UL 732

STANDARD FOR SAFETY

Oil-Fired Storage Tank Water Heaters

UL Standard for Safety for Oil-Fired Storage Tank Water Heaters, UL 732

Sixth Edition, Dated January 31, 2018

Summary of Topics

This revision of ANSI/UL 732 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS).

The requirements are substantially in accordance with Proposal(s) on this subject dated May 18, 2018.

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Standard for Oil-Fired Storage Tank Water Heaters

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This ANSI/UL Standard for Safety consists of the Sixth Edition including revisions through August 9, 2018.

The most recent designation of ANSI/UL 732 as a Reaffirmed American National Standard (ANS) occurred on August 9, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

ELECTRICAL COMPONENTS

PERFORMANCE

INTRODUCTION

1 Scope

1.1 These requirements cover oil-fired storage-tank water-heating appliances having a fuel input of not more than 200,000 Btu per hour (60 kW). These requirements do not apply to heaters that include storage vessels having a water capacity of more than 120 gallons (454.2 liters), or that are intended for heating water to a temperature of more than 200°F (93.3°C).

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.

2 Glossary

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

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

2.3 APPLIANCE FLUE – The flue passages within the appliance.

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

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

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

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

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

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

2.10 BURNER, VAPORIZING – 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 fuel vapor in combustible proportions.

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

2.12 CHIMNEY CONNECTOR – The pipe that connects a solid or liquid fuel-burning appliance to a chimney.

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

2.14 COMBUSTION – The rapid oxidation of fuel accompanied by the production of heat, or heat and light.

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

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

2.17 CONSTANT-LEVEL VALVE – A device that maintains a constant level of fuel oil in a reservoir for delivery to the burner.

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

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

2.20 CONTROL, SAFETY – An automatic control including a relay, switch, or other auxiliary equipment used in conjunction therewith to form a safety control system that is intended to reduce the likelihood of operation of the controlled equipment that would result in a risk of fire or injury to persons.

2.21 CONTROL, PRIMARY-SAFETY – An automatic safety control intended to reduce the likelihood of abnormal discharge of fuel at the burner in case of ignition failure or flame failure.

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

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

2.24 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 rms alternating-current (42.4 volts peak or direct current) and supplied by:

1) A primary battery;

2) A Class 2 transformer; or

3) A combination of transformer and fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer.

A circuit derived from 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.

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

2.26 FLUE GASES – Combustion products and excess air.

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

2.28 HEATING SURFACE – A surface that transmits heat directly from flame or flue gases to the medium to be heated.

2.29 INDIRECT-FIRED APPLIANCE – An appliance constructed so that combustion products or flue gases are not mixed in the appliance with the medium to be heated; hence is provided with a flue collar.

2.30 MAINTENANCE – 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 maintenance. Some examples of maintenance 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.

3 Units of Measurement

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

4 Components

4.1 Except as indicated in 4.2, 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.

4.2 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.

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

4.4 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

5 Assembly

5.1 An oil-fired water heater shall be factory built as a single complete assembly or a group of subassemblies and shall include all of the essential components necessary for its function when installed as intended. An oil-fired water heater may be shipped as two or more major subassemblies.

5.2 An oil-fired storage-type water heater may be furnished as two major subassemblies, each factory built to accommodate the other. The assembly formed when the two subassemblies are joined shall comply with the requirements in this standard. One subassembly is to consist of the oil burner, which may include safety controls. The other subassembly is to consist of the tank assembly and its appurtenances, including the safety controls if not furnished with the burner. The two subassemblies need not originate at, nor be shipped together from, the same factory but are to be marked to identify the subassemblies to be joined.

5.3 An oil-fired water heater that is not assembled by the manufacturer as a single complete assembly shall be arranged in major subassemblies, see 5.4. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or more subassemblies, that must bear a definite relationship to each other for the intended operation of the heater, shall be:

a) Arranged and constructed so that they can be incorporated into the complete assembly, without the need for alteration or alignment, and only in the correct relationship with each other; or

b) Assembled, tested, and shipped from the factory as one single complete assembly.

5.4 The burner assembly and the water-storage vessel, including its base, combustion chamber, and casing are considered to be major subassemblies. The controls and a wiring harness, if employed, may be packaged with either of the subassemblies.

5.5 A radiation shield or baffle employed to reduce the likelihood of excessive temperature shall be:

a) Assembled as part of the water heater;

b) Part of a subassembly that must be attached to the water heater for its normal operation; or

c) Constructed so that the water heater cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

5.6 The construction of a water heater shall be such that, for any typical installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to reduce the likelihood of excessive temperatures is not required.

5.7 A water heater shall be constructed so that parts requiring attention or manipulation during typical use can be easily operated.

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

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

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

5.11 A water heater equipped with an anti-flooding device shall be constructed so that a level heater has a minimum distance of 3/4 inch (19.1 mm) between the intended maximum oil level maintained by the oil control device and the lowest level of the point at which overflow is able to occur.

6 Accessibility for Servicing

6.1 A water heater shall be constructed so that parts, such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers, can be cleaned without major dismantling of the water heater or removal of parts required by 5.2 to be factory assembled.

6.2 The removal of an access panel, burner, blower, cap, plug, or the like, specifically constructed to permit removal and replacement for servicing and the detachment of the chimney connector is not considered major dismantling with regard to the requirement in 6.1.

6.3 Burners, controls, and safety devices shall be accessible for cleaning, inspection, repair, and replacement when the water heater is installed as recommended by the manufacturer. The arrangement of parts in the assembly that may be removed for maintenance shall be such that their replacement, following removal, will not necessitate their realignment to maintain their intended relationship with other parts of the assembly. Specific tools required for maintenance to be done by the operator shall be provided with the heater.

7 Base

7.1 A water heater shall be provided with a base or frame that will support the heater. The base or frame shall be constructed of steel or equivalent material.

8 Casing

8.1 The outer casing or jacket shall be made of steel or equivalent material, reinforced or formed if necessary, so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet-metal casings shall be made of:

a) Steel not less than 0.020 inch (0.51 mm) thick if uncoated, or 0.023 inch (0.58 mm) thick if galvanized; or

b) Nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

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

8.3 A removable panel through which air is drawn for combustion shall be constructed to prevent being attached in a manner that may result in a risk of fire or injury to persons and so that it is not attachable in a manner that would impede air flow.

8.4 A removable panel shall be constructed so that it cannot be interchanged with other panels on the same heater if interchange may result in a risk of fire or injury to persons.

8.5 The casing of a heater intended for installation on combustible flooring shall completely close the bottom or be constructed to provide an effective radiation barrier between the floor and the bottom of a combustion chamber, fire box, or vaporizing burner.

9 Radiation Shields

9.1 A radiation shield or liner shall be constructed, formed, and supported to provide for its intended positioning and to reduce the likelihood of distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the heater is tested for compliance with these requirements. Any finish used to provide the required resistance to corrosion shall not be damaged by heat when the heater is tested under these requirements.

10 Insulation Materials

10.1 Thermal insulation that is not acceptably self-supporting shall be securely applied to solid surfaces in a manner to reduce the likelihood of sagging. The insulating value of the material shall be unimpaired when the heater is tested under these requirements. An adhesive required for securing insulating material shall retain its adhesive qualities at any temperature attained by the adhesive when the heater is tested under these requirements and at 0°F (minus 17.8°C).

11 Combustion Chamber

11.1 A combustion chamber and flueway shall be constructed of cast iron, sheet steel, or other material having the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel not less than 0.042 inch (1.07 mm) thick.

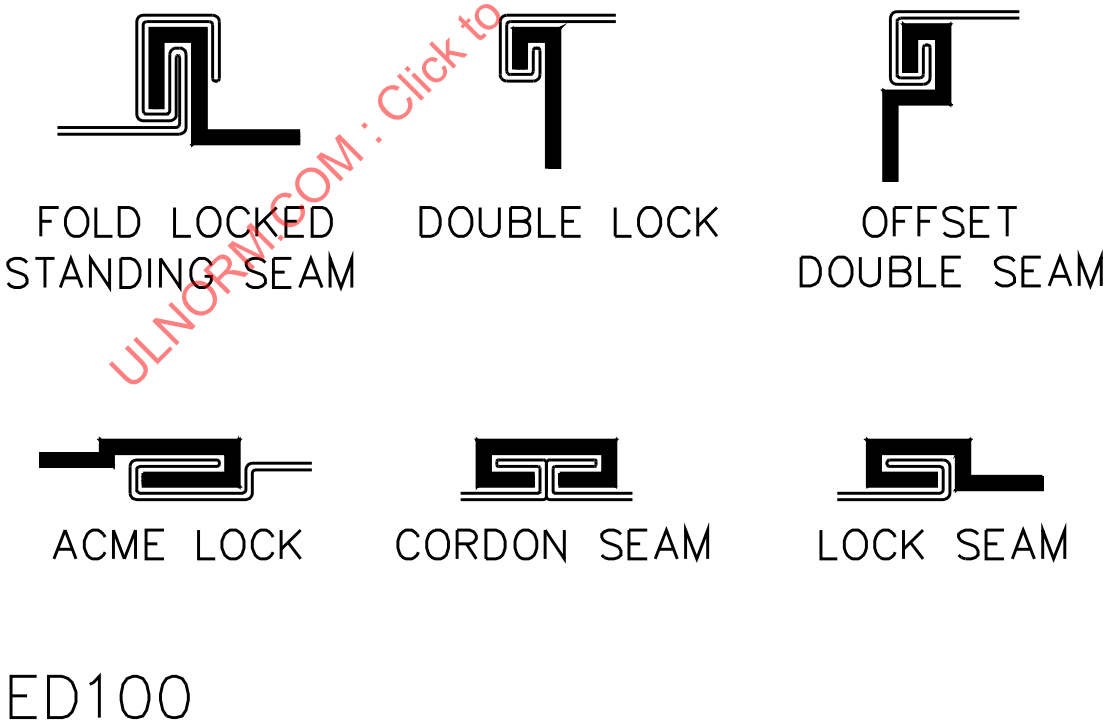
11.2 A combustion chamber (fire box) lining material shall be durable, secured in place, and accessible for replacement with equivalent material.

12 Heating Surface Joints

12.1 Joints in heating surfaces shall be mechanically secure and tight, for example, welded, lock-seamed, machined and bolted, riveted, or the like. A joint shall not depend on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

12.2 Examples of some acceptable lock-seams are illustrated in Figure 12.1.

Figure 12.1
Types of acceptable lock-seams



13 Baffles

13.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be constructed and arranged to remain in its intended position. A flue baffle shall be made of material having rigidity, heat, and corrosion resistance equivalent to AISI C1010 sheet steel not less than 0.042 inch (1.07 mm) thick.

13.2 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall be constructed so that it can be removed and replaced in a manner that does not result in a risk of fire or injury to persons.

13.3 If it is necessary to remove a flue baffle to clean the flueway, the flue baffle of a water heater having an internal flue shall be constructed to allow removal within a clearance above the floor of 78 inches (2.00 m), or 24 inches (0.61 m) above the flue collar on a heater taller than 54 inches (1.37 m).

14 Flue Collars

14.1 A flue collar shall have rigidity and heat and corrosion resistance at least equivalent to that of AISI C1010 steel not less than 0.032 inch (0.81 mm) thick. The collar shall be constructed and arranged to permit secure attachment of the chimney connector.

15 Damper and Draft Regulator

15.1 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.

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

15.3 A water heater to be equipped with a barometric draft regulator shall be assembled 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.

16 Materials Contacting Water

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

17 Water-Storage Vessels

17.1 A water-storage vessel shall be constructed to withstand the applicable hydrostatic test specified in the Hydrostatic Test on Water-Storage Vessels, Section 45, without rupture, leakage, or visible permanent distortion, or the water-storage vessel shall carry one of the following symbols of the ASME Boiler and Pressure Vessel Code:

″H″ – Designating a Steam Heating Boiler, Hot Water Heating Boiler, or Hot Water Supply Boiler, constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers.

″HLW″ – Designating a Complete Potable Water Heater, constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers.

″U″ – Designating a pressure vessel, constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 Rules for Construction of Pressure Vessels.

17.2 The working pressure of a water-storage vessel that does not carry one of the symbols of the ASME Boiler and Pressure Vessel Code, specified in 17.1 shall not be higher than 50 percent of the hydrostatic-test pressure specified in Section 45.

17.3 The inside surfaces of a steel water-storage vessel shall be protected against corrosion by galvanizing, porcelain enameling, or the equivalent.

17.4 A storage vessel shall be equipped with a valve to facilitate draining of the tank.

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

a) Shall be located:

1) In the top of the tank; or

2) With its centerline in the upper 6 inches (152 mm) of the side.

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

c) Shall be threaded in conformity with the Standard for Welding Procedure and Performance Qualification, AWS B2.1-1984.

d) Shall accommodate a 3/4-inch or larger trade-size pipe.

18 Dip Tubes

18.1 A dip tube shall be provided with an antisiphoning hole located so that after the dip tube is installed, the hole is within 6 inches (152 mm) of the top of the tank.

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

18.3 Nonmetallic material for a dip tube shall have a specific gravity greater than 0.94.

18.4 A nonmetallic dip tube shall be investigated for acceptability, particularly with respect to solubility, brittleness, and resistance to deformation, collapse, and sagging at temperatures likely to be encountered in service. Specific tests are described in Nonmetallic Dip Tube Tests, Section 50.

19 Controls

19.1 Application

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

19.1.2 A short circuit or combination of short circuits to ground shall not render a safety control or protective device inoperative. Safety-control circuit arrangements other than described in 19.1.1 may be considered if they accomplish the intent of this requirement.

19.1.3 The requirement in 19.1.1 does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

19.1.4 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.

19.1.5 A safety control shall be accessible.

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

19.1.7 Nothing shall be provided for the purpose of rendering any safety control ineffective or to allow firing of the water heater without the protection of each of the required safety controls.

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

19.2 Limit control

19.2.1 A water heater shall be provided with an automatic fuel-shutoff system (for example, temperature-limit control) actuated by high-water temperature as an integral part of the heater. The shutoff system may be manually reset or automatically reset and shall be arranged to interrupt the fuel supply to the heater when the water has attained a temperature of not more than 210°F (99°C).

19.2.2 An automatic fuel-shutoff system is one that has been investigated and found to be acceptable for 6000 cycles of operation if manually reset and 100,000 cycles or operation if automatically reset.

19.2.3 An automatically reset shutoff system shall not reset at a water temperature above 120°F (49°C).

19.2.4 A manually reset shutoff system shall have a drip-free reset mechanism and be readily accessible for resetting. A location under a cover plate in the jacket is considered accessible.

19.2.5 The automatic-shutoff system shall have no operating parts in common with the temperature-regulating device or control mentioned in 19.3.1, but a common mounting bracket or a common enclosure may be employed for both devices.

19.2.6 An immersion-type temperature-limiting device shall be located so that the temperature-sensitive element is immersed in the water within the tank and controls the temperature of the water within the top 6 inches (152 mm) of the tank.

19.2.7 A surface-mounted limit control shall be mounted and located so that the temperature-sensitive element senses the water temperature within the top 6 inches (152 mm) of the tank. Such a surface-mounted temperature-sensitive element shall be insulated or located to isolate it from flue-gas heat or other ambient conditions that are not indicative of stored-water temperature.

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

19.2.9 A limit control shall be provided with a fixed stop that complies with the Limit-Control Cutout Test, Section 40.

19.3 Water-temperature regulating control

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

Exception: When the temperature-regulating control or controls and the limit control have cutout temperature tolerances not greater than ±5°F (±2.8°C), the maximum water temperature shall be 200°F (93°C).

19.3.2 The temperature-regulating control for an automatically fired heater shall recycle automatically.

19.3.3 A temperature-regulating control is one that has been investigated and found acceptable for continuous operation under rated electrical load for 30,000 cycles of operation without any mechanical or electrical breakdown, impairment of operation, or any apparent damage. Any change in calibration as a result of the continued operation test shall not exceed ±10°F (±5.6°C).

19.3.4 A temperature regulating control shall be set at the factory to a control position corresponding to a 130°F (54.4°C) or lower setting. This setting may be approximate as in the case of a marking that reads ″Low-Medium-High″ or the equivalent, instead of directly in °F or °C.

20 Field Wiring

20.1 A water heater shall have provision for connection of a wiring system in accordance with the National Electrical Code, NFPA 70-1993.

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

20.3 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.

20.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall not be less than that specified in Table 20.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. It should be noted that according to the National Electrical Code, NFPA 70-1993, 14 AWG (2.1 mm^2) is the smallest conductor that may be used for branch-circuit wiring, and thus is the smallest conductor that may be anticipated at a terminal for the connection of a power-supply conductor.

Table 20.1
Size of junction boxes

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

20.5 A knockout for connection of a field-wiring system to a terminal box or compartment shall accommodate conduit of the trade size specified in Table 20.2.

Table 20.2
Trade size of conduit in inches (mm od)

Wire size		Number of wires									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)

NOTE – This table is based on the assumption that all conductors will be of the same size and there will not be 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.

20.6 Wiring terminals or leads not less than 6 inches (152 mm) long shall be provided 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.

Exception: A lead may be less than 6 inches (152 mm) long if it is evident that the use of a longer lead might result in damage to the lead insulation.

20.7 A lead intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring if such stress may cause the lead to separate from its termination or may result in damage to the lead from sharp edges. See Strain Relief Test, Section 49.

20.8 A terminal or lead intended to be connected to the grounded conductor of the supply circuit shall not be electrically connected to a single-pole manual switching device that has an off position or to a single-pole overcurrent (not inherent overheating) protective device.

20.9 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by using a pressure-terminal connector, soldering lug, crimped eyelet, soldering all strands of the wire together, or equivalent means. An open slot-type connector shall not be used unless it is constructed to reduce the likelihood of disconnection resulting from loosening of the clamping means. The shank of a terminal connector 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 insulation on the shanks shall not be less than 0.028 inch (0.71 mm) thick.

20.10 A lead provided for a spliced connection to an external high-voltage circuit shall not be connected to a wire-binding screw or pressure terminal connector located in the same compartment as the splice and shall not be visible to the installer, unless:

a) The screw or connector is rendered unusable for field-wiring connections; or

b) The lead is insulated at the unconnected end.

20.11 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors, secured in place as specified in 20.16, 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.

20.12 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 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 may be used for the connection of 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductors.

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

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

20.15 A wire-binding screw shall thread into metal.

20.16 Field-wiring terminals shall be secured to their supporting surfaces by means other than friction between surfaces so that they cannot turn or shift in position if such motion may result in reduction of spacings to less than those required. This may be accomplished by:

a) Two screws or rivets;

b) Square shoulders or mortices;

c) A dowel pin, lug, or offset;

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

e) Some other equivalent method.

20.17 A conductor provided for connection of a grounded conductor shall be finished a white or gray. No other leads, other than grounded conductors, shall be so identified. A terminal for connection of a grounded conductor shall be of or plated with metal 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.

20.18 Wiring exterior to a 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 heater if instructions for installing such wiring are furnished with each water heater. See 21.4.

20.19 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 maintenance of the unit. This requirement does not apply to separate limit controls and stack switches to which metal-clad cable or flexible metallic conduit is to be directly attached.

20.20 A box or enclosure in which field-installed conductors are to be connected shall be located so that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the heater is tested for compliance with the requirements in this standard.

20.21 Except as noted in 21.4, wiring to be connected in the field between the heater and devices not attached to the heater or between separate devices that are field-installed and located shall comply with these requirements if done with Type R wire enclosed in conduit or with metal-clad cable.

21 Internal Wiring

21.1 The wiring of high-voltage and safety-control circuits shall comply with the requirements in 21.2 – 21.26.

21.2 Insulated conductors having ampacity, voltage, and temperature ratings consistent with their use shall be provided. A conductor, other than an integral part of a component, shall not be smaller than 18 AWG (0.82 mm ^{2}).

21.3 Except as noted in 20.18, the wiring for all heater circuits shall be furnished by the manufacturer as part of the water heater. If the heater is not assembled and wired at the factory, such wiring shall be provided as a harness with each heater and shall 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.

21.4 If insulated conductors rated for use at temperatures higher than 60°C (140°F) are required for compliance with these requirements, the devices to be connected by such wiring shall be factory located on the heater assembly.

Exception: The requirement does not apply to a primary safety control to be field-installed on the chimney connector.

21.5 Electrical wiring to a part that must be moved for intended maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. Conductors to be disconnected from terminals of such a part shall terminate in eyelets or connectors. If the wiring to a part that 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 stress the wiring or its connections.

21.6 Except as noted in 21.18 and 21.19, conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable.

21.7 Some wiring materials acceptable for use if enclosed as specified in 21.6 are given in Group A of Table 21.1.

Table 21.1
Typical wiring materials

Group	Type of wire, cord, cable or appliance wiring material with insulation thicknesses shown at the right corresponding to wire sizes specified[a]	Wire size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	RF-2, FF-2, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, T, THW, XHHW, MTW, THW-MTW, THWN, TW or thermoplastic appliance wiring material.	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, 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	8/64	3.2

[a] Thermoplastic wiring materials, as specified in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, 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) thick thermoplastic insulating tubing of a type acceptable for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, flammability, and the like.

21.8 Flexible metal conduit shall not be smaller than 3/8 inch (9.525 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads.

21.9 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (0.31 m) on each side of every junction box except for lengths not over 36 inches (0.91 m) where flexibility is necessary.

21.10 A splice and connection shall be mechanically secure and bonded electrically. A soldered connection shall be mechanically secured before being soldered if breaking or loosening of the connection may result in a risk of fire or electric shock.

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

21.12 A splicing device, such as a fixture-type splicing connector, pressure wire connector, or the like, may be employed if it has insulation acceptable for the voltage to which it is 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.

21.13 A splice is to be enclosed by installation in a junction box, control box, or other compartment in which high-voltage wiring materials as specified in Group A of Table 21.1 may be employed.

21.14 A splice shall be located, enclosed, and supported so that it is not subject to damage, flexing, motion, or vibration. A splice in an enclosed machinery compartment is to be secured to a fixed member in the compartment so that it is not subject to movement or damage during servicing.

21.15 A conductor shall be protected at all points where conduit or metal-clad cable terminates. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided and the connector or clamp shall be constructed so that the insulating bushing or its equivalent will be visible for inspection.

21.16 The construction of a wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and will maintain electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges that may damage the insulation on wires.

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

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

a) It is not practical to do the wiring in accordance with 21.7.

b) The cord is not required to be bent, twisted, or otherwise displaced during 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.

21.19 A cord or appliance wiring material specified in Group B of Table 21.1 may be employed if the wiring is enclosed by a water 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 the 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) If combustible material other than electrical insulation is located within the compartment, the wiring is separated from such material and the material has the characteristics specified in 21.20.

21.20 With reference to 21.19(e), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

21.21 A cord and other wiring material acceptable in accordance with 21.19 shall be supported and arranged so that it will not be damaged, such as by closely following surfaces. Strain relief, if required, shall be provided.

21.22 A hole in a wall or partition through which insulated wires or cords pass shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires or cords may bear so that the insulation will not be abraided. A bushing shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

21.23 A fiber bushing shall:

a) Not be less than 3/64 inch (1.2 mm) thick;

b) Be located so that it will not be exposed to moisture; and

c) Not be employed where it will be subjected to a temperature higher than 90°C (194°F) under normal operating conditions.

21.24 Except as indicated in 21.25, conductors of motor circuits having two or more motors (one or more of which have thermal or overcurrent protection) wired for connection to one supply line shall withstand the Short Circuit Test, Section 46, without creating a risk of fire or electric shock.

21.25 Conductors that comply with the following are considered acceptable without test.

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

b) Conductors that are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.22 m) long if the appliance will be protected by a 60-ampere fuse or smaller. This applies to any of the wiring materials specified in this standard, including those enclosed in raceways; or

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

21.26 Factory wiring in a low-voltage safety circuit may be:

a) SP-2 cord having all-neoprene insulation;

b) SPT-2 cord of appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness; or

c) Low-energy safety control wire, if such wiring is located in a cavity or compartment of an appliance and is shielded from damage.

22 Separation of Circuits

22.1 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, in any case, be so separated or segregated from uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

22.2 Segregation of insulated conductors as specified in 22.1 may be accomplished by clamping, routing, or equivalent means that maintains permanent separation from insulated or uninsulated live parts of a different circuit.

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

22.4 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts of the 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 metal 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 intended 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 22.3, that the conductors entering an opening will be connected to the terminals opposite that opening.

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

c) To determine if a heater complies with the requirements in 22.3 it is to be wired as it would be in service and in doing so slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack in the wiring compartment.

22.5 If a barrier is used to provide separation between operating parts and field-installed conductors, it shall be made of metal or insulating material and shall be held in place.

22.6 A metal barrier shall have a thickness not less than that specified in Table 26.1 based on the size of the barrier. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick and shall be thicker if its deformation may defeat its purpose. Any clearance at the edges of a barrier shall not be more than 1/16 inch (1.6 mm) wide.

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

23 Bonding for Grounding

23.1 An exposed or accessible dead metal part that may become energized and that may be contacted by the user or by service personnel during service operations that are likely to be performed when the equipment is energized, shall be electrically connected to the point of connection of an equipment ground.

23.2 Except as noted in 23.3, 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 service personnel.

23.3 Metal parts, as described below, need not be grounded.

a) Adhesive attached metal-foil markings, screws, handles, and the like, that 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 a magnet frame and armature, small assembly screws, and the like that are separated from wiring and uninsulated live parts.

c) A panel or cover that does not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover.

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

23.4 If a component, such as a switch, is likely to become separated from its 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.

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

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

23.7 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.

23.8 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 higher than 454°C (850°F). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

23.9 A connection that depends upon the clamping action exerted by rubber of similar materials is acceptable if it complies with the requirements in the Bonding-Conductor Test, Section 50, 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 that 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.

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

23.11 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. The size of the conductor or strap shall be as specified in Table 23.1 unless a smaller size conductor or strap is found to be acceptable when subjected to the Bonding Conductor Test, Section 50.

Table 23.1
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)	11	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)

[a] Or equivalent cross-sectional area.

23.12 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.

23.13 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 to be sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

23.14 The following are acceptable connections to a ground:

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

b) In equipment intended to be connected by a nonmetal enclosed wiring system, for example, metal-clad cable – an equipment-grounding terminal or lead.

23.15 A terminal for connection of an equipment-grounding conductor shall be located in the field-wiring compartment and shall be acceptable for connection of a conductor of the size required by the National Electrical Code, NFPA 70-1993.

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

23.17 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 terminal 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 terminal connector shall be secured to the frame or enclosure and shall be located so that it is unlikely to be removed during servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors, and if it could be mistaken for the neutral of a grounded supply:

a) A marking shall be additionally provided indicating EQUIPMENT GROUND;

b) The connector shall be identified by a green color; or

c) Both.

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

ELECTRICAL COMPONENTS

24 General

24.1 Electrical components and wiring shall be arranged to reduce the likelihood of oil or water dripping or running on them during usage or from a connection required to be uncoupled for servicing the appliance.

24.2 An attachment plug or a separable connector shall not be used in a circuit if the breaking or making of the circuit by the device may result in a risk of fire, electric shock, or injury to persons.

25 Mounting of Electrical Components

25.1 A switch, fuseholder, lampholder, or similar component shall be mounted securely and shall be prevented from turning.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

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

b) The means for mounting the switch is unlikely to loosen as a result of operation of the switch.

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

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

Exception No. 2: 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.

25.2 The means for preventing turning is to consist of more than friction between surfaces. A toothed lock washer that provides both spring takeup 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.

25.3 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the required values.

26 Electrical Enclosures

26.1 An uninsulated high-voltage live part shall be enclosed or guarded to reduce the likelihood of unintentional contact by persons during intended use of the equipment. This requirement also applies to parts located in a compartment into which access is required for servicing of the equipment such as resetting controls, replacing filters, lubrication, cleaning, and the like.

26.2 Sheet metal of the thickness specified in Table 26.1 or 26.2 is acceptable for the individual enclosure of electrical components.

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

a) Mechanical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

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

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

26.4 If the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of metal thinner than specified in Table 26.1 or 26.2 may be employed.

26.5 A terminal housing of a motor, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, NFPA 70-1993.

26.6 A steel enclosure shall be protected against corrosion by painting, plating, or other equivalent means.

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

26.8 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 not be 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 not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that provides protection to the conductors equivalent to that provided by a standard conduit bushing and that has an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

26.9 In an enclosure intended to be supported by rigid conduit, the threaded opening for connection to the conduit shall be provided with at least five full threads.

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

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

Table 26.1
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)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)				
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
35.0	(88.9)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)				
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes a single sheet with single formed flanges (formed edges), a single sheet that is corrugated or ribbed, and an enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

Table 26.2
Thickness of sheet metal for enclosures of aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness, inches (mm)
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	5.5	(24.1)	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)

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

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

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

26.12 A plate or plug for an unused conduit opening or other hole in the enclosure shall not be less than:

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

b) 0.027 inch (0.69 mm) thick if steel or 0.032 inch (0.81 mm) thick if 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 a plate or plug shall be securely mounted.

26.13 The enclosure shall reduce the likelihood of 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.

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

26.15 All intended mounting positions of the appliance are to be considered when determining compliance with the requirements in 26.13.

26.16 A junction box that is formed in part by another part, such as a fan scroll or a motor casing, shall fit so that:

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

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

26.17 An opening in an electrical enclosure shall comply with Section 27, Accessibility of Uninsulated Live Parts, Film-Coated Wire and Moving Parts.

26.18 During the examination for compliance with the requirements of 26.17, any part of the enclosure that may be removed without the use of a tool is to be removed.

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

26.20 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 exposing moving parts or uninsulated live parts.

26.21 The assembly shall be arranged so that an overcurrent-protective device, such as a fuse, the intended function of which requires renewal, can be replaced or a 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 26.25.

26.22 A required protective device shall be inaccessible from outside the appliance without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually reset motor protector, the reset button of a manually reset pressure switch, and similar parts may project outside the appliance enclosure.

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

26.24 A fuseholder shall be constructed, installed, or protected so 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 not be less than 0.028 inch (0.71 mm) thick.

26.25 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manually reset overload-protective device, except as indicated in 26.26.

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

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

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

c) Fuses in low-voltage circuits.

26.27 A hinged cover, if required, shall not depend solely upon screws or other means requiring the use of tools to hold it closed, but shall be provided with a catch or spring latch.

26.28 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 to open is an acceptable means for holding the door in place as required by 26.27.

26.29 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 that provides equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

26.30 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.

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

27.1 To reduce the likelihood of unintentional contact that may involve a risk of:

a) Electric shock from an uninsulated live part or film-coated wire; or

b) Injury to persons from a moving part, an opening in an enclosure shall comply with either (1) or (2):

1) For an opening that has a minor dimension (see 27.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 27.1.

2) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 27.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 27.2.

Figure 27.1
Probe for uninsulated live parts

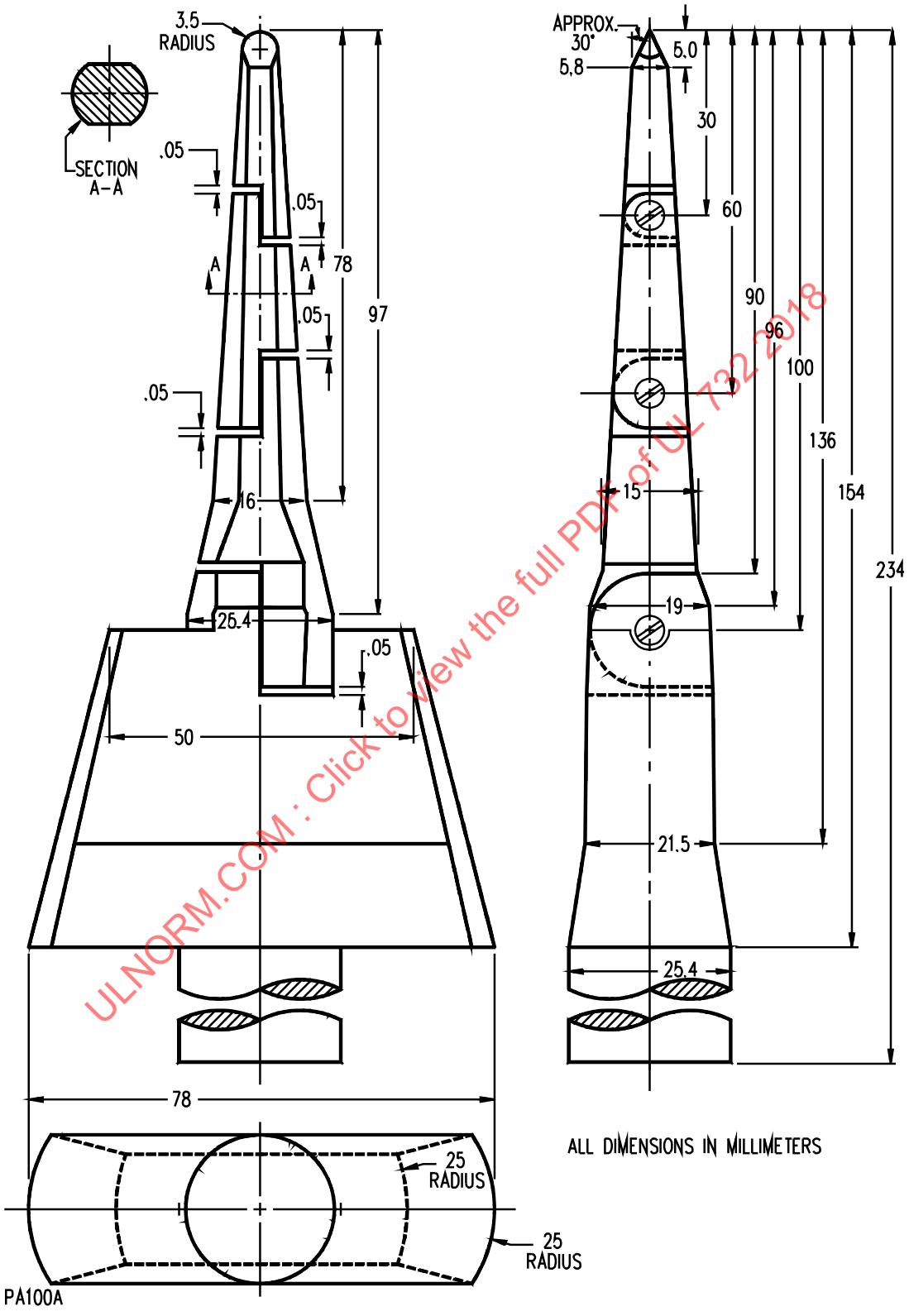


Table 27.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

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

[a] See 27.5.
[b] Between 3/4 inch and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch applies to a motor only.
[d] More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

27.2 With respect to a part or wire as mentioned in 27.1, in an integral enclosure of a motor as mentioned in the Exception to 27.1:

a) An opening that has a minor dimension (see 27.5) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 27.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 27.3;

3) In a directly accessible motor (see 27.7), an uninsulated live part cannot be contacted by the probe illustrated in Figure 27.4; and

4) In an indirectly accessible motor (see 27.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 27.2.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 27.1.

Figure 27.2
Probe for moving parts and uninsulated live parts

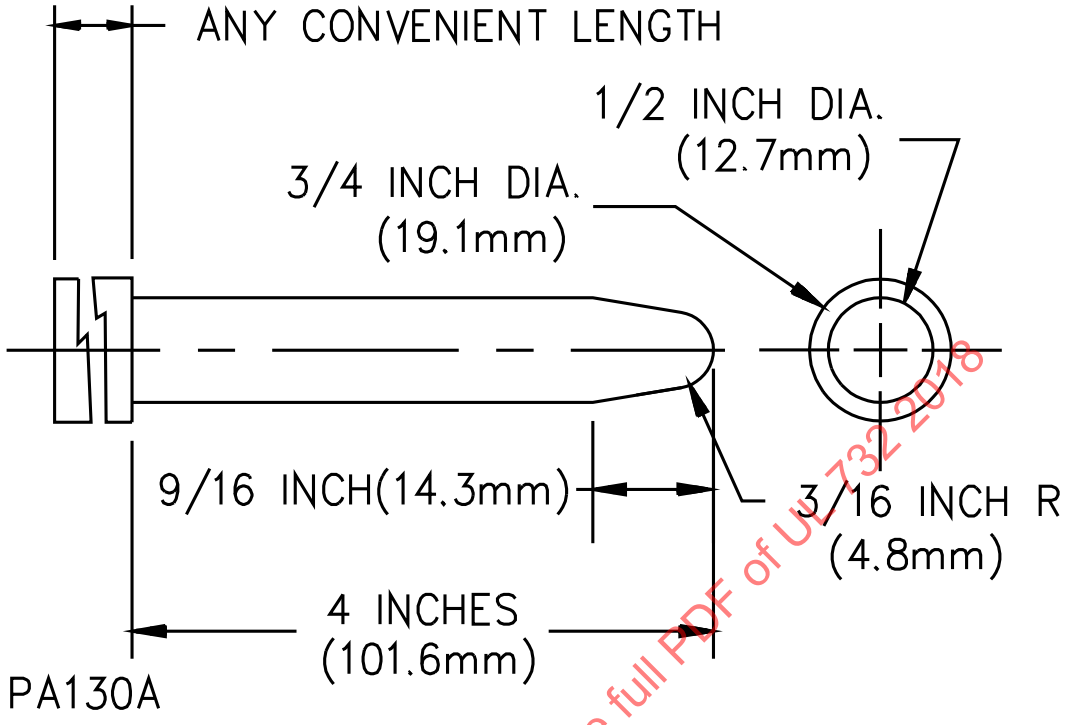


Figure 27.3
Probe for film coated wire

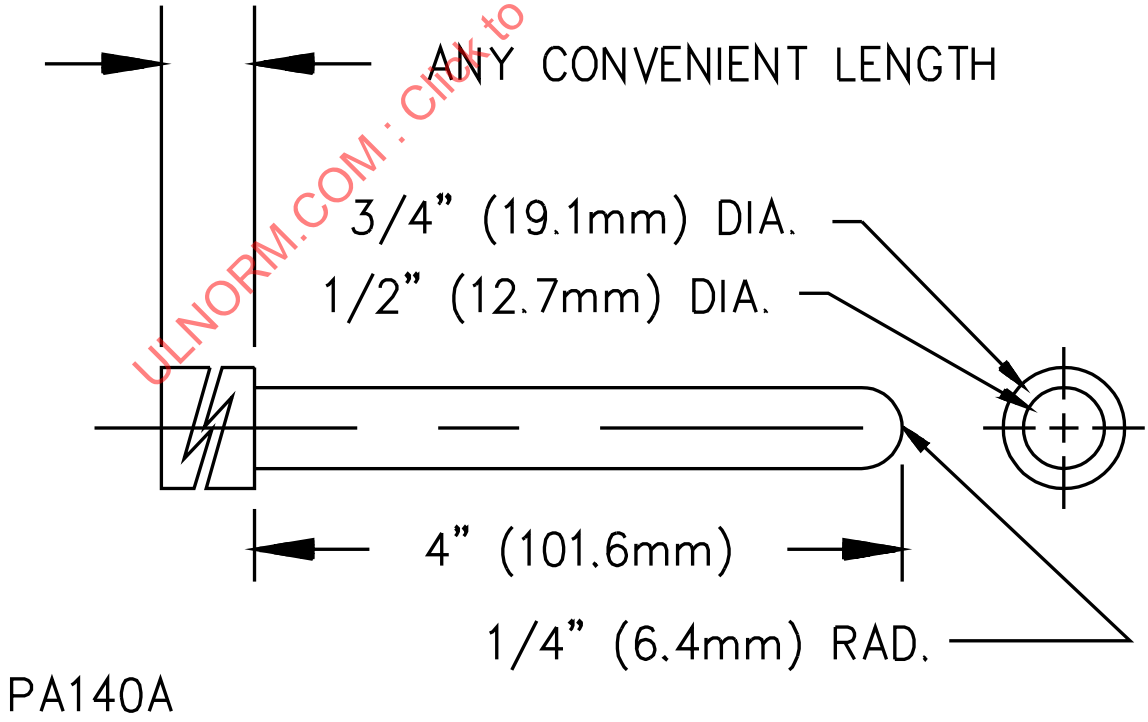
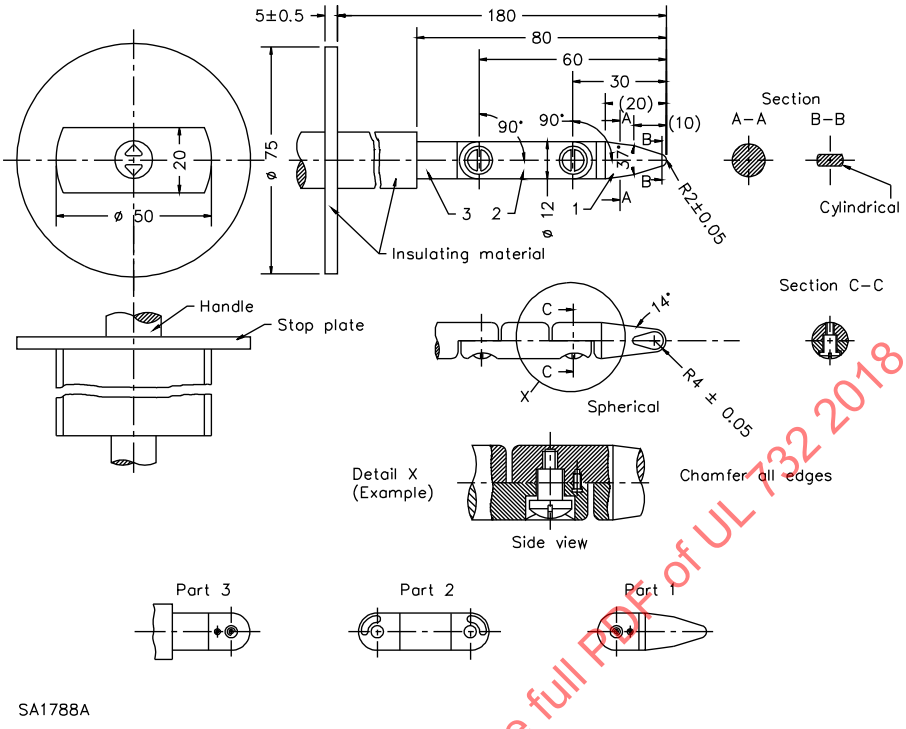


Figure 27.4
IEC Articulate probe



27.3 The probes mentioned in 27.1 and 27.2 and illustrated in Figures 27.1 – 27.4 shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figures 27.1 and 27.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

27.4 The probes mentioned in 27.3 and 27.5 shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

27.5 With reference to the requirements in 27.1 and 27.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

27.6 With reference to the requirements in 27.2, an indirectly accessible motor is a motor:

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

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

27.7 With reference to the requirements in 27.2, a directly accessible motor is a motor:

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

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

27.8 During the examination of a product to determine whether it complies with the requirements in 27.1 or 27.2, a part of the enclosure that may be removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

27.9 With reference to the requirements in 27.1 and 27.2, insulated brush caps are not required to be additionally enclosed.

28 Motors and Motor Protection

28.1 A motor shall be protected by an integral thermal- or overload-protective device, or combination thereof.

28.2 An overload-protective device as referred to in 17.1 is one that complies with the requirements in the National Electrical Code, NFPA 70-1993, as follows:

a) A separate overload device that is responsive to motor current. This device shall be rated or selected to trip at not 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 connection is to be considered separately and the motor is to be protected at all speeds.

b) If the values specified for motor-running overload protection do not correspond to the standard sizes or ratings of fuses, 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

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

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

28.5 A motor, such as a direct-drive fan motor, that is not normally subjected to overloads, and that is determined to be protected against overheating due to locked-rotor current by a thermal- or overload-protective device is acceptable if it is determined that the motor will not overheat under actual conditions of use.

28.6 Impedance protection is acceptable for a motor that is determined to be protected against overheating due to locked-rotor current, if the motor does not overheat under actual conditions of use.

28.7 A fuse shall not be used for motor-overload protection unless the motor is protected by a fuse rated in accordance with Table 430-152 of the National Electrical Code, ANSI/NFPA 70-1996.

28.8 A motor shall not exceed the temperature rises specified in Table 43.1 when tested as described in the Temperature Test, Section 43.

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

28.10 Interruption of the circuit to a motor by the overload- or thermal-protective device shall not result in operation of the equipment or discharge of fuel that results in a risk of fire, electric shock, or injury to persons. 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.

28.11 An automatically reset protective device shall not be used if the automatic reclosing of the circuit to the motor by the device may result in risk of fire, electric shock, or injury to persons.

28.12 The enclosure of a motor shall have no openings that will permit a drop of liquid or a particle falling vertically onto the motor to enter the motor.

28.13 Compliance with the requirement in 28.12 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor installed in the heater.

28.14 A motor having openings in the enclosure or frame shall be installed or shielded to reduce the likelihood of particles falling out of the motor onto combustible material located within or under the assembly.

28.15 The requirement in 28.14 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 product when the motor is energized under each of the following fault conditions, as applicable to the type of motor:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor or a permanent split-capacitor motor short-circuited; 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 exceeding 125°C (257°F) under the maximum load which the motor will run without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked.

28.16 The barrier mentioned in 28.15 shall:

a) Be horizontal;

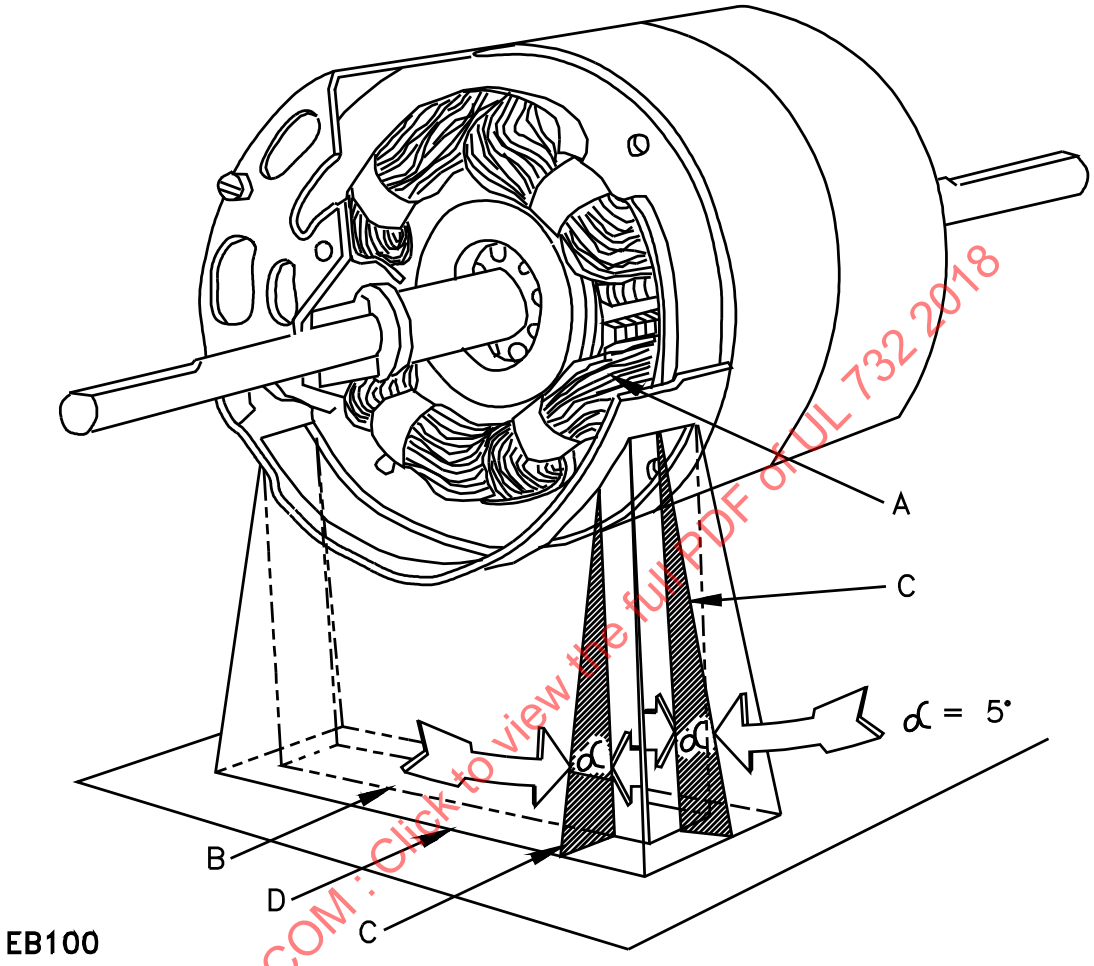
b) Be located as illustrated in Figure 28.1; and

c) Have an area not less than that described in that figure.

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

Figure 28.1

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.

28.17 An overload-protective device or thermal-protective device for a motor shall comply with the requirements in the Short-Circuit Test, Section 46.

29 Switches and Controllers

29.1 Except as noted in 29.2, a controller or controllers 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 126 – 600 volts or less, and having 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 54.4 if the same controller contacts handle a remote motor or motors in addition to the motor or motors 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 required 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 A controller that is cycled by the operation of an automatically reset overload device shall be one that has been investigated and found to withstand an endurance test under locked-rotor conditions without breakdown. 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 A motor controller shall be arranged so that it will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

30 Capacitors

30.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for radio-interference elimination, shall be housed within an enclosure or container so that mechanical damage to the plates will not occur, and flame or molten material will not be emitted as a result of breakdown of the capacitor. The construction shall comply with one of the following:

a) The capacitor container shall be of sheet steel not less than 0.020 inch (0.51 mm) thick or shall be constructed to provide equivalent protection; or

b) A capacitor having a sheet-steel container thinner than 0.020 inch or of other acceptable material shall be mounted in an enclosure that houses other parts of the appliance and that is acceptable for the enclosure of live parts.

30.2 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. Otherwise, it shall be separated from dead metal parts by spacings in accordance with Table 32.1.

30.3 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 in this standard, including faulted-overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 46.

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 46.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component or components.

31 Electrical Insulating Material

31.1 A material used for the sole support, separation, or both, 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 sold support for uninsulated live parts if shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock. Plastic materials may be used for the sole support of uninsulated live parts, if found to have acceptable mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric strength, and other properties as needed for the application.

31.3 A hole in porcelain, phenolic composition, or other acceptable nonconducting material, having a smoothly rounded surface is considered to be the equivalent of a bushing.

31.4 Ceramic materials and some molded compositions are acceptable for insulating bushings. Bushings of wood or hot-molded shellac and tar compositions are not acceptable.

32 Spacings – High-Voltage Circuits

32.1 Except as noted in 32.2 – 32.5, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than the values specified in Table 32.1.

Table 32.1
Spacings

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

[a] 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) thick, except that a liner or barrier not less than 0.013 inch (0.33 mm) thick 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.

[b] The spacings at wiring terminals of a motor shall be 1/4 inch (6.4 mm) for a motor rated 250 volts or less and 3/8 inch (9.5 mm) for a motor rated more than 250 volts.

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

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

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

32.2 The through air and over surface spacings in Table 32.1 at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load or loads that the component controls. However, the spacing from the component to the enclosure shall be judged on the basis of the total load on all components in the enclosure. For example, the through air and over surface spacings at a component that controls only a motor are judged on the basis of the volt-amperes of the motor. A component that 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 that independently controls separate loads is judged on the basis of the volt-amperes of the larger load. The volt-ampere values for the loads are to be determined by the measured input.

32.3 For a circuit not exceeding 300 volts, the over surface spacings for glass-insulated terminals of motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in Table 32.1; and may be 1/4 inch where 3/8 inch (9.5 mm) is specified.

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

32.5 All uninsulated live parts connected to different circuits, except subdivided circuits or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements in 32.1 – 32.4 and shall be judged on the basis of the highest voltage involved.

33 Spacings – Low-Voltage Circuits

33.1 The spacings for low-voltage electrical components installed in a circuit that includes a motor overload-protective device shall comply with the requirements in 33.2– 33.5.

33.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall not be less than 1/8 inch (3.2 mm). See 32.5.

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) that may be grounded when the device is installed shall not be 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, that may be grounded when the device is installed shall not be less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be maintained.

33.5 The spacings in low-voltage circuits that do not contain a device as mentioned in 33.1 are not specified.

34 Protection of Users and Service Personnel

34.1 An uninsulated high-voltage live part and moving parts that may cause injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by personnel performing service functions that may have to be performed with the equipment energized.

34.2 Service functions that 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 a control trip mechanism;

c) Operating a manual switch; or

d) Adjusting an air-flow damper.

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

34.3 The requirements in 34.1 do not apply to mechanical service functions that are not performed with the equipment energized.

34.4 An adjustable or resettable electrical control or manual-switching device 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 intended direction of access if uninsulated high-voltage live parts or moving parts that may cause injury to persons are:

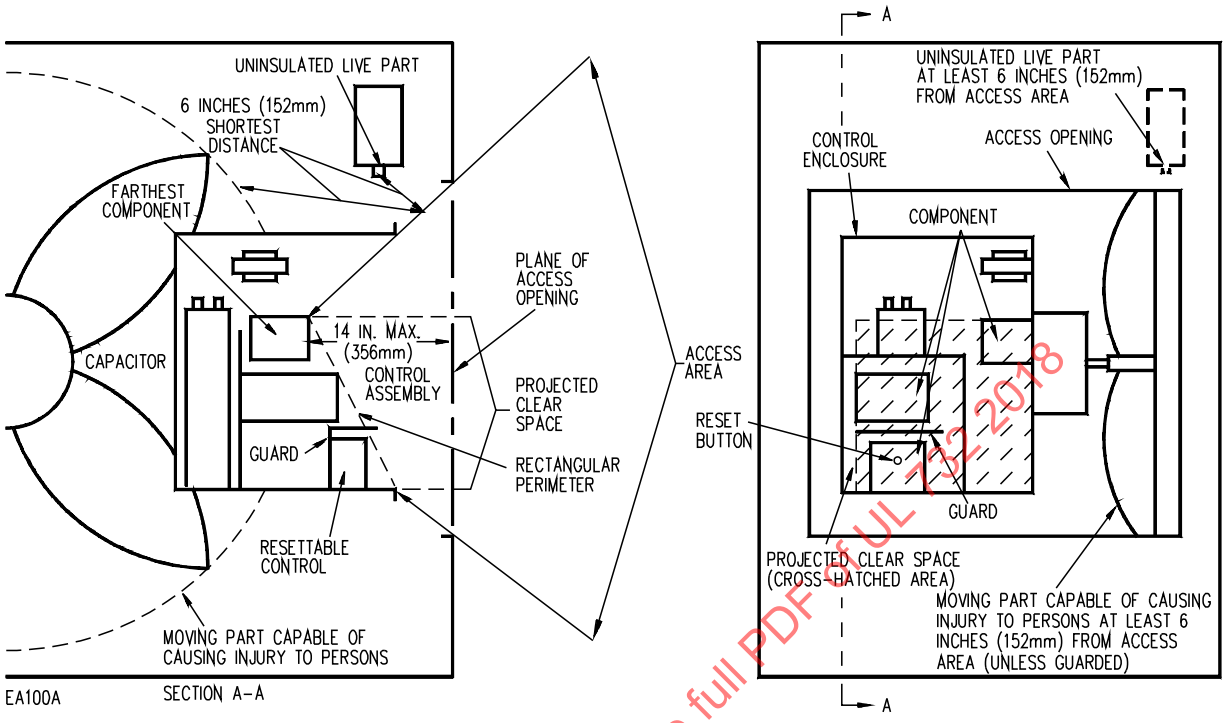
a) Not located in front, in the direction of access of the mechanism; and

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

34.5 An electrical control component that 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 a risk of electric shock from adjacent uninsulated live parts or to injury from adjacent moving parts.

34.6 Accessibility and protection to reduce the risk of electric shock and injury to persons 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. 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. Uninsulated high-voltage live parts outside the control assembly projected clear space, except for live parts within a control panel, or unguarded moving parts that may cause injury to persons are located not closer than 6 inches (152 mm) from any side of the access area.

Figure 34.1
Accessibility and protection



34.7 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. 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. 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. An extractor type fuseholder or snap switch mounted through the control assembly enclosure is located so that there is unimpeded access to the component through the access opening in the outer cabinet and so that it is not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless the live parts are guarded.

34.8 A component in a low-voltage circuit shall comply with the requirements in 34.5 in its relation to uninsulated live parts in a high-voltage circuit and to moving parts that may cause injury to persons.

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

a) Coils of a controller;

b) Coils of a relay or solenoid;

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

d) Enclosed motor windings;

e) An insulated terminal or splice; and

f) Insulated wire.

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

34.11 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 provided as specified in 54.11.

34.12 The distance from an opening in a required guard or enclosure to the moving parts mentioned in 34.10 shall be as specified in Table 34.1, but the minor dimension of the opening shall not exceed 3 inches (76 mm). For an opening having a minor dimension intermediate between two of the values specified in the table, the distance from the opening to the moving part shall not be less than that determined by interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 34.1
Dimensions of openings in enclosure

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

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

34.13 A moving part is not to be considered when judging compliance with 34.1 and 34.10 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

PERFORMANCE

35 General

35.1 A water heater shall comply with the applicable test requirements in Sections 35 – 52. A heater of a type not specifically described in this standard shall be investigated in accordance with the intent of the requirements. If there are any indications during the investigation that a heater will not continue to comply with the requirements during intended use, supplementary tests may be necessary to determine acceptability of the appliance.

35.2 A water heater is investigated for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than specified in Table 35.1. At the manufacturer's request, a heater may be investigated for installation on combustible floors.

Table 35.1
Standard clearances

Water heater under 100 cubic feet (2.8 m^3)	Minimum clearance, inches[a] (mm)											
	A		B		C		D		E		F	
	Above		Front		Chimney connector		Rear		Sides		Below	
Form II	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	NC[b]	
Form IIa	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	C[c]	

[a] These clearances are based on the water heater being installed in a room that is large compared to the size of the heater.
[b] NC – Noncombustible.
[c] C – Combustible.

35.3 At the manufacturer's request, a water heater may also be investigated for installation in alcoves or closets, with clearances to combustible construction less than specified in Table 35.1. All clearances are to be in integral inches.

35.4 If an appliance is to be tested in a partial enclosure at clearances less than those specified in Table 35.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are not to be less than 9 inches (229 mm). When the chimney connector clearances are less than those specified in Table 35.1, the connector arrangement is to be as specified in 37.2.3 and Figure 37.2.

35.5 All clearances specified in Table 35.1, or by the manufacturer as an option, are to be in integral inches for testing purposes.

36 Test Installation for Other Than Alcove-or Closet-Installed Heaters

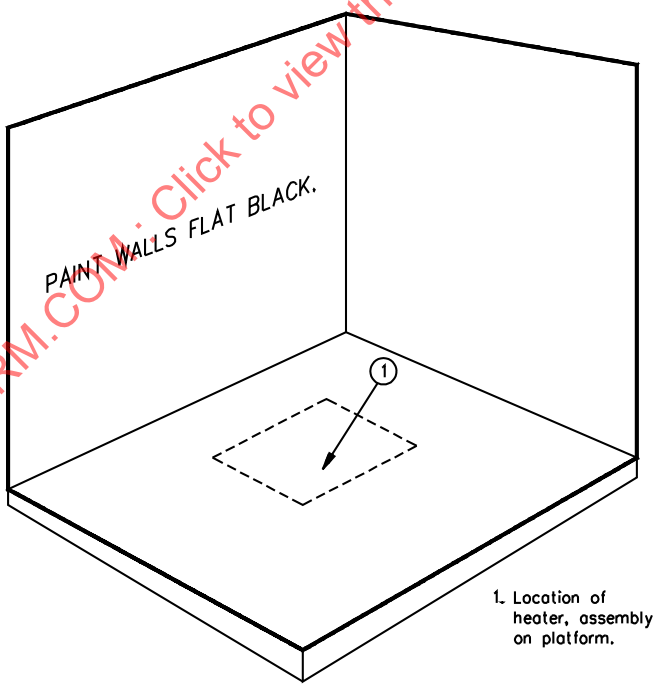
36.1 Enclosure

36.1.1 The water heater is to be placed in a partial enclosure in the as-received condition. 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 as specified in Table 35.1. If one side of the heater may create a higher wall temperature than the other, that side of the heater is to be directly opposite one wall.

36.1.2 The heater is to be level. Any leveling means are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the heater as close to the floor as the means permits.

36.1.3 The partial enclosure is to be formed by two walls of nominal 1-inch thick wood boards or 3/4-inch thick plywood, set at right angles to each other 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 and in accordance with 36.1.2. 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

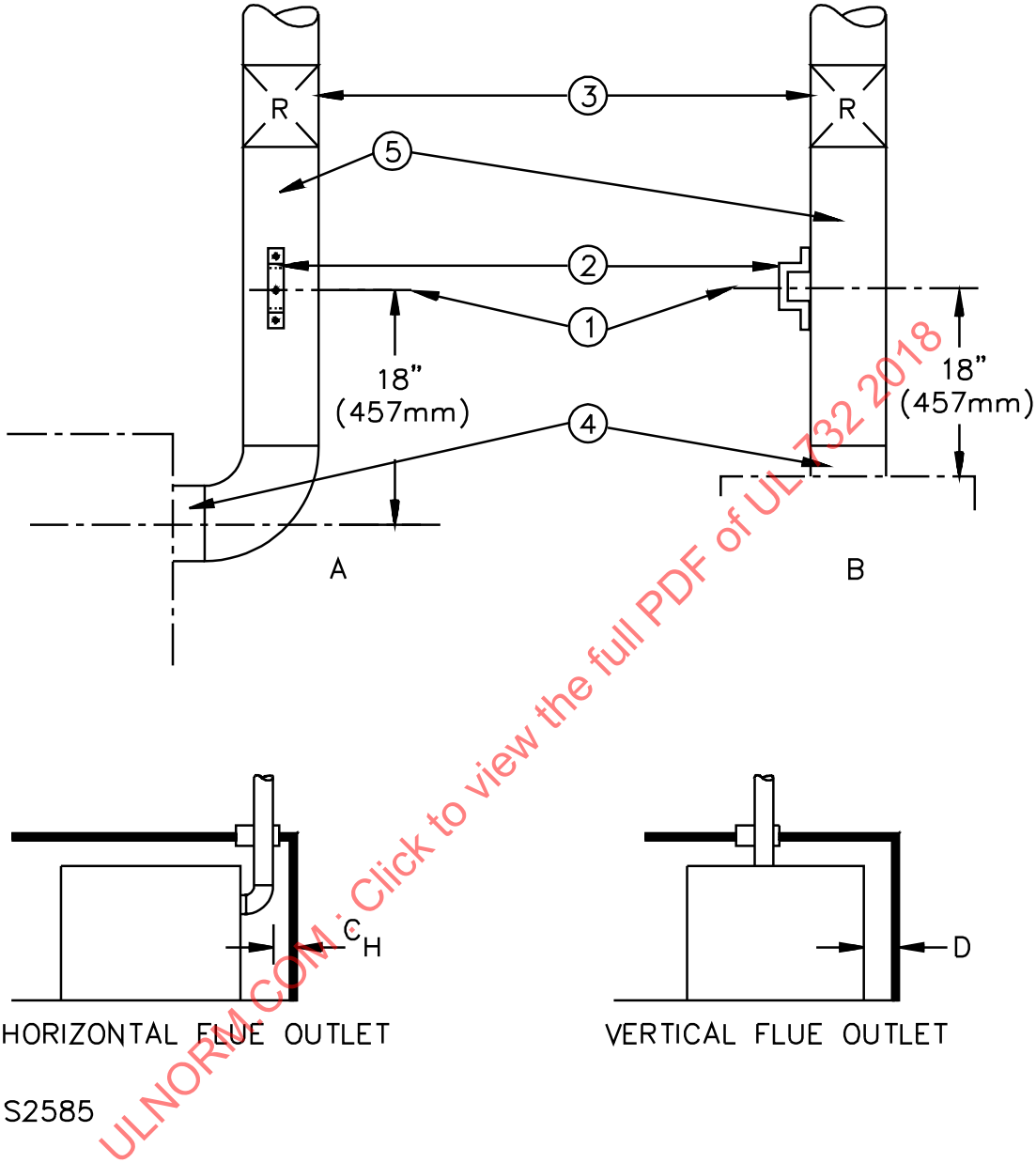


36.1.4 If the heater is intended for direct installation on combustible flooring, the floor beneath the heater is to be 1-inch white-pine flooring covered with one thickness of building paper, and then by 3/4-inch-thick plywood, unpainted or finished with a clear sealer.

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 more than 0.032 inch (0.58 mm) thick is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure. The connector is to be directly connected to and extended vertically above a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree sheet metal elbow at the bottom of the vertical section. See Figure 36.2.

Figure 36.2
Chimney connector – standard clearance test



1. Centerline of thermocouple.

2. Thermocouple support bracket.

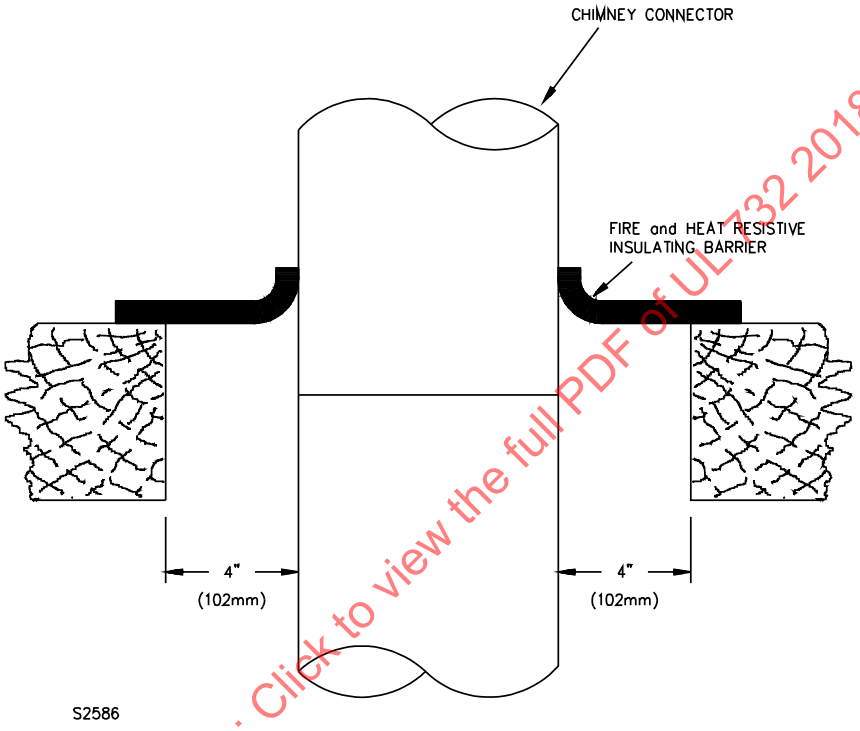
3. Draft regulator.

4. Flue collar.

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

36.2.2 Where the chimney connector passes through the enclosure, an opening having a diameter 8 inches (203 mm) larger than the diameter of the chimney connector is to be cut and the chimney connector centered in the opening. The annulus thus formed is to be sealed by a fire- and heat-resistive insulating barrier at least 1/8 inch (3.2 mm) thick, placed on the exterior surface. 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 36.3
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 illustrated in Figure 36.2.

36.2.4 A primary safety control that is furnished separately for mounting in the chimney connector exterior to the water 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 using the clearances specified in Table 35.1.

36.2.5 A draft regulator is to be provided for test purposes and is to be 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 heater is to be fixed in the position allowing maximum draft.

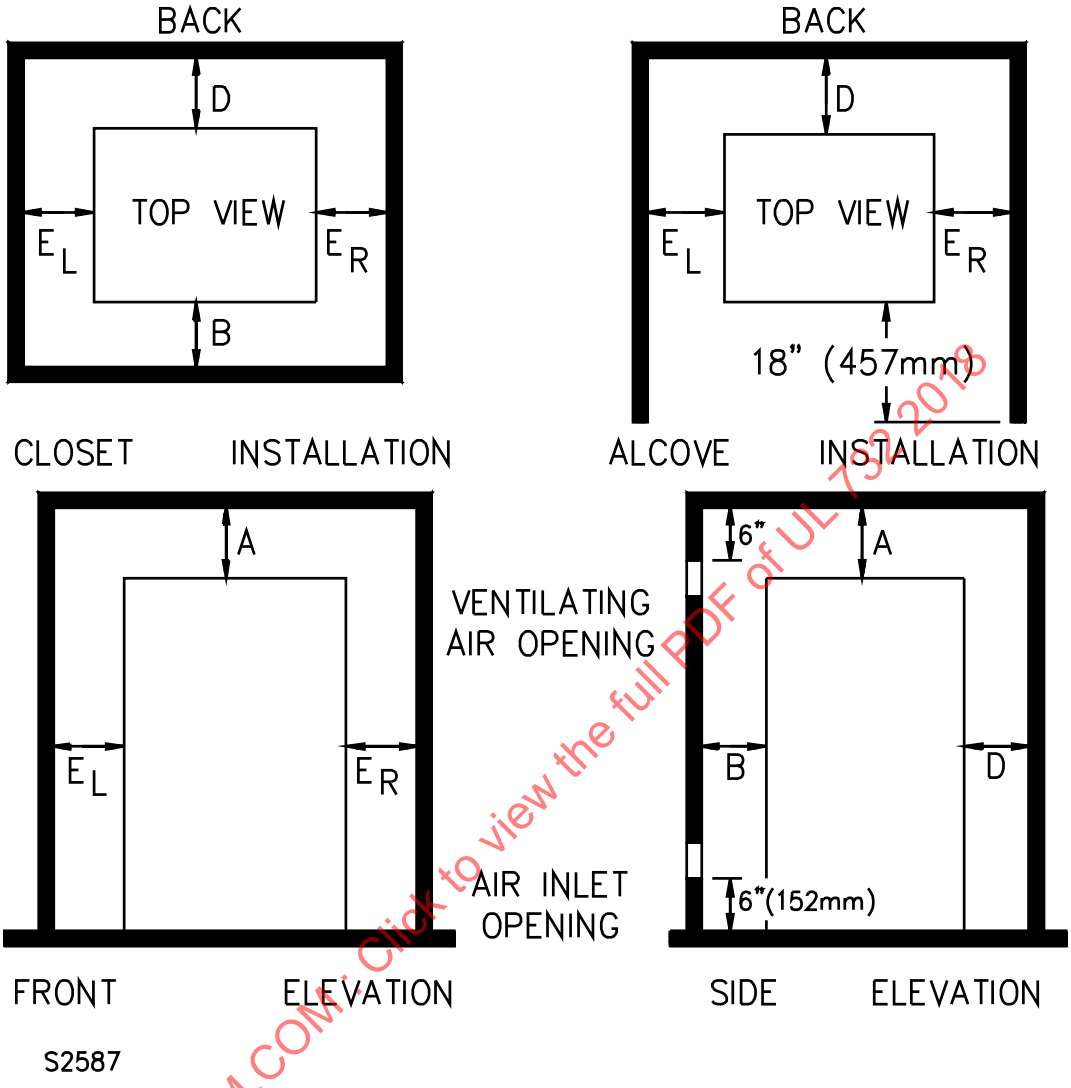
36.2.7 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

37 Test Installation for Alcove-or Closet-Installed Units

37.1 Enclosure

37.1.1 The heater in the as-received condition is to be installed in an enclosure with clearances in integral inches, as selected by the manufacturer, to walls and ceiling of the test enclosure. The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the heater to the ceiling specified by the manufacturer, but not more than 7 feet 6 inches (2.29 m). See Figure 37.1.

Figure 37.1
Test enclosure for alcove or closet installation



A – From top of water heater.

B – From front of water heater.

C_H – From chimney connector, measured horizontally or below connector. See Figure 37.2.

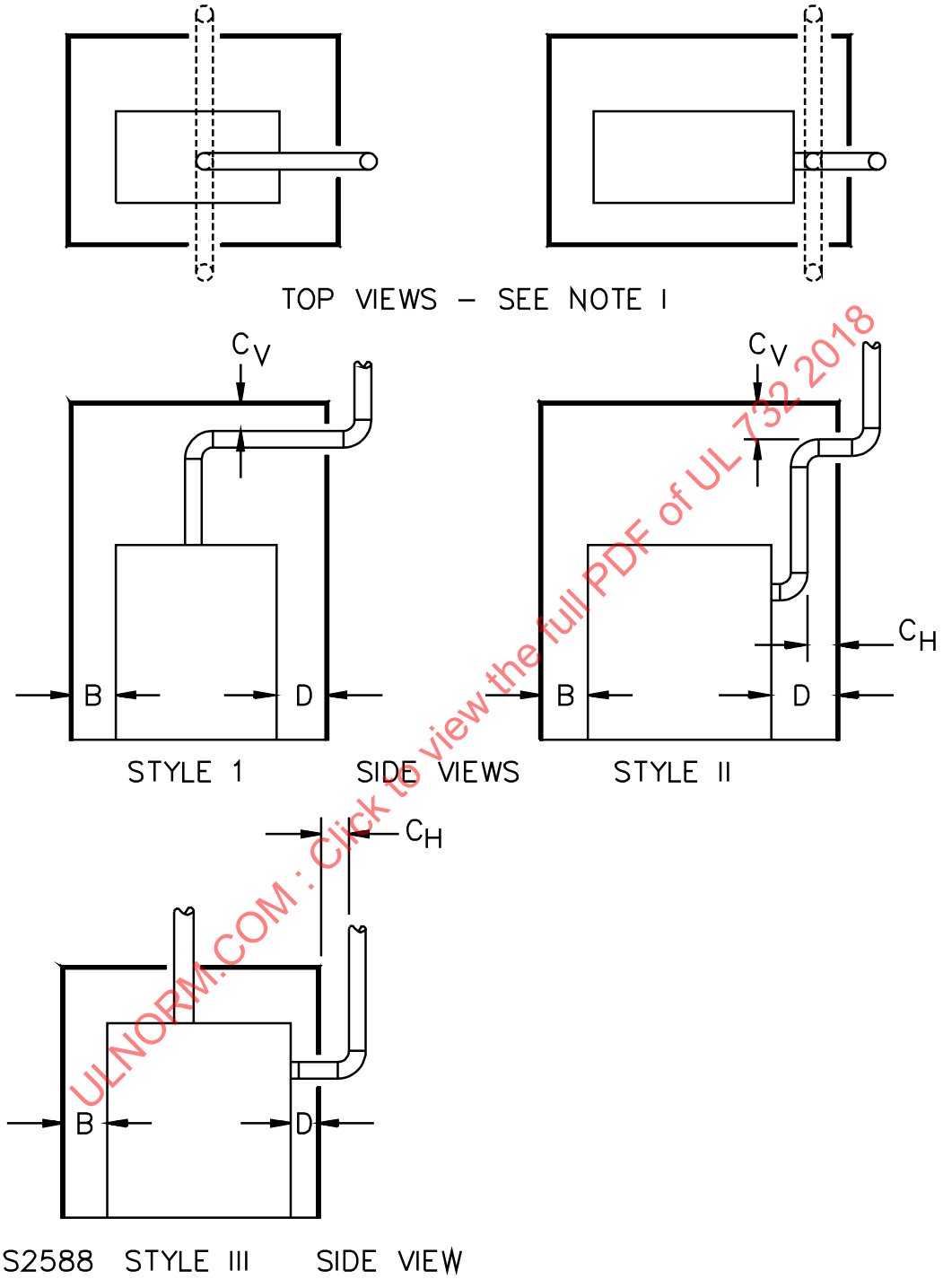
C_V – From chimney connector, measured vertically above connector. See Figure 37.2.

D – From back of heater.

E_L – From left side of heater.

E_R – From right side of heater.

Figure 37.2
Chimney connector arrangement for alcove and closet installation



Note: With chimney connector arrangement, Styles I and II, the horizontal run is to pierce the back or a side wall, whichever is farthest from the vertical run.

37.1.2 The walls and ceiling of the enclosure are to be made of nominal 1-inch thick wooden boards or 3/4-inch thick plywood. The walls are to be vertical and at right angles to each other. The interior surfaces of the walls and ceiling are to be finished in flat black. All joints in the enclosure are to be sealed. The floor is to be of combustible or noncombustible material, as specified by the manufacturer for testing purposes. Combustible floors are to be made of 1-inch thick flooring covered with one thickness of building paper superimposed by 3/4-inch thick plywood, unpainted or finished with clear sealer.

37.1.3 For an alcove-installation test, the enclosure is to be open opposite the front of the heater. The side walls and ceiling are to extend 18 inches (457 mm) beyond the front of the heater, and a wall is to be placed opposite the open side of the enclosure at a distance of 48, 36, or 24 inches, (1.22, 0.91, or 0.61 m) as specified by the manufacturer for testing purposes.

37.1.4 For a closet-installation test, a simulated door is to be provided for the enclosure. The door is to have two openings located so that the lower edge of the lower opening is 6 inches (152 mm) above the floor level of the enclosure and the other opening is located so that its upper edge is 6 inches below the ceiling of the enclosure. The height of each opening is to be one-half the width. The free area of each opening is to be at least 1 square inch (6.5 cm^2) per 1000 Btu per hour (300 W) of the heater input rating but not more than an area equivalent to 20 percent of the total area of the simulated door. Both openings are to be centered on the vertical centerline of the enclosure.

37.1.5 The heater is to be level. Any leveling means are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the heater as close to the floor as the means permits. The storage tank of a floor-mounted circulating heater is to be exterior to the test enclosure.

37.1.6 If a storage heater is intended to be insulated in service, it is to be tested with the insulation furnished by the manufacturer as standard equipment with each heater.

37.1.7 The inlet-air temperature is to be measured by a thermocouple that is not larger than 24 AWG (0.21 mm^2) and shielded from direct radiation. For an alcove installation, the thermocouple is to be placed centrally 24 inches (0.61 m) in front of the heater and 24 inches above the floor of the test enclosure. For a closet installation, the thermocouple is to be placed in the center of the lower ventilating opening into the closet.

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 water heater. Galvanized stovepipe not more than 0.023 inch (0.58 mm) thick is to be used.

37.2.2 The clearance between the nearest surfaces of the chimney connector and the walls and ceiling shall not be less than 9 inches (229 mm) nor more than 18 inches (457 mm).

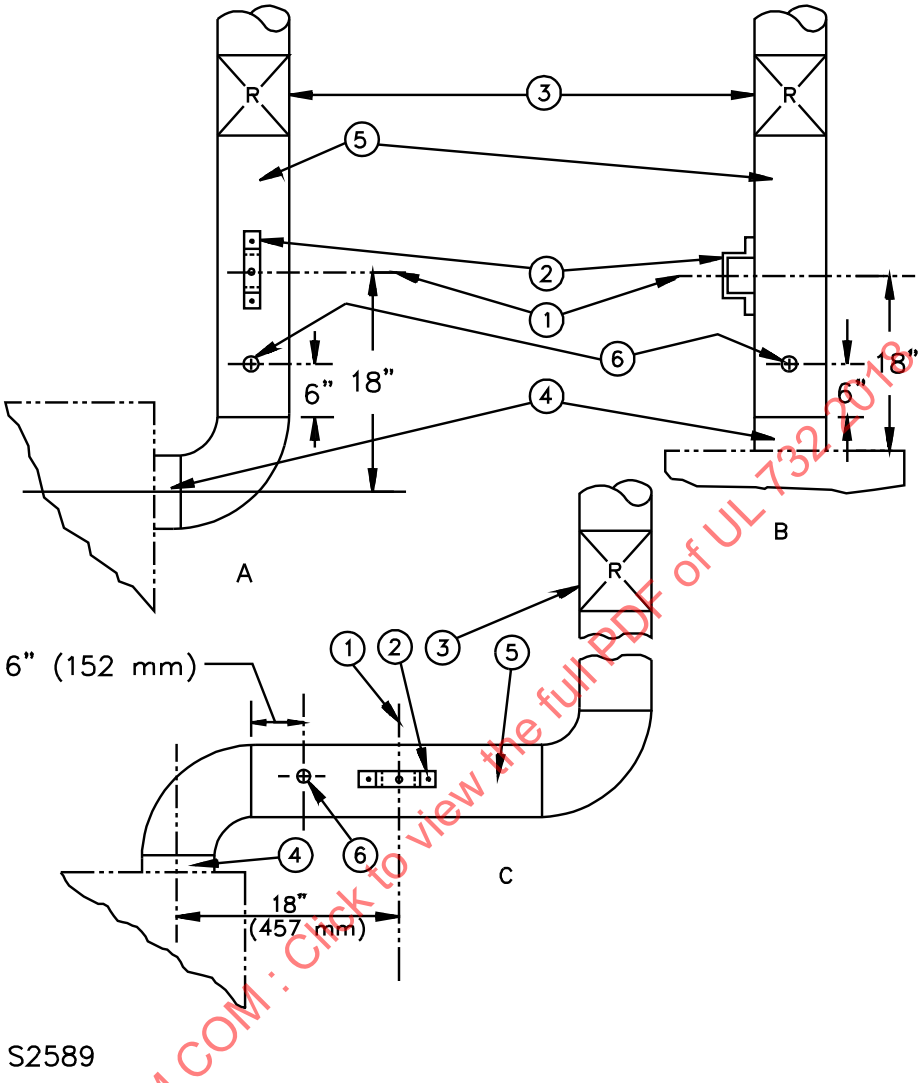
Exception: If the construction of the heater is such that, when installed with the clearances selected by the manufacturer, the clearance between the chimney connector and the interior walls of the test enclosure is less than 9 inches, the test may be conducted with the lesser clearance if the portions of the wall located within 9 inches of the chimney connector are protected. In this case, directions that such surfaces should be protected shall be included in the instructions furnished with the heater.

37.2.3 A heater with a vertical flue outlet is to be tested with two chimney connector arrangements, Styles I and III as illustrated in Figure 37.2. A heater with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III as illustrated in Figure 37.2. The test need only be conducted with the Style I or Style II arrangement if the manufacturer elects to specify the minimum clearance from the heater as that obtained when tested with that arrangement.

37.2.4 Where the chimney connector passes through the enclosure, an opening having a diameter 8 inches (203 mm) larger than the diameter of the chimney connector is to be cut and the chimney connector centered in the opening. The annulus thus formed is to be sealed by a fire- and heat-resistive insulating barrier at least 1/8 inch (3.2 mm) thick, placed on the exterior surface. 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.

37.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as illustrated in item 2 of Figure 37.3.

Figure 37.3
Chimney connector – alcove and closet test



1. Centerline of thermocouple.

2. Support bracket.

3. Draft regulator.

4. Flue collar.

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

6. Location of stack element of safety control.

1 inch = 25.4 mm

37.2.6 A primary safety control that is furnished separately for mounting in the chimney connector is to be located with its element in a plane perpendicular to the axis of the flue-gas flow:

a) 6 inches (152 mm) downstream from the flue collar; or

b) If an elbow is attached directly to the flue collar, 6 inches downstream from the downstream end of the elbow.

See item 6 of Figure 37.3.

37.2.7 A draft regulator is to be provided for test purposes and is to be located in the chimney connector outside the test enclosure. See Figure 37.3.

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

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

38 Instrumentation

38.1 Draft measurement

38.1.1 Draft is to be measured by a draft gauge that can be read directly to 0.005 inch (0.10 mm) water column and that has an accuracy of ±0.0025 inch (±0.050 mm). The gauge is to be checked for zero reading at the beginning and at the end of each test.

38.2 Fuel-input measurement

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-mass (0.004 kg) or a burette capable of the same resultant accuracy.

38.3 Power measurement

38.3.1 The total electrical input to a water heater is to be measured in amperes at rated voltage.

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

38.4 Speed measurement

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

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 larger 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 passes through 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 materials and parts such as those mentioned in Table 43.1.

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 the temperature of which is being measured. Acceptable thermal contact will usually result from securely taping or cementing the thermocouple in place. If 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 the insulated portion of the wire and with the tip held in thermal contact with the surface by pressure-sensitive tape.

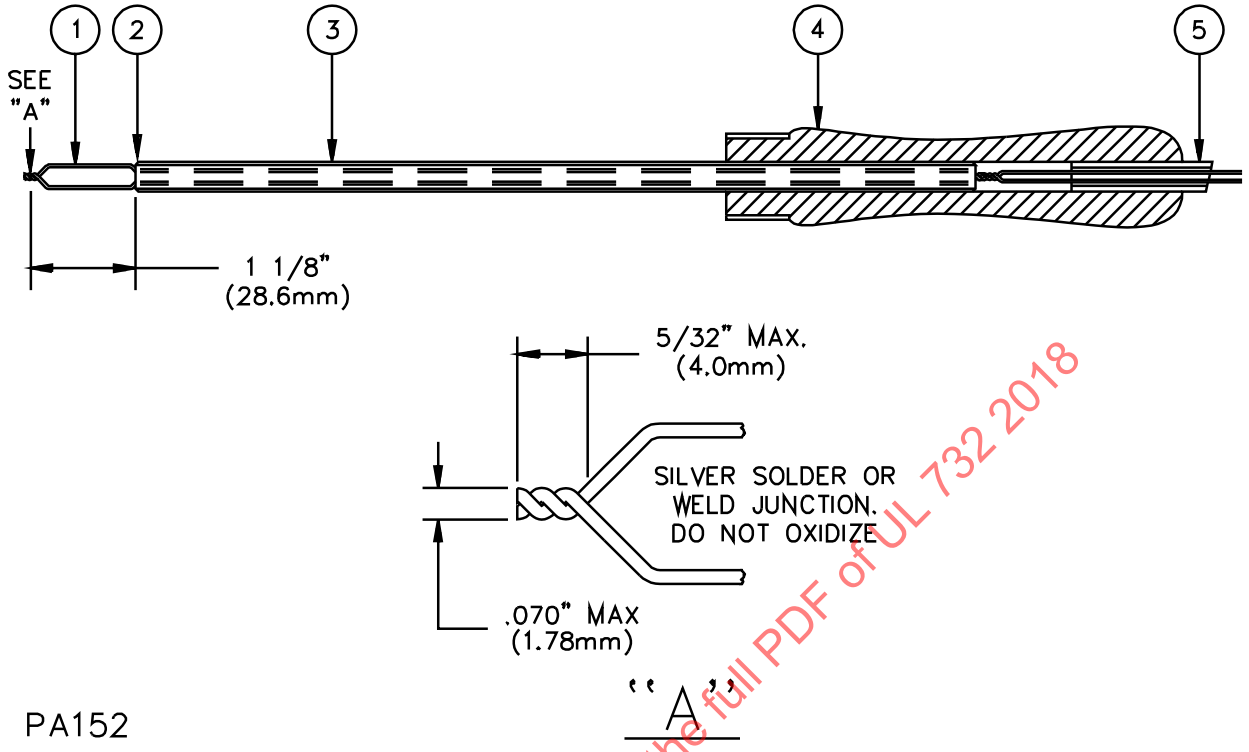
38.5.5 For zero clearance, the thermocouples are to be applied to surfaces of the heater at points of zero clearance.

38.5.6 The flue-gas temperature is to be measured by a thermocouple, such as illustrated in Figure 38.1. The thermocouple is to be inserted into the chimney connector as illustrated in 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 securely sealed in the position allowing maximum draft during all tests.

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

38.5.8 The inlet-air temperature is to be measured by a thermocouple not larger 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 above the floor of the test enclosure.

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. 1-1/4 inch (6.4 mm) outside diameter, two-hole porcelain insulator cut to length and ends beveled on two sides.

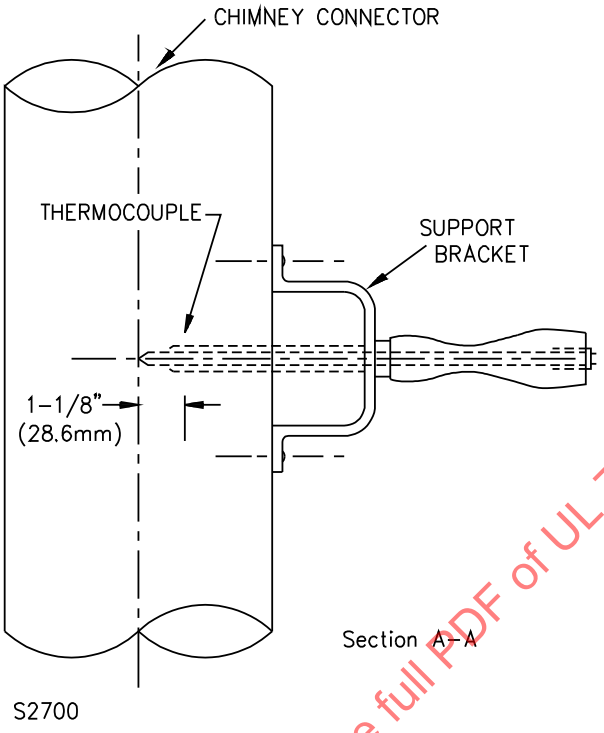
3. 1-5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

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 heater assembly is to be set up for test in the appropriate enclosure and manner described in Section 36 or 37, whichever is applicable.

39.1.2 Unless otherwise specified, a water heater is to be tested at the potential specified in Table 39.1.

Table 39.1
Test voltages

Rated voltage	Test voltage
110 to 120	120
200 to 208	208
220 to 240	240
254 to 277	277
440 to 480	480
550 to 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 (W) 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.

39.3 Heater equipped with vaporizing burner

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

39.3.2 No. 1 fuel oil having a viscosity as specified in Table 39.2 is to be used for firing vaporizing burners.

Table 39.2
Fuel oil viscosity

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

39.3.3 The pilot-fire burning rate is to be a rate equivalent to the pilot-fire rate obtained at the maximum allowable setting of the metering device with No. 1 oil plus the valve's positive tolerance. The high-fire burning rate is to be adjusted to deliver the rated high-fire input.

39.3.4 If an adjustable oil-shutoff control is provided, it is to be adjusted to the maximum allowed timing for shutoff.

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

39.3.6 The draft at the flue collar is to be as recommended by the manufacturer, which is not to be less than 0.02 inch (0.5 mm) nor more than 0.06 inch (1.5 mm) water column.

40 Combustion Test – Burner and Water Heater

40.1 A water heater shall acceptably function uniformly and acceptably without producing smoke in excess of that specified in 40.2.

40.2 The heater is to be installed and adjusted in accordance with the manufacturer's instructions. The heater is then to be fired at rated input and such that the stack loss is not more than 25 percent and operated until steady-state 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 No. 2 spot on the Shell-Bacharach smoke scale with a Model RDC smokemeter.

41 Water-Temperature Control Test

41.1 A water heater, when tested as described in 41.3 and with the temperature-regulating control set at the maximum temperature position allowed by a fixed stop, shall not exceed an outlet-water temperature of 194°F (90°C).

Exception: A maximum water temperature of 200°F (93°C) may be accepted if the temperature-regulating control or controls and the limit control have cutout temperature tolerances not greater than ±5.0°F (±2.8°C).

41.2 A water heater provided with a continuous-burning pilot fire during the standby burning period shall be tested as described in 41.4. Water temperature at the top of the heater shall not exceed 100°F (38°C) above room temperature.

41.3 The heater is to be filled with water at a temperature of 65 ±5°F (18.3 ±2.8°C). The temperature-regulating control is to be adjusted to its maximum allowable setting. A pressure-relief device followed by a quick-acting valve is to be installed on the outlet connection of the storage vessel. A flow restriction, calibrated to permit a flow of 5 gallons per minute (18.9 L/min), is to be connected to the outlet of the valve. A water-pressure regulator is to be located in the water-supply line to the heater and adjusted so that at full flow the pressure at the inlet connection to the heater will be maintained at the value required to deliver a steady flow of 5 gallons per minute when water is drawn from the heater. During the test, the inlet-water temperature is to be maintained at 65 ±5°F (18.3 ±2.8°C). The heater is to be fired at rated high-fire input with the inlet-water valve opened and the outlet-water valve closed, until the temperature control functions to reduce the fuel supply to the burner to a minimum. Water is then to be drawn immediately at the rate of 5 gallons per minute until the temperature-regulating control functions to turn on the fuel supply to the burner, and the maximum outlet-water temperature is recorded. This operation is to be repeated, until a constant or continually receding outlet water temperature is attained.

41.4 A heater equipped with a burner that operates on pilot fire when the thermostat reduces the fire is to be allowed to continue operation following the test described in 41.3, but with the inlet-water valve closed and the outlet-water valve open, until equilibrium or continually receding water temperatures are obtained.

42 Limit-Control Cutout Test

42.1 A water heater shall be operated as described in 42.2 until the limit control functions. The temperature of the water shall not exceed 210°F (99°C) but shall be higher than that maintained by the temperature-regulating control as determined in the Water-Temperature Control Test, Section 41.

42.2 With the heater installed as described in the Water-Temperature Control Test, Section 41, the temperature-regulating control is to be made inoperative. The heater is to be fired at rated high-fire input with the inlet-water valve opened and the outlet-water valve closed, until the limit control functions. The water temperature is to be measured in accordance with 38.5.7.

43 Temperature Test

43.1 A water heater shall be tested in accordance with 43.2 – 43.4. No part shall attain a temperature that will:

a) Damage required corrosion protection;

b) Adversely affect operation of safety controls;

c) Reduce the value of required thermal or electrical insulation; or

d) Cause creeping, distortion, sagging, or similar damage if such damage to the material or part may increase the risk of fire, electric shock, or injury to persons.

The temperature rises at specific points shall not exceed those specified in Column 1 of Table 43.1.

43.2 The temperature-regulating control is to be bypassed to permit continuous operation during this test.

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

43.4 Firing of the heater is to be continued until constant temperatures are attained. A temperature is considered to be constant when three consecutive readings taken at 15-minute intervals indicate no change.

Table 43.1
Maximum temperature rises

Device or material			Column 1		Column 2	
			°C	(°F)	°C	(°F)
A.	Motors[a,b]					
	1.	Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).				
		a. In open motors –				
		Thermocouple or resistance method	75	(135)	115	(208)
		b. In totally enclosed motors –				
		Thermocouple or resistance method	80	(144)	115	(208)
	2.	Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
		a. In open motors –				
		Thermocouple method	65	(117)	115	(208)
		Resistance method	75	(135)	115	(208)
		b. In totally enclosed motors –				
		Thermocouple method	70	(126)	115	(208)
		Resistance method	80	(144)	115	(205)
	3.	Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors).				
		a. In open motors –				
		Thermocouple or resistance method	95	(171)	140	(252)
		b. In totally enclosed motors–				
		Thermocouple or resistance method	100	(180)	140	(252)
	4.	Class B insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
		a. In open motors–				
		Thermocouple method	85	(153)	140	(252)
		Resistance method	95	(171)	140	(252)
		b. In totally enclosed motors –				
		Thermocouple method	90	(162)	140	(252)
		Resistance method	100	(180)	140	(252)
B.	Components					
	1.	Capacitors				
		Electrolytic type[c]	40	(72)	(Not specified)	
		Other types[d]	65	(117)		
	2.	Field wiring	35	(63)	60	(108)
	3.	Relay, solenoid, and other coils with:[b]				
		a. Class 105 insulated windings –				
		Thermocouple method	65	(117)	115	(208)
		b. Class 130 insulated windings–				
		Thermocouple method	85	(153)	140	(252)
	4.	Sealing compounds	40°C (104°F) less than its melting point			
	5.	Transformer enclosures[b] –				
		a. Class 2 transformer	60	(108)	85	(153)
		b. Power and ignition transformers	65	(117)	90	(162)
C.	Insulated conductors[e,f]					

Table 43.1 Continued on Next Page

Table 43.1 Continued

Device or material			Column 1		Column 2	
			°C	(°F)	°C	(°F)
	1.	Appliance wiring material				
		75°C rating	50	(90)	65	(117)
		80°C rating	55	(99)	70	(126)
		90°C rating	65	(117)	80	(144)
		105°C rating	80	(144)	95	(171)
		200°C rating	175	(315)	200	(360)
		250°C rating	225	(405)	250	(450)
	2.	Flexible cord – Types SO, ST, SJO, SJT	35	(63)	60	(108)
	3.	GTO cable	35	(63)	60	(108)
	4.	Wire, Code				
		Types RF, FF, RUW	35	(63)	60	(108)
		Types RH, RFH, FFH, RHW, THW, THWN	50	(90)	75	(135)
		Types T, TF, TFF, TW	35	(63)	60	(108)
		Type TA	65	(117)	90	(162)
	5.	Other types of insulated wires	See note f			
D.	Electrical Insulation – General[f]					
	1.	Class C electrical insulation material	Not specified			
	2.	Class (180) electrical insulation material	As determined by test			
	3.	Fiber used as electrical insulation or cord bushings	65	(117)	90	(162)
	4.	Phenolic composition used as electrical insulation or as a part the deterioration of which may result in a risk of fire or electric shock	125	(225)	150	(270)
	5.	Thermoplastic material	25°C (77°F) less than its temperature rating			
	6.	Varnished cloth insulation	60	(108)	85	(153)
E.	Metals					
	1.	Aluminum Alloys				
		a. 1100	183	(330)	239	(430)
		b. 3003	239	(430)	294	(530)
		c. 2014, 2017, 2024, 5052	294	(530)	350	(630)
	2.	Aluminum-Coated Steel[g]	656	(1180)	767	(1380)
	3.	Carbon Steel Sheet, Cast Iron	517	(930)	683	(1230)
	4.	Carbon Steel-Coated with Type A19 Ceramic	572	(1030)	683	(1230)
	5.	Galvanized Steel[h]	267	(480)	350	(630)
	6.	Stainless Steel				
		Types 302, 303, 304, 316, 321, 347	767	(1380)	878	(1580)
		Type 309	961	(1730)	1072	(1930)
		Type 310	1017	(1830)	1128	(2030)
		Type 405	683	(1230)	795	(1430)
		Types 403, 409, 410, 416	572	(1030)	683	(1230)
		Type 430	711	(1280)	822	(1480)
		Type 442	877	(1580)	933	(1680)
		Type 446	961	(1730)	1072	(1930)
	7.	Zinc Castings	89	(160)	145	(260)
F.	General					
	1.	Air Filter	50	(90)	97	(175)
	2.	Flue gases	517	(930)	738	(1330)
	3.	Oil inconstant level valve or tank	14	(25)	22	(40)

Table 43.1 Continued on Next Page