

Oil-Fired Storage Tank Water Heaters



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September 22, 1995

Standard for

Oil-Fired Storage Tank Water Heaters

UL 732, Fifth Edition

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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 Requirements for the installation and use of oil-burning equipment are included in the Standard for the Installation of Oil Burning Equipment, ANSI/NFPA 31 and the BOCA Basic/National Mechanical Code.

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

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 General

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 need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

4.4 Specific components are recognized as being 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 for which they have been recognized.

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

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.

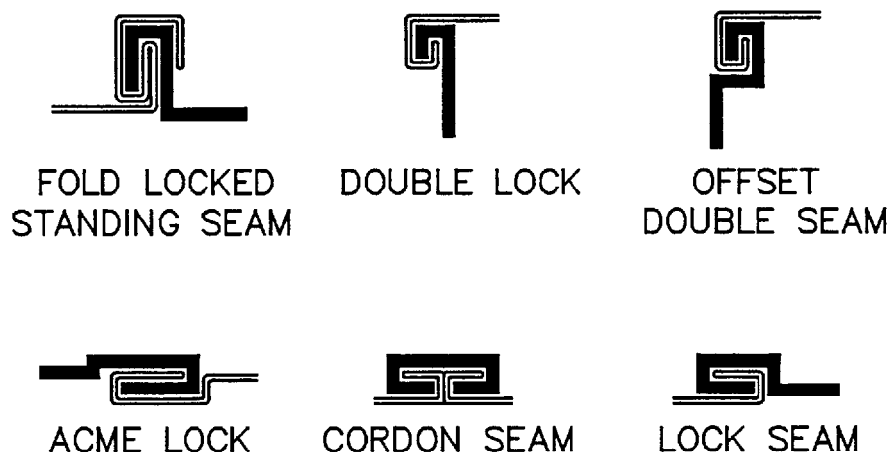
11.2 A combustion chamber (fire box) lining material shall be durable, secured in place, and accessible for replacement with equivalent material.

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



ED100

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 43, 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 43.

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 of 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 A water heater shall be controlled by a temperature-regulating control or control system so that the water will not attain a temperature of more than 194°F (90°C), except that 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 $\pm 5^\circ\text{F}$ ($\pm 2.8^\circ\text{C}$).

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 $\pm 10^{\circ}\text{F}$ ($\pm 5.6^{\circ}\text{C}$).

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 degrees 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, No. 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:

- The screw or connector is rendered unusable for field-wiring connections; or
- 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 No. 10 AWG (5.3 mm²) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire-binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

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 No. 14 AWG (2.1 mm²).

Exception No. 2: A No. 6 screw may be used for the connection of No. 16 or 18 AWG (1.3 or 0.82 mm²) 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 No. 14 AWG (2.1 mm²) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than No. 14 AWG (2.1 mm²). 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 natural 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 No. 18 AWG (0.82 mm²).

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	
		No. 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
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 No. 16 or 18 AWG (1.3 or 0.82 mm²) and 3/64 inch (1.2 mm) for No. 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm²), 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 94V-0, 94V-1, 94V-2, 94-5V, 94HF-1, or 94HF-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 abraded. 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 No. 18 AWG (0.82 mm²) 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.