted in the table. At the option of the manufacturer, a floor-mounted heater may be tested for installation on combustible floors and when so tested is classified under Form Ia or Form IIIa, depending on its physical size.

Table 35.1
Standard clearances

Type of unit heater	Minimum clearance, inches (mm)											
	A		B		C		D		E		F	
	Above		Front		Chimney connector		Rear		Sides		Below	
Form I	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	NC	
Form Ia	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	C	
Form III	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	NC	
Form IIIa	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	C	
Form IIIb	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	18	(457)
Form V	6	(152)	24	(610)	18	(457)	18	(457)	18	(457)	18	(457)
Where: C – Combustible. NC – Noncombustible.												
Forms I and Ia – A floor-mounted unit heater not larger than 100 cubic feet (2.8 m^3) in size (excluding blower or fan compartment and burner.) Forms III, IIIa, and IIIb – A unit heater larger than one classified under Form I or Form V. Form V – A suspended type unit heater not larger than 100 cubic feet (2.8 m^3) in size (excluding fan compartment and burner equipment).												

35.3 A suspended type unit heater is tested normally for installation with clearances to combustible construction not less than indicated under Forms IIIb and V in Table 35.1.

35.4 The standard clearances designated in Table 35.1 are based on the heater being installed in a room that is large compared to the size of the heater. All clearances designated in Table 35.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

35.5 A unit heater classified under Forms I, Ia, or V may be tested as suitable for installation with clearances to combustible construction less than indicated in Table 35.1.

36 Test Installation – Floor-Mounted Heaters

36.1 Enclosure

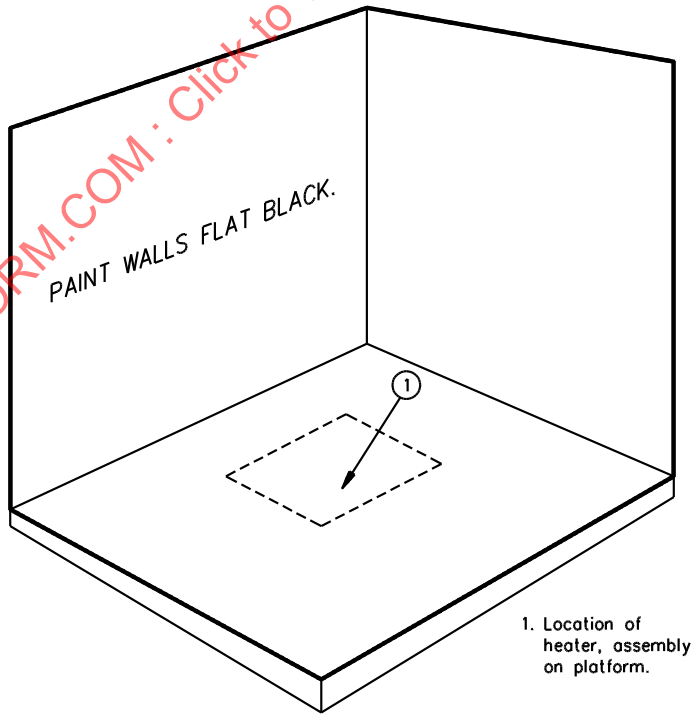
36.1.1 The heater is to be placed in a partial enclosure in the as-received condition as described below. The distance from the back, side, and top of the heater and from the chimney connector to the walls and ceiling of the enclosure is to be not more than as indicated in Table 35.1. Warm air outlets are to be faced away from the walls of the test enclosure. If outlets extend more than 180 degrees around the periphery of the heater, those facing the walls are to be closed, or the heater is to be tested when placed as it may be installed in service.

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

36.1.3 The partial enclosure is to be formed by two walls of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. See Figure 36.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to be such as to obtain the minimum clearance above the heater specified in Table 35.1. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the heater. The walls are to be the minimum distance specified in Table 35.1 from the side and back of the heater except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 36.2.1.

Figure 36.1

Test enclosure for standard clearances floor-mounted unit heaters



36.1.4 If the heater is intended for direct installation on combustible flooring, the floor beneath the heater is to be 1 inch (25.4 mm) white-pine flooring covered with one thickness of building paper, and then by 3/4 inch (19.1 mm) thick plywood, unpainted or finished with a clear sealer.

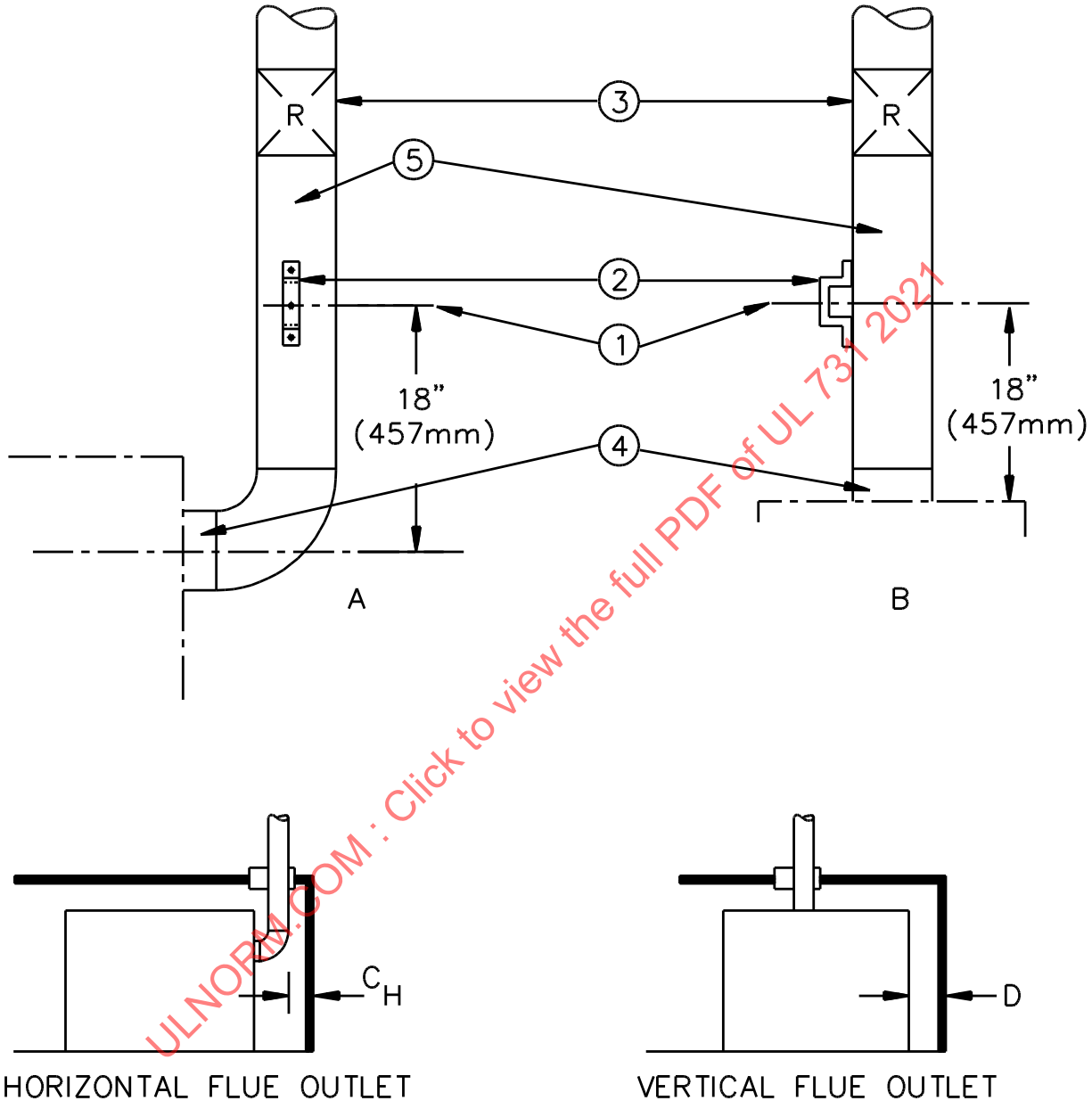
36.2 Chimney connector

36.2.1 The chimney connector is to be 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. The chimney connector is to extend vertically through the ceiling of the test enclosure, being directly connected to and extended vertically above a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree sheet metal elbow at the bottom of the vertical section. See Figure 36.2.

36.2.2 Where the chimney connector passes through the enclosure, an opening 8 inches (203 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 36.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (51 mm) from the outer edge of the annulus.

Figure 36.2

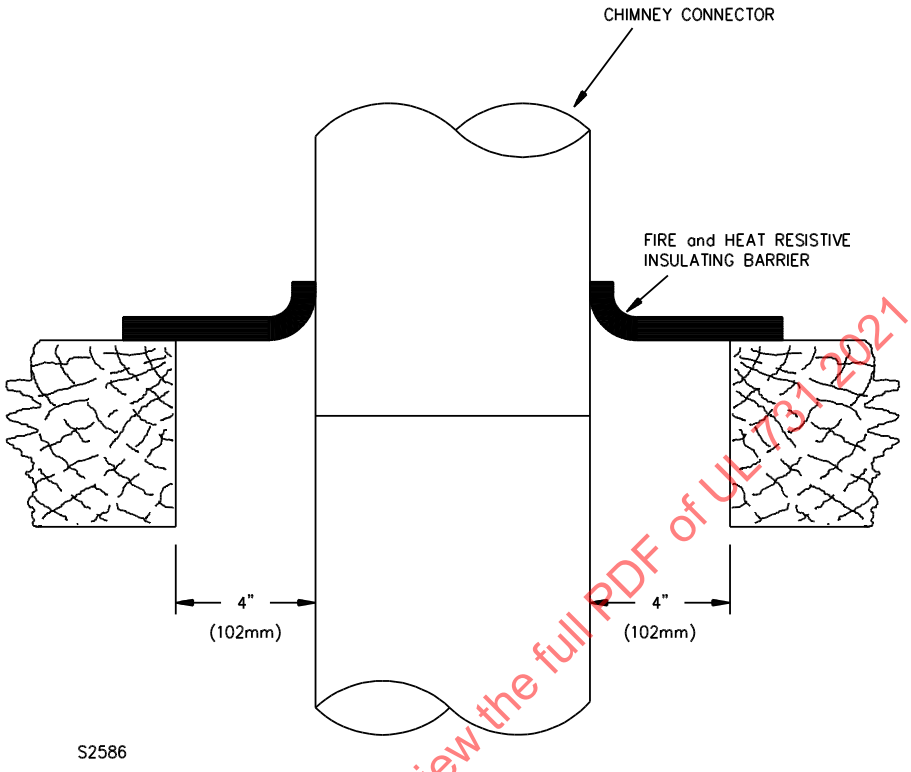
Chimney connectors – standard clearance test



1. Centerline of thermocouple.
2. Support bracket.
3. Draft regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.

Figure 36.3

Sealing of annulus around chimney connector



36.2.3 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by Item 2, Figure 36.2.

36.2.4 The primary safety control, if furnished separately for mounting in the chimney connector exterior to the heater, may be located at any appropriate point either within or exterior to the test enclosure. No temperature measurements in or on a control so located are to be made during tests for standard clearances.

36.2.5 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 36.2.

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

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

36.3 Air outlet and inlet

36.3.1 Each air outlet opening of a floor-mounted unit heater is to be fitted with a straight duct extending 3 feet (0.91 m) from the face of the normal air outlet opening and of the same cross-sectional area and shape as the outlet opening. This duct, for testing purposes only, is to be furnished by the manufacturer. To provide a means to symmetrically restrict the outlet end of the duct, an adjustable restrictor is to be provided which forms a diamond-shaped opening at the outlet end of the duct. If the design of the air outlet

does not permit the attachment of such a duct, an equivalent means is to be provided to restrict the air flow and to measure the outlet air temperature.

36.3.2 The outlet air temperature is to be measured by a single bead-type thermocouple, not larger than 24 AWG (0.21 mm^2) located in the center of the air discharge opening of the test duct.

36.3.3 The inlet air temperature is to be measured by a thermocouple not heavier than 24 AWG (0.21 mm^2) shielded from direct radiation and located centrally 24 inches (610 mm) in front of the heater and 24 inches (610 mm) above the floor of the test enclosure.

37 Test Installation – Suspended Type Heaters

37.1 Enclosure

37.1.1 The heater is to be hung in a suspended tunnel-type enclosure so that the clearance between the top portion of heater and the ceiling is 6 inches (152 mm). Clearance between the vertical side walls and the vertical sides of the heater is to be 18 inches (457 mm). The enclosure is to extend at least 18 inches (457 mm). The enclosure is to extend at least 18 inches (457 mm) beyond the front and back and 12 inches (305 mm) below the heater. The vertical walls and ceiling of the enclosure are to be at right angles and constructed of 1 inch (25.4 mm) nominal thickness wooden boards or 3/4 inch (19.1 mm) thick plywood, finished a flat black. All joints in the test enclosure are to be tight or sealed. If clearances less than specified above are desired, the manufacturer may specify in integral inches the clearances to be employed in test. The heater is to be level.

37.2 Chimney connector

37.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the heater. Galvanized stove pipe not heavier than 0.023 inch (0.58 mm) (No. 24 GSG) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure, being directly connected to and extended vertically from a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree elbow at the bottom of the vertical section. See Figure 36.2.

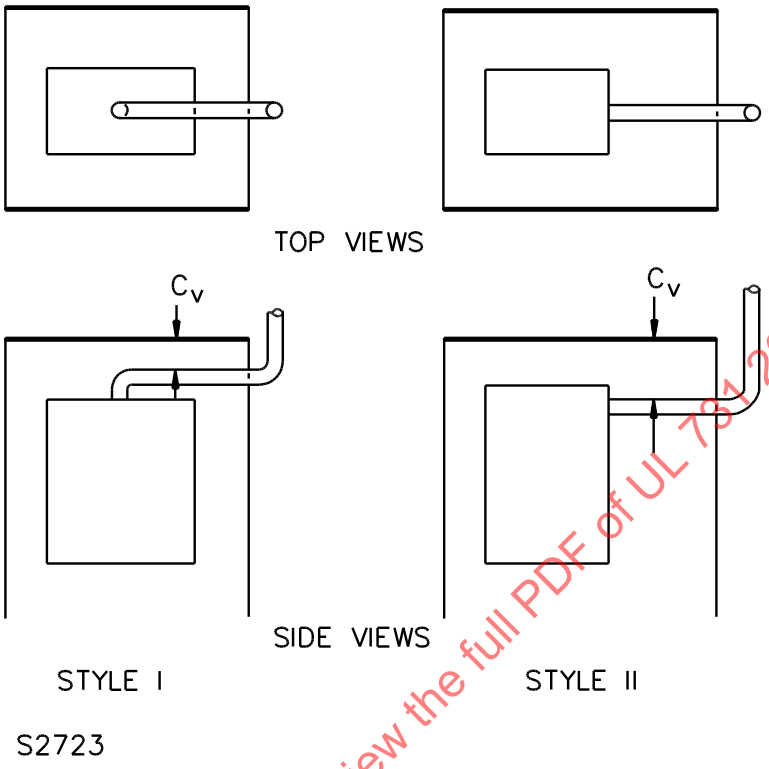
37.2.2 Where the chimney connector pierces the ceiling, an opening 8 inches (203 mm) larger than the flue pipe is to be cut in the enclosure, and the annulus thus formed sealed on the upper surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 36.3. Temperatures on surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50.8 mm) from the outer edge of the annulus.

37.2.3 When a clearance of less than 18 inches (457 mm) between the chimney connector and combustible construction is desired, a heater with a vertical flue outlet is to be tested also with a flue arrangement as indicated by Style I, and a heater with a horizontal flue outlet is to be tested also with a flue arrangement as indicated by Style II in Figure 37.1. The clearance between the chimney connector and the interior surfaces of the test enclosure is to be not less than 9 inches (229 mm).

37.2.4 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2, Figure 36.2.

Figure 37.1

Optional chimney connector arrangement for suspended type heaters



37.2.5 The primary safety control, if furnished separately for mounting in the chimney connector, may be located at any appropriate point either within or exterior to the test enclosure. No temperature measurements in or on a control so located are to be made during tests for standard clearances.

37.2.6 A draft regulator is to be provided for test purposes and located in the chimney connector outside the enclosure. See Figure 36.2.

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

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

37.3 Air outlet and inlet

37.3.1 Each air outlet opening of a suspended type unit heater is to be fitted with a straight duct extending 3 feet (0.91 m) from the face of the air outlet opening of the same cross-sectional area and shape as the air outlet opening. This duct, for testing purposes only, is to be furnished by the manufacturer. To provide a means to symmetrically restrict the outlet end of the duct, an adjustable restrictor is to be provided which forms a diamond-shaped opening at the outlet end of the duct.

37.3.2 The outlet air temperature is to be measured by a single bead-type thermocouple, not larger than 24 AWG (0.21 mm^2), located in the center of the air discharge opening of the test duct.

37.3.3 The inlet air temperature is to be measured by a shielded thermocouple, not larger than 24 AWG (0.21 mm^2), located 24 inches (610 mm) behind and directly opposite the center of the air inlet end of the heater.

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 (0.10 mm) water column and which has an accuracy of ±0.0025 inch (0.050 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 or a burette capable of the same resultant accuracy.

38.3 Power measurement

38.3.1 The total electrical input to a unit 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 mechanism driven by it. The load imposed by the counter is not to reduce motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (93 watts).

38.5 Temperature measurement

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

38.5.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 45.1.

38.5.3 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, acceptable 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.

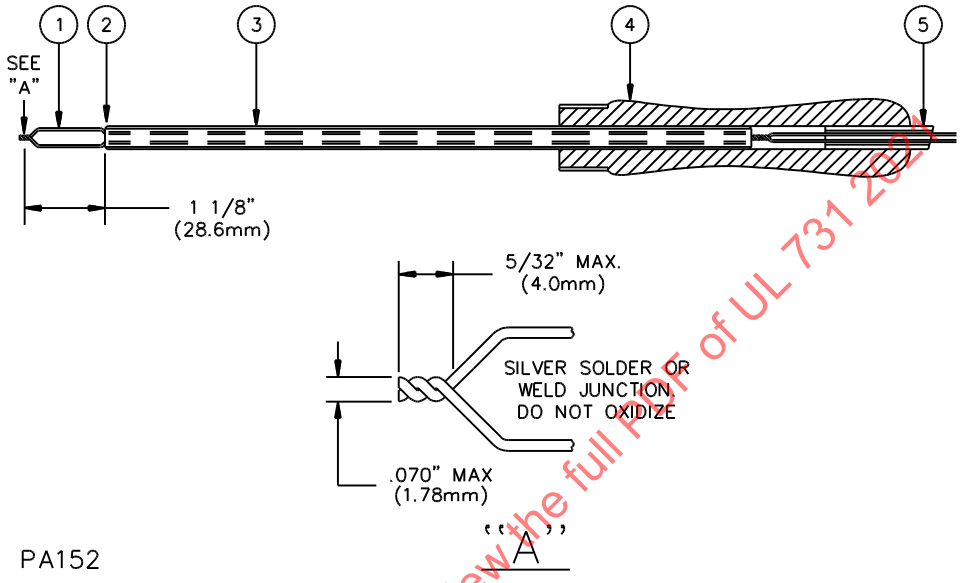
38.5.4 Thermocouples are to be secured to wood surfaces by staples over insulated portions of the wire with the tip held in a good thermal contact with the surface by pressure-sensitive tape, except that for zero clearance, the thermocouples are to be applied to surfaces of the heater at points of zero clearance.

38.5.5 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 good thermal contact with the surface.

38.5.6 The flue-gas temperature is to be measured by a thermocouple such as illustrated by Figure 38.1 inserted into the chimney connector as shown on Figure 38.2. 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 38.1

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. 1/4 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.

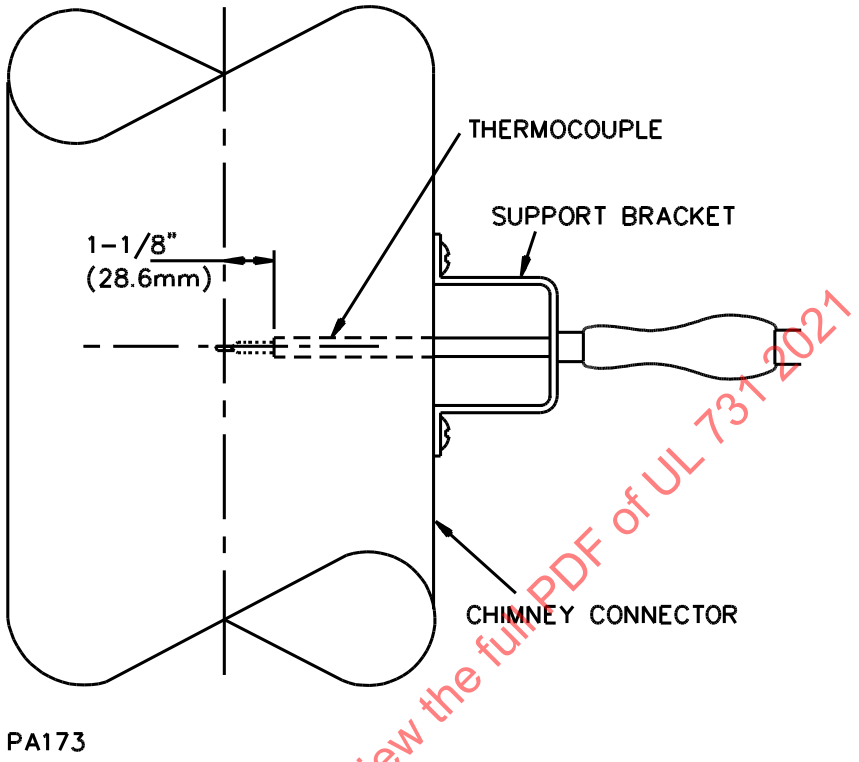
4. 1 – Small wooden handle.

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 38.2

Flue gas thermocouple and support bracket



39 Initial Test Conditions

39.1 General

39.1.1 The unit heater is to be set up for test in the appropriate enclosure and manner described in Sections 36 and 37 of these requirements.

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

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

39.1.4 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).

39.1.5 When a heater is to be equipped with air filters, they are to be in place. Disposable filters 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).

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

Table 39.1
Test voltages

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

39.2 Heater equipped with mechanical atomizing burner

39.2.1 The heater is to be fired at its rated Btu per hour 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 dm^3 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 dm^3 per second).

40 Combustion Test – Burner and Heater

40.1 A unit 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 such that the stack loss is not more than 25 percent 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.

41 Continuous Operation Tests

41.1 The limit control, when adjusted to its maximum setting allowed by a fixed stop, shall prevent a heater from delivering air at a temperature in excess of 200°F (93°C) for a suspended-type heater with a horizontal outlet in the bottom and 250°F (121°C) for other styles of heaters. See the Limit Control Cutout Test, Section 42.

41.2 A heater fired at and delivering rated output shall be capable of continuous operation without the limit control functioning to cause reduction in the input when the heater is being tested. See the Continuity of Operation Test, Section 43.

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 The test duct or ducts described in 36.3.1 and 37.3.1 are to be in place. A preliminary test is to be made to approximate the degree of restriction necessary at the outlet of the test duct to cause the limit control to function.

42.3 The restriction is then to be relieved sufficiently to permit continuous operation of the heater, and the heater operated until substantially equilibrium outlet air temperature is obtained.