UL 1453

STANDARD FOR SAFETY

Electric Booster and Commercial Storage Tank Water Heaters

UL Standard for Safety for Electric Booster and Commercial Storage Tank Water Heaters, UL 1453

Sixth Edition, Dated March 29, 2016

Summary of Topics

This revision of ANSI/UL 1453 is being issued to revise Table 45.1 – Maximum acceptable temperature rise, to provide for a maximum temperature rise for phenolic components used as electrical insulation, and editorial corrections.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated March 16, 2018.

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

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Standard for Electric Booster and Commercial Storage Tank Water Heaters

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The most recent designation of ANSI/UL 1453 as an American National Standard (ANSI) occurred on May 18, 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.

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INTRODUCTION

1 Scope

1.1 These requirements cover electric booster water heaters, electric commercial storage tank water heaters, and remote control assemblies for such heaters, rated 600 volts or less, to be employed in ordinary locations in accordance with the National Electrical Code, NFPA 70, and that meet at least one of the following conditions:

a) Over 120 gallons (454 L) in capacity;

b) Rated over 12 kilowatts; or

c) Equipped with one or more temperature-regulating controls that permit a water temperature of more than 85°C (185°F).

1.2 These heaters are intended for installation in accordance with model mechanical and plumbing codes.

1.3 An electric water heater not exceeding 120 gallons (454 L) capacity, rated no more than 12 kilowatts, and equipped with a temperature-regulating thermostat having no marked dial setting more than 77°C (171°F) and provided with a stop to prevent adjustment to a higher setting, shall be judged in accordance with the requirements in the Standard for Household Electric Storage Tank Water Heaters, UL 174.

1.4 These requirements do not cover electric boilers, commercial cooking appliances, medical and dental equipment, or other electric heating equipment or appliances that are covered in or as part of individual requirements that are separate from this standard. Electrode type boilers are not covered by these requirements.

1.5 In the following text, a requirement that applies only to booster water heaters or to commercial storage-tank water heaters is so identified by a specific reference in that requirement to the equipment involved. Absence of such a specific reference or use of the term water heater indicates that the requirement applies to all of the equipment covered in this standard unless the context indicates otherwise.

2 Components

2.1 Except as indicated in this clause, a component of a product covered by this standard shall comply with the requirements for that component. See the individual sections of this standard for component requirements.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

3.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are root mean square (rms).

4 Undated References

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

5 Glossary

5.1 For the purpose of this standard the following definitions shall apply.

5.2 BOOSTER WATER HEATER – A water heater furnishing hot water from initially heated water, which is usually 60°C (140°F), with the minimum output water temperature being 77°C (171°F).

5.3 ELECTRICAL CIRCUITS –

a) Line Voltage Circuit – A circuit involving a potential of no 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 no more than 30 volts rms (42.4 volts peak) supplied by a battery or by a standard Class 2 transformer or other transforming device, or by a combination of transformer and fixed impedance having output characteristics in compliance with requirements established for a Class 2 transformer. A circuit obtained by connecting resistance in series with a line voltage supply circuit as a means of limiting the voltage and current is not considered to be a low voltage circuit.

5.4 ENCLOSURE – The part of an electric water heater that surrounds insulated and uninsulated current-carrying live parts and that is intended to contain a fire resulting from an electrical fault.

5.5 FRAME – 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.

5.6 HEATING ELEMENT ACCESSORY – An attachment to the water heater that will allow electrical rating modification. The heating element accessory consists of a heating element(s), a new rating label, and associated hardware to mount the element(s).

5.7 OPERATING CONTROL – A control intended to start or regulate the appliance during normal operation. An example would be a water temperature-regulating control. An operating control could provide Type 1 or Type 2 action. (See definitions 5.13 and 5.14.)

5.8 OUTER JACKET – The part of the water heater that surrounds the storage tank and that is intended to provide mechanical protection for the tank and for thermal insulation when the insulation is provided. The outer jacket also serves as an enclosure of current-carrying parts and insulated conductors between heating elements in separate control or wiring compartments.

5.9 PROTECTIVE CONTROL – A control intended to prevent the risk of electric shock, fire, or injury to persons during abnormal operation of the appliance. An example would be a water temperature limit control. A protective control always provides Type 2 action. (See definitions 5.13 and 5.14.)

5.10 QUALIFIED SERVICE PERSONNEL – Persons having appropriate technical training and experience necessary to:

a) Perform tasks in service access areas of the equipment; and

b) Be aware of risks of injury to which they are exposed in performing a task, and of measures to minimize these risks to themselves or other persons.

5.11 SAFETY CONTROL – A control that is relied upon to reduce the risk of fire, electric shock, or injury to persons – for example, an interlock. A safety control may include such devices as relays, switches, interlocks, and other auxiliary equipment used to form a safety control system.

5.12 TEMPERATURE-PRESSURE RELIEF VALVE – An automatic resetting pressure relieving device actuated by water pressure or an integral thermal element that is in contact with and responsive to the heated water.

5.13 TYPE 1 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have not been declared and tested to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

5.14 TYPE 2 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have been declared and tested to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

CONSTRUCTION

6 Frame and Enclosure

6.1 General

6.1.1 A water heater shall be provided with an enclosure housing all parts that present a risk of fire, electric shock, or injury to persons under any condition of use.

6.1.2 The frame, if provided enclosure, and outer jacket of a water heater shall have strength and rigidity to resist the abuses likely to be encountered during intended use. The degree of resistance inherent in the water heater shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects that alone or in combination constitute an increase in the risk of fire, electric shock, or injury to persons.

6.1.3 An enclosure for individual electrical components, an outer enclosure, and combinations of the two shall be considered in determining compliance with the requirements in this section.

6.1.4 An enclosure shall be reinforced or formed so that it is not likely to be damaged through handling in shipment, installation and use.

6.1.5 A sheet metal outer jacket that also encloses insulated or uninsulated current-carrying parts shall have a minimum thickness as indicated in Table 6.1 or Table 6.2, as applicable.

6.1.6 An outer jacket of polymeric material that also encloses insulated or uninsulated current-carrying parts shall comply with the enclosure requirements in Tables 6.3 and 6.4.

Exception: An outer jacket is required to comply only with the requirements in Table 6.5, when the outer jacket:

a) Does not enclose any current-carrying parts; or

b) Encloses parts that are completely covered with minimum 1/32 inch (0.8 mm) thick electrical insulation.

6.2 Enclosure materials

6.2.1 Among the factors to be taken into consideration when an enclosure is judged for acceptability are its:

a) Physical 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 all conditions for use.

For a nonmetallic enclosure or part of an enclosure, all these factors shall be considered with respect to thermal and chemical aging according to the requirements in the Standard for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C. An enclosure complying with the requirements of the Standard for Industrial Control Panels, UL 508A or the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, would be considered to comply with the requirements of 6.2.1 (a) – (f).

6.2.2 An outer cabinet shall be judged with respect to the size, shape, and thickness of metal in accordance with 6.2.3.

6.2.3 The minimum thickness of sheet metal that serves as an electrical enclosure shall be as specified in Table 6.1 or 6.2.

Exception: An enclosure thinner than specified in Table 6.1 or 6.2 may be employed, as described in 6.2.4 and 6.2.5 if:

a) The location of the enclosure meets the criteria described in 6.1.2;

b) The construction and location of components meet the criteria described in 6.1.2; or

c) The strength and rigidity of the frame and enclosure meet the criteria described in Section 47, Enclosure Strength Test.

Table 6.1
Minimum thickness of sheet metal for enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Zinc coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inch	(mm)	Inch	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d]	(0.51)[d]	0.023[d]	(0.58)[d]
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[d]	(0.66)[d]	0.029[d]	(0.74)[d]
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:

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

2) A single sheet that is corrugated or ribbed; and

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

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

[c] For panels not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified.

[d] Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.

Table 6.2
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

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

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

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

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

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

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

[c] For panels not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified.

[d] Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.

Table 6.3
Polymeric material enclosure application code

Supply connection	Encloses current-carrying parts		Direct support of current-carrying parts	Indirect support of current-carrying parts	Enclosure application code
	Parts with insulation less than 0.028 inch (0.71 mm) thick	No parts with insulation less than 0.028 inch (0.71 mm) thick			
Conduit	X	–	–	–	1
Conduit	–	X	–	–	2
Conduit	X	–	X	–	3
Conduit	X	–	–	X	4
Conduit	–	X	–	X	5
Cord	X	–	–	–	6
Cord	–	X	–	–	7
Cord	X	–	X	–	8
Cord	X	–	–	X	9
Cord	–	X	–	X	10

Table 6.4
Polymeric material enclosure property and test requirements

Application code (see Table 6.3 for code)	Minimum flammability classification[a]	Resistance to ignition		Electrical				End product tests[d]			
		Maximum hot wire (HWI)[b] PLC[c]	Maximum high current (HAI)[b] PLC[c]	Minimum dielectric strength, volts[b]	Maximum high voltage track rate (HVTR)[b] PLC[c]	Maximum comparative tracking index (CTI)[b] PLC[c]	Volume resistivity[b] 50 megohms /cm wet	Input resistance	Crush resistance	Mold stress relief	Strain relief
1	5V	3	2	5000	–	–	X	X	X	–	–
2	5V	–	2	5000	–	–	–	X	–	X	–
3	5V	3	2	5000	1	4	X	X	X	X	–
4	5V	3	2	5000	–	–	X	X	X	–	–
5	5V	–	2	5000	–	–	–	X	–	–	–
6	5V	3	2	5000	–	–	X	X	X	–	X
7	5V	–	2	5000	–	–	–	X	–	X	X
8	5V	3	2	5000	1	4	X	X	X	X	X
9	5V	3	2	5000	–	–	X	X	X	–	X
10	5V	–	2	5000	–	–	–	X	–	–	X

[a] The flammability classification is to be determined by tests described in the Standard for Tests for Flammability of Plastic Material for Parts in Devices and Appliances, UL 94, unless it has already been determined to be 5V.

[b] Tests are to be conducted in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[c] The Performance Level Category (PLC) value is as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[d] Tests are to be conducted in accordance with UL 746C.

Table 6.5
Polymeric outer jacket

Part	Impact test[a]	Burning characteristics		Moisture resistance[d]
		Maximum flame spread index[b]	Minimum flammability classification[c]	
Outer jacket, indoor only				
A. Less than 10 square feet (0.93 m^2) and all dimension less than 6 feet (1.83 m)	X	–	HB	–
B. 10 square feet or more, or a single dimension greater than 6 feet	X	200	HB	–
Outer jacket, damp locations				
A. Less than 10 square feet (0.93 m^2) and all dimension greater than 6 feet (1.83 m)	X	–	HB	X
B. 10 square feet or more, or a single dimension greater than 6 feet	X	200	HB	X

[a] Test is to be conducted in accordance with the Resistance to Impact Test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[b] The maximum flame spread index is to be determined by the method described in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, or in accordance with the Test for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E162.

[c] The flammability classification is to be determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[d] Moisture resistance is to be determined in accordance with the Standard Test Method for Water Absorption of Plastics, ASTM D570, and the method for measuring water absorption of polymeric materials in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

6.2.4 Unless thinner sheet metal would be acceptable in accordance with Table 6.1 or 6.2, a sheet metal enclosure that, in accordance with item (a) of the Exception to 6.2.3, is not likely to be subjected to damage shall be made of uncoated steel at least 0.026 inch (0.66 mm) thick, of galvanized steel at least 0.029 inch (0.74 mm) thick, or of aluminum, copper, or brass at least 0.036 inch (0.91 mm) thick.

6.2.5 With reference to item (b) of the Exception to 6.2.3, the minimum thickness of an enclosure may be less than specified in Table 6.1 or 6.2 for the size enclosure as indicated below. The thickness shall be no less than 0.026 inch (0.66 mm) if uncoated steel, 0.029 inch (0.74 mm) if coated steel, or 0.036 inch (0.91 mm) if aluminum, copper, or brass unless a lesser thickness would be acceptable in accordance with Table 6.1 or 6.2.

a) If the electrical components are located at least 2-1/2 inches (64 mm) from the enclosure surface, the minimum thickness may be the value indicated in the first line above the normal value.

b) If the electrical components are located at least 5 inches (127 mm) from the enclosure surface, the minimum thickness may be the value indicated in the second line above the normal value.

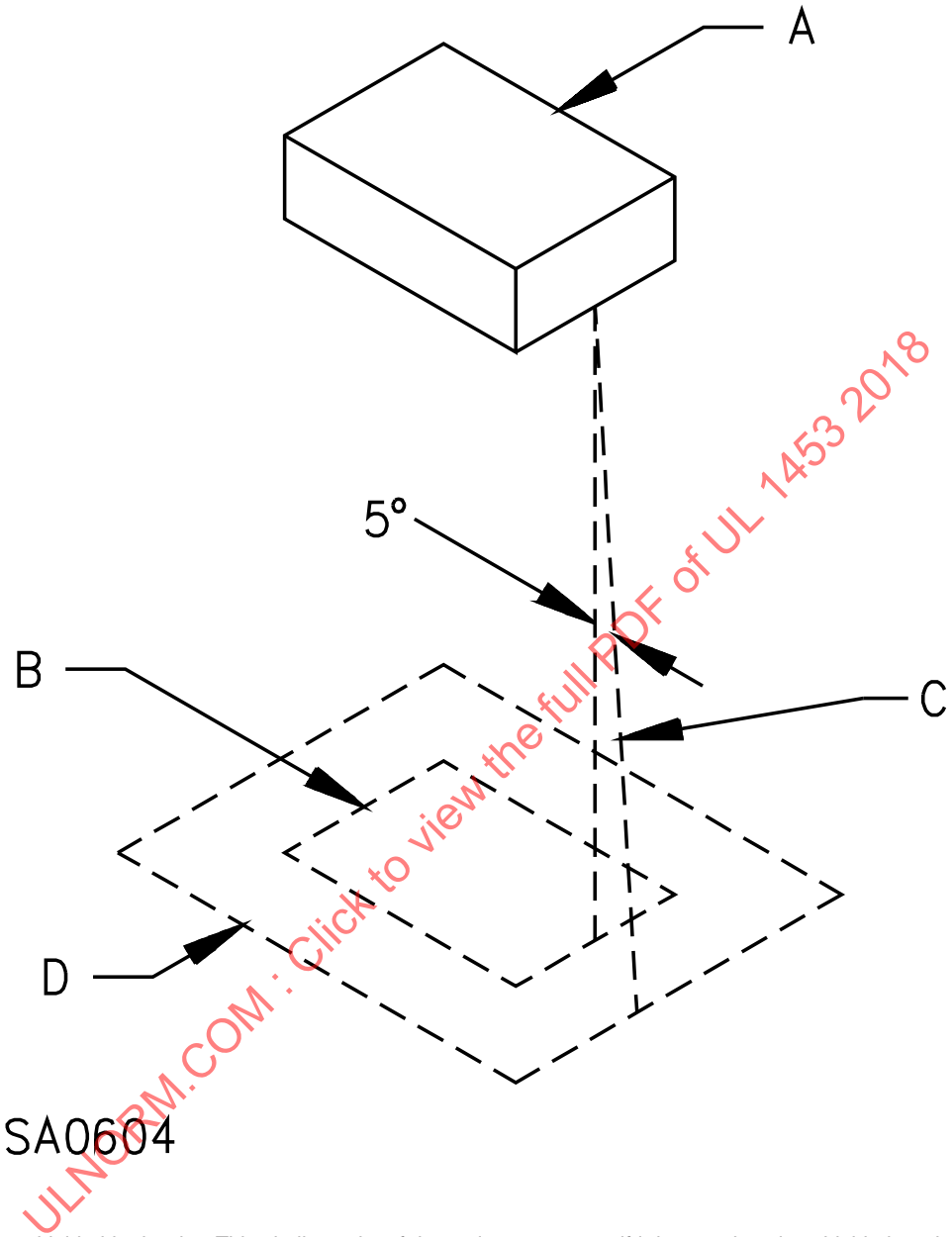
6.3 Emission of burning particles or molten metal

6.3.1 The enclosure of a water heater shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the water heater is supported.

6.3.2 A switch, relay, solenoid, or the like shall be individually and completely enclosed, other than at terminals, unless it can be shown that malfunction of the component does not result in a risk of fire, or there are no openings in the bottom of the water heater enclosure. It shall also require the use of a barrier of combustion resistant material under wiring, unless the wiring is insulated with neoprene, asbestos, or thermoplastic.

6.3.3 The barrier mentioned in 6.3.2 shall be horizontal, shall be located as illustrated in Figure 6.1, and shall have an area no less than that described in Figure 6.1. Openings for drainage, ventilation, and the like may be employed in the barrier, provided that such openings do not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 6.1
Location and extent of barrier



A – Region to be shielded by barrier. This shall consist of the entire component if it is not otherwise shielded, and shall consist of the unshielded portion of a component which is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. When moving, the line is always tangent to the component, 5 degrees from the vertical, and so oriented that the area traced out on a horizontal plane is maximum.

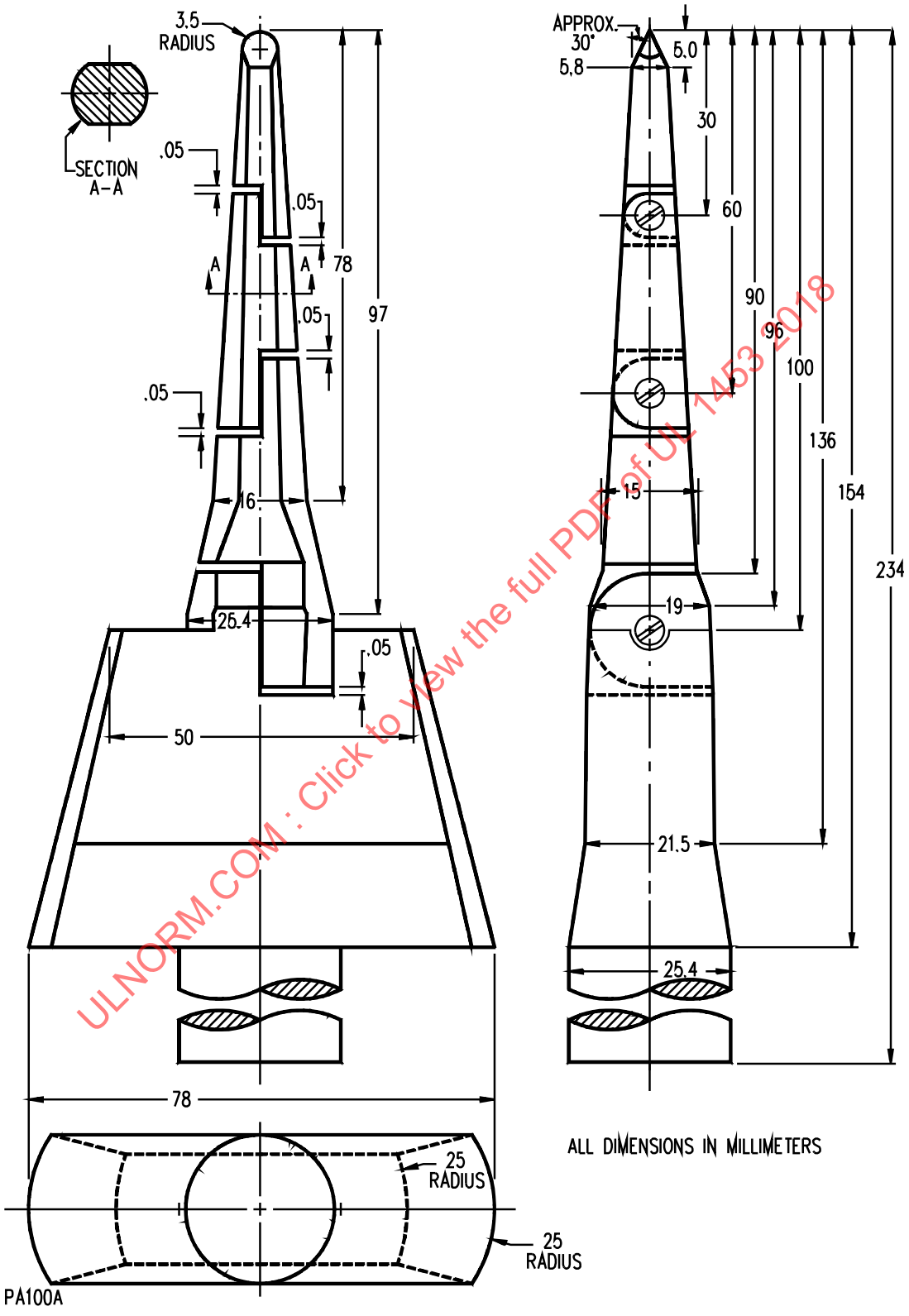
D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

6.4 Accessibility of live parts

6.4.1 An electrical part of a water heater shall be located or enclosed to reduce the risk of unintentional contact with an uninsulated live part.

6.4.2 The enclosure may have an opening that has a minor dimension of less than 1 inch (25.4 mm) if a probe, as illustrated in Figure 6.2, inserted through the opening cannot be made to touch any uninsulated live part or enamel insulated wire that may cause an electric shock. The probe shall be applied in all possible articulated positions before, during, and after insertion.

Figure 6.2
Articulate probe



6.4.3 During the examination of a water heater in connection with the requirements in 6.4.1 and 6.4.2, a part of the outer enclosure that can be removed by the user without the use of a tool (to permit the attachment of accessories, to allow access to means for making operating adjustments, or for other reasons) is to be removed. Such a part shall not be considered to provide protection against electric shock or personal injury whether or not the marking specified in 58.8 is provided.

6.4.4 An uninsulated live part located within 6 inches (152 mm) of a control or device that may need to be adjusted shall not be exposed to contact by the user or service personnel adjusting the setting of a temperature-regulating thermostat, operating the resetting mechanism of a temperature-limiting control, operating a water drain valve, or performing a similar operation. This requirement applies even if the unit is marked as indicated in 58.5.

6.5 Ventilation openings

6.5.1 An opening for ventilation in the enclosure of a water heater or in an externally mounted component shall be located so that it does not vent into concealed spaces of a building structure, such as into a false ceiling space, into hollow spaces in the wall, or the like, when the heater is installed as indicated.

Exception: This requirement does not apply to an opening for a mounting screw or nail or for a manufacturing operation, such as paint drainage, if the opening has no dimension larger than 17/64 inch (6.7 mm) or area greater than 0.055 square inch (35.5 mm^2).

6.5.2 An opening for ventilation in the enclosure, other than in the bottom, shall be provided with one or more baffles that prevents the emission of flame, molten metal, burning insulation, or the like from the water heater.

Exception: In a compartment other than one that houses a motor overload relay or overcurrent protective device such as a fuse or circuit breaker, the baffles are not required when:

a) No ventilating opening in a vertical wall is greater than 3/8 inch (9.5 mm) wide; or

b) The water heater is constructed so that it does not result in a risk of fire as shown by an investigation including short circuit testing.

7 Heating Element Accessories

7.1 A water heater having provisions for the use of a heating element accessory intended to be attached in the field shall comply with the requirements in this standard, with or without the accessory installed.

7.2 The installation of a heating element accessory by qualified service personnel shall be by means of receptacles, plug-in connectors, insulated wire connectors, or by connection to existing wiring terminals. A heating element accessory shall not be intended for installation by the user.

7.3 An installation shall not require the cutting of wiring or the soldering of connections by the installer. Installations shall not require cutting, drilling, or welding in electrical enclosures and in other areas where such operation may damage electrical components and wiring within the enclosure.

7.4 A means for strain relief shall be provided for the wiring in the accessory if there is a possibility of transmitting stress to the terminal connections during the installation.

7.5 All terminals and wiring intended to be field connected shall be identified on the accessory, on the water heater if connections are made between the accessory and the water heater, and on the wiring diagram.

7.6 The mounting location of the accessory shall be indicated on the water heater.

Exception: If the mounting location is obvious due to the function of the accessory and arrangement of the water heater, and instructions are provided covering the installation and location for the accessory, the mounting location of the accessory need not be indicated on the water heater.

7.7 As part of the investigation, an accessory is to be trial installed to determine that the installation is feasible, the instructions are detailed and correct, and the use of the accessory does not introduce a risk of fire, electric shock, or injury to persons.

8 Doors and Covers

8.1 A door or a cover of an enclosure shall be provided with a means for holding it securely in place in the closed position.

8.2 A door or a cover of an enclosure shall be hinged if:

a) It gives access to any fuse, circuit breaker, or manually reset temperature control in other than a low voltage circuit; and

b) An uninsulated live part is exposed during replacement of the fuse or resetting of the manually reset device.

Exception: A hinged cover is not required for a water heater in which the only fuse enclosed is:

a) A control circuit fuse, provided the fuse and control circuit loads (other than a fixed control circuit load, such as a pilot lamp) are within the same enclosure; or

b) An extractor type fuse with its own enclosure.

8.3 With reference to the requirement in 8.1, a door or a cover of an enclosure shall be provided with one of the following:

a) An automatic latch such as a spring latch, a magnetic latch, or a dimple, or any other mechanical arrangement that will hold the door or cover closed and requires some effort by the user to open it;

b) An automatic latch, as described in (a), and a captive screw or equivalent means that requires the use of a tool or key to open, if any live part other than the screw shell of a plug fuseholder is exposed inside the enclosure; or

c) A cover or door interlocking mechanism that:

1) Must be engaged in the closed position of the cover or door before a part is energized; and

2) Will secure the door or cover in the closed position if provided as the sole means for securing the door or cover closed.

8.4 With reference to the requirement in 8.3(b), the captive screw may be omitted from the door or cover to a compartment housing uninsulated live parts if a captive screw is provided in a cover that must be opened to gain access to the inner door or cover.

8.5 With reference to the requirement in 8.3(b), an arrangement employing two mating hinged doors is acceptable if the automatic latch and captive screw are provided only on one door:

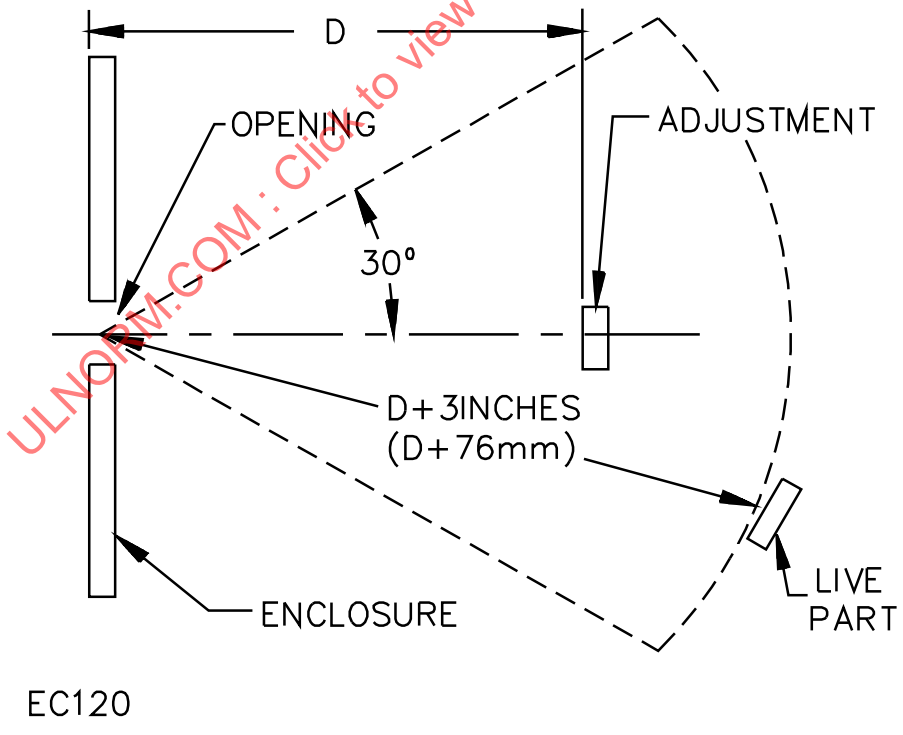
a) If that door is designed to be opened first and closed last; and

b) If the latch and screw will hold the other door closed.

8.6 A door or cover giving access to a fuse, circuit breaker, overload relay, or other overload protective device in other than a low voltage circuit shall be tight fitting and shall overlap the surface of the enclosure around the opening.

8.7 If an opening is provided to gain access to a control that is intended to be reset, adjusted, or otherwise manipulated by the user or service personnel, it shall not be possible to contact a live uninsulated or enamel insulated part with a 1/16 inch (1.6 mm) diameter rod applied as described in 8.8 and as illustrated in Figure 8.1.

Figure 8.1
Accessibility of live part through adjustment opening



8.8 With reference to the requirement in 8.7, the rod is to be inserted through the opening shown in Figure 8.1 to its maximum depth and positioned in all possible directions without producing an angle of more than 30 degrees between the rod and a line connecting the center of the opening with the center of the face of the adjusting mechanism. The length of the rod beyond the opening is not to exceed the distance between the opening and the face of the adjusting mechanism by more than 3 inches (76.2 mm).

9 Mechanical Assembly

9.1 A water heater or an externally mounted component shall be assembled so that it will not be affected adversely by the vibration likely to occur during operation.

9.2 A switch, lampholder, attachment plug receptacle, or similar component shall be mounted securely and shall be prevented from turning or shifting.

Exception No. 1: The requirement does not apply to a switch that complies with all four of the following conditions:

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 the normal operation of the switch.

b) Means for mounting the switch make it unlikely that operation of the switch will loosen it.

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

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

Exception No. 2: A lampholder of a type in which the lamp cannot be replaced (such as a neon pilot or indicated light in which the lamp is sealed in a nonremovable jewel) need not be prevented from turning or shifting if rotation cannot reduce spacings below the minimum required values.

9.3 The means for preventing the turning mentioned in 9.2 is to consist of more than friction between surfaces – for example, a lock washer is acceptable as a means of preventing a device having a single hole mounting means from turning or shifting.

9.4 An uninsulated live part shall be mounted so that it will be prevented from turning or shifting if such motion may result in a reduction of spacings below the minimum required in 28.1.

9.5 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a lock washer is acceptable.

10 Corrosion Resistance

10.1 Iron and steel parts shall be made corrosion resistant by painting, galvanizing, plating, or other equivalent means if the corrosion of such unprotected parts results in a risk of fire, electric shock, or injury to persons.

Exception: Cast iron parts, portions of heating element flanges exposed to air, and ASME coded pressure vessels are not required to be corrosion resistant.

10.2 The sheath employed to enclose a heating element shall be of a metal resistant to corrosion by water.

11 Supply Connections – Permanent Connection

11.1 General

11.1.1 A water heater shall have provision for connection of one of the permanent wiring systems that is acceptable for the water heater.

Exception: A water heater that is designed to permit removal for maintenance and repair may be connected as described in 12.1.1.

11.1.2 For the purpose of these requirements, field wiring terminals or leads are considered to be the terminals or leads to which power supply, equipment grounding, or control connections will be made in the field when the water heater is installed unless the wire is provided as part of the water heater and a pressure terminal connector, soldering loop, crimped eyelet, or other means for making the connection is factory assembled to the wire.

11.1.3 Electrical (Junction) boxes shall comply with the Standard for Metallic Outlet Boxes, UL 514A.

11.1.4 Fittings for conduit and/or metal clad cable shall comply with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

11.1.5 Electrical Quick Connect Terminals shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

11.1.6 If provided as part of the water heater, conduit shall comply with the Standard for Flexible Metal Conduit, UL 1 or the Standard for Electrical Rigid Metal Conduit Steel, UL 6.

11.2 Wiring compartments

11.2.1 The location of a terminal box or compartment in which power supply connections are to be made shall be such that these connections are readily inspected after the water heater is installed as intended.

11.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the water heater to prevent it from turning or shifting.

11.2.3 A terminal or splice compartment shall be complete and shall enclose all field wiring terminals and all splices to be made in the field unless the water heater enclosure is otherwise complete; for example, unless all sides and a complete bottom are provided when the water heater is shipped from the factory. A ventilating opening shall not be located in the bottom of the terminal compartment. Baffled openings are acceptable in the sides of a terminal compartment.

11.2.4 A terminal or splice compartment shall be located so that when conduit connections are being made, internal wiring and electrical components are not exposed to mechanical damage or strain.

11.2.5 Sheet metal to which a wiring system is to be connected in the field shall have a thickness of no less than 0.053 inch (1.35 mm) if uncoated steel, no less than 0.056 inch (1.42 mm) if galvanized steel, and no less than 0.075 inch (1.91 mm) if nonferrous. For sheet metal in an application other than part of a wiring system, Tables 6.1 and 6.2 shall be used for minimum acceptable thicknesses.

11.2.6 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall be no less than three, nor more than five threads, in the metal, and the construction of the device shall be such that a conduit bushing can be attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be no less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that:

a) Affords protection to the conductors equivalent to that provided by a standard conduit bushing; and

b) Has an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

11.2.7 A knockout in a sheet metal enclosure shall be secured in place, but shall be removable without undue deformation of the enclosure.

11.2.8 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 does not result in spacings between uninsulated live parts and the bushing less than the minimum acceptable spacings specified in Section 28, Spacings.

11.2.9 An outlet box, a terminal box, and a wiring compartment shall have the volume to accommodate the intended wiring. A trial installation is to be made using wires of the size indicated in 11.3.1 and conduit and fittings sized for the wire.

11.3 Field wiring terminals and leads

11.3.1 A water heater shall be provided with wiring terminals or leads for the connection of branch circuit conductors that have an ampacity as follows:

a) For a water heater of 120 gallons (454 L) or less, no less than 125 percent of the current rating of the appliance; or

b) For a water heater of more than 120 gallons, equal to or greater than the noncontinuous load plus 125 percent of the continuous load.

11.3.2 A field wiring terminal shall be provided with a soldering lug or with a pressure wire connector securely fastened in place; for example, firmly bolted or held by a screw.

Exception: A wire binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

11.3.3 A field wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces.

11.3.4 With reference to the requirement in 11.3.3, a field wiring terminal may be prevented from turning or shifting by two screws or rivets, by square shoulders or mortices, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by an equivalent method.

11.3.5 A field wiring terminal shall be marked as described in 57.18 to indicate whether it is acceptable for use with copper conductors only, aluminum conductors only, or either copper or aluminum conductors.

11.3.6 A wire binding screw at a field wiring terminal shall be no smaller than No. 10 (4.8 mm major diameter).

Exception No. 1: A No. 8 (4.2 mm) screw may be used at a terminal intended only for connection to a 14 AWG (2.1 mm^2) conductor.

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

11.3.7 A field wiring terminal plate tapped for a wire binding screw shall be of metal no less than 0.050 inch (1.27 mm) thick.

Exception: A plate no less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have mechanical strength equivalent to a 0.050 inch thick plate.

11.3.8 A field wiring terminal plate tapped for a wire binding screw shall have at least two full threads in the metal of the plate.

11.3.9 A field wiring terminal plate formed from stock having the minimum required thickness specified in 11.3.10 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

11.3.10 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 11.3.1, but no smaller than. 14 AWG (2.1 mm^2), under the head of the screw or the washer.

11.3.11 A wire binding screw shall thread into metal.

11.3.12 A water heater intended for connection to a grounded power supply conductor shall have one terminal or lead identified for connection of the grounded conductor if the water heater employs:

a) A lampholder of the Edison screw shell type;

b) A single pole switch; or

c) A single pole automatic control.

This terminal or lead shall be connected to the screw shell of the lampholder.

11.3.13 A terminal intended for the connection of a grounded conductor shall be of, or plated with, a metal substantially white in color and shall be readily distinguishable from other terminals; or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

11.3.14 A lead intended for the connection of a grounded conductor shall be finished to show a white or gray color and shall be readily distinguishable from the other leads. No other lead shall be so color coded.

11.3.15 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152.4 mm) or more and no larger than 6 AWG (13.3 mm^2) if the lead is intended for field connection to an external circuit.

Exception: The lead may be less than 6 inches (152.4 mm) in length if the field wiring supply connections are enclosed in a terminal box or wiring compartment.

11.3.16 A pigtail lead shall be no more than two sizes smaller than the supply conductor (copper) to which it will be connected.

Exception: Multiple leads, if provided, may be smaller than specified, but the sum of the conductor cross-sectional areas of such leads for any given pole shall be equivalent to the size specified in this paragraph; however, in no case shall any pigtail lead be smaller than 14 AWG (2.1 mm^2).

11.3.17 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined in accordance with Table 11.1.

Table 11.1
Trade size of conduit in inches

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	3/4	1	1
6	(13.3)	3/4	1	3/4	1-1/4	1-1/4
4	(21.2)	1	1	1-1/4	1-1/4	1-1/4
3	(26.7)	1	1	1-1/4	1-1/4	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	1-1/2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
1/0	(53.5)	1-1/4	1-1/2	2	2	2
2/0	(67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107)	2	2	2-1/2	2-1/2	2-1/2
kcm						
250	(127)	2	2	2-1/2	2-1/2	3
300	(152)	2	2-1/2	2-1/2	3	3
350	(177)	2-1/2	2-1/2	2-1/2	3-1/2	3
400	(203)	2-1/2	2-1/2	3	3	3-1/2
500	(253)	2-1/2	2-1/2	3	3-1/2	3-1/2

NOTE – This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires (based on the cross-sectional area of Type THW wire). Reference may be made to the National Electrical Code, ANSI/NFPA 70 for the cross-sectional area of conduit wires and other than Type THW wire.

12 Supply Connections – Cord Connection

12.1 Supply cord

12.1.1 A water heater intended for cord connection to the supply circuit in accordance with the Exception to 11.1.1 to permit removal for maintenance and repair shall be provided with a length of Type S, SO, ST, STO, HS, HSO, HSOO, or HSJOO cord or the cord shall be of a type having properties for the particular application. The length of the cord external to the water heater, measured to the face of the attachment plug, shall be no less than 6 feet (1.83 m). The cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

12.1.2 An attachment plug shall be provided on the cord for connection to the supply circuit. If a directly attached flexible cord is not provided, the water heater shall have terminals employing male blades or the equivalent which accommodates a matching plug on the load end of the cord. The attachment plug shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

12.1.3 The ampacity of the cord and the rating of the fittings for a water heater rated at 15 amperes or less shall be no less than that of the water heater. For a water heater rated at more than 15 amperes, the ampacity of the cord shall be no less than the current rating of the water heater and the current rating of the attachment plug shall be no less than 125 percent of the current rating of the boiler.

Exception: A 20 ampere attachment plug is acceptable for a water heater rated at no more than 4000 watts at 240 volts.

12.1.4 Supplementary insulation, if employed on a flexible cord, shall not extend more than 1/2 inch (12.7 mm) outside the water heater unless provided with additional mechanical protection, shall be guarded against fraying or unraveling, and shall not affect adversely the means for providing strain relief.

12.2 Bushings

12.2.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or equivalent that shall be secured in place; or the opening shall have a smooth, rounded surface against which the cord may bear.

12.2.2 A bushing of soft rubber, neoprene, or polyvinyl chloride may be employed at any point in a water heater if used in conjunction with a type of cord for which an insulating bushing is not required and if the edges of the hole in which the bushing is mounted are smooth and free from burrs, fins, and the like.

12.3 Strain relief

12.3.1 Strain relief shall be provided to prevent a mechanical stress on a flexible supply cord from being transmitted to terminals, splices, or interior wiring, as determined by the test described in 48.1.

12.3.2 Means shall be provided to prevent the flexible cord from being pushed into the enclosure of a water heater through the cord entry hole when such displacement results in:

a) Subjecting the cord to mechanical damage;

b) Exposing the cord to a temperature higher than that for which it is rated; or

c) Reducing spacings, such as to a metal strain relief clamp, below the minimum required values.

To determine compliance, the flexible cord shall be tested in accordance with Section 49, Push Back Relief Test.

12.4 Pin terminals

12.4.1 Any pin terminals that are provided as the power supply connection for a water heater shall be guarded or recessed to prevent any pin, while live, from being accessible to unintentional contact by persons while the cord connector or specific purpose appliance plug supplied with the water heater is fully seated or is being removed from or placed on the pins. The guard or recess is to be judged as specified in 12.4.2 and 12.4.3.

12.4.2 With no plug or cord connector on the pins, a straight edge placed in any position across and in contact with the guard or recess shall not touch any pin that is live while the water heater is connected to a branch circuit.

12.4.3 With the contact openings in the plug or cord connector aligned with the pins and with the face of the plug or connector located in the plane perpendicular to the end of the farthest projecting pin that is live while the water heater is connected to a branch circuit, it shall not be possible by means of the probe illustrated in Figure 6.2 to touch any pin that is live while the water heater is connected to a branch circuit.

12.4.4 If the pins on the water heater are of a standard appliance plug configuration, the plug specified in 12.4.3 shall be a standard appliance plug.

12.4.5 If the pins on the water heater are not of a standard appliance plug configuration, the plug specified in 12.4.3 shall be the plug supplied with the water heater.

12.4.6 If a water heater employs three or more pin terminals designed for use with a plug that covers all the pins, the terminals shall be spaced so that they do not accommodate a two pin appliance plug or cord connector. The plug that the pins accommodate shall be of a type intended for such use.

12.4.7 A pin terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by an equivalent method.

12.4.8 Pin terminals of a commercial water heater shall not accommodate a plug that accommodates the pin terminals of a household appliance.

13 Current-Carrying Parts

13.1 Plated iron or steel may be used for current-carrying parts if the temperature of such parts during normal operation is more than 100°C (212°F) but unplated iron or steel shall not be used regardless of temperatures. A copper conductor, unless tinned, nickel coated, silver plated, or otherwise protected, shall not be subjected to a temperature rise of more than 125°C (225°F) at a pressure terminal connector, or to a temperature rise of more than 175°C (315°F) elsewhere.

Exception: Iron or steel, if provided with a corrosion resistant coating, may be used as a current-carrying part as follows:

a) Within a motor or associated governor;

b) On control devices; and

c) For heating element assemblies, including its terminations.

13.2 Stainless steel and other corrosion resistant alloys may be used as a current-carrying part regardless of temperature.

14 Internal Wiring

14.1 General

14.1.1 The internal wiring of a water heater shall consist of wires of a size and type rated with consideration for:

a) The temperature and voltage to which the wiring is likely to be subjected;

b) Exposure to oil or grease; and

c) Other conditions of service to which it is likely to be subjected.

14.1.2 For the purpose of these requirements, the internal wiring of a heater is considered to be all the interconnecting wiring beyond the wiring terminals or leads for field wiring connections even though some of the wiring:

a) May not be completely enclosed; or

b) May be in the form of flexible cord.

14.1.3 A conductor utilizing beads shall not be used outside an enclosure. The number and arrangement of beads shall be such that the minimum acceptable spacings specified in Table 28.1 will be maintained. The temperature limits applicable to a conductor provided with beads of noncarbonizable material is specified in Table 45.1.

14.1.4 Insulated wire employed for internal wiring shall be standard building wire, fixture wire, flexible cord, or appliance wiring material, as described in 14.1.5 – 14.1.9.

14.1.5 Building wire for internal wiring includes Types RH, RHH, RHW, T, TW, THWN MTW, AI, and AIA.

14.1.6 Fixture wires for internal wiring include rubber insulated conductors such as Types RFH-2, SF-2, SFF-2, and FFH-2; and thermoplastic insulated conductors such as Types TF, TFF, TFN, and TFFN.

14.1.7 Flexible cords for internal wiring include Types HPN, HS, HSJ, HSJO, HSO, S, SJ, SJO, SJT, SJTO, SO, ST, STO, SP-2, SP-3, SPT-2, and SPT-3.

14.1.8 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62.

14.1.9 Appliance wiring material having thermoplastic insulation no less than 2/64 inch (0.8 mm) thick for 18 – 10 AWG (0.82 – 5.3 mm^2), 3/64 inch (1.2 mm) thick for 8 AWG (8.3 mm^2), and 4/64 inch (1.6 mm) thick for 6 – 2 AWG (12.3 – 33.6 mm^2) is acceptable for internal wiring.

14.1.10 Thermoplastic wiring material shall comply with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

14.1.11 Thermoset wiring material shall comply with the Standard for Thermoset-Insulated Wires and Cables, UL 44.

14.1.12 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B or the Standard for Splicing Wire Connectors, UL 486C.

14.1.13 Terminal Blocks shall comply with the Standard for Terminal Blocks, UL 1059.

14.2 Methods

14.2.1 The wiring and connections between external parts of a water heater shall be guarded or enclosed.

Exception: If flexibility of the wiring is essential, a length of flexible cord of a type described in 12.1.1 may be employed for external interconnections, or for internal connections that are exposed during servicing.

14.2.2 Internal wiring that is exposed through an opening in the enclosure of a water heater is considered to be guarded as required in 14.2.1 if, when judged as though it were an uninsulated live part or enamel insulated wire, the wiring would be acceptable according to 6.4.3 and 6.4.4. Internal wiring within an enclosure is acceptable, even though it can be touched with the probe, if it is guarded so that it cannot be grasped or hooked in a manner that would subject the wire to stress.

14.2.3 If the wiring of a water heater is located so that it is in proximity to combustible material or may be subjected to mechanical damage, it shall be in metal clad cable, rigid metal conduit, electrical metallic tubing, metal raceway, or shall otherwise be guarded in an equivalent manner.

14.2.4 Wiring space or other compartments intended to enclose wires shall be free of any sharp edge (including screw threads), burr, fin, moving part, or the like that might damage the conductor insulation.

14.2.5 A hole through which insulated wires pass in a sheet metal wall within the overall enclosure of a water heater shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 14.2.1 shall be provided with a bushing and strain relief in accordance with 14.2.6 unless the construction is such that the cord is not subject to stress or motion.

14.2.6 Strain relief shall be provided, in accordance with 12.3.2, to prevent a mechanical stress on a flexible cord from being transmitted to terminals or splices.

14.2.7 A water heater comprising several units intended to be interconnected in the field shall have provision for accepting field wired conductors between the units. The water heater is to be designed so that conduit, metal raceway, armored cable, or the like can be employed for connection of such wiring between units.

15 Splices

15.1 All splices and connections shall be mechanically secured and shall provide electrical contact. A soldered connection shall be made mechanically secure before being soldered.

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

15.3 In determining if splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration shall be given to such factors as its dielectric properties, heat resistance and moisture resistance characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

15.4 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire shall be restrained from contacting other live parts not always of the same polarity as the wire and from contacting dead metal parts. This shall be accomplished by use of pressure wire connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other equivalent means.

16 Separation of Circuits

16.1 Unless provided with insulation rated for the highest voltage involved, conductors of different circuits (internal wiring, including wires in a terminal box or compartment) shall be separated by barriers or shall be segregated and shall, in any case, be so separated or segregated from any uninsulated live parts connected to a different circuit.

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

16.3 Field installed conductors of any circuit shall be segregated by barriers from:

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

b) Uninsulated live parts of any other circuit of the water heater and from any uninsulated live part the short circuiting of which would result in a risk of fire or electric shock.

Exception No. 1: A construction in which field installed conductors may make contact with wiring terminals is acceptable provided that Type T or equivalent conductors are installed.

Exception No. 2: A construction is acceptable in which field installed conductors, having less than Type T or equivalent insulation, may contact low voltage terminals provided with the short circuiting of such terminals would not result in a risk of fire or electric shock.

16.4 With respect to 16.3(a), a removable barrier or one having openings for the passage of conductors may be employed, provided instructions for the use of the barrier are a permanent part of the water heater. If complete instructions in conjunction with a wiring diagram will provide for the separation of the high and low voltage circuits, the barrier may, upon investigation, be omitted.

16.5 Segregation of field installed conductors from other field installed conductors and from uninsulated live parts of the water heater connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live parts) so that intermingling of the conductors or parts of different circuits is unlikely. If the number of openings in the enclosure does not exceed the minimum required for the wiring of the water heater, and if each opening is located opposite a set of terminals, it is to be assumed that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings is provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated.

16.6 To determine whether a water heater complies with the requirements in 16.3, it is to be wired as it would be in service, and in doing so, a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack in the wiring compartment.

17 Barriers

17.1 A barrier used to provide separation between the wiring of different circuits shall be of grounded metal or equivalent material, shall have mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, and shall be securely held in place. Openings in a barrier for the passage of conductors shall be no 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 present 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.

17.2 A barrier of metal or of insulating material shall be no less than 0.028 inch (0.71 mm) thick and shall be of greater thickness if its deformation may be readily accomplished to defeat its purpose.

18 Heating Elements

18.1 A heating element shall be guarded against mechanical injury and contact with outside objects, and shall be securely supported.

18.2 In determining whether a heating element complies with the requirement in 18.1, consideration is to be given to sagging, opening, and other adverse conditions of the element resulting from:

a) Continuous heating; or

b) Flexing of the element supports or related wiring due to alternate heating and cooling.

18.3 A sheathed heating element shall comply with the requirements of the Standard for Sheathed Heating Elements, UL 1030.

19 Electrical Insulation

19.1 An insulating washer, bushing, or the like that is an integral part of a water heater and a base or support for the mounting of a current-carrying part shall be of a moisture resistant material that is not adversely affected by the temperatures to which it is subjected under conditions of actual use. A molded part shall be constructed so that it has mechanical strength and rigidity to withstand the stresses of actual service.

19.2 Insulating material employed in a water heater shall be judged with respect to its acceptability for the application. Materials such as mica, some molded compounds, and certain refractory materials are usually acceptable for use as the sole support of live parts; and some other materials that are not for general use, such as magnesium oxide, may be considered to be acceptable if used in conjunction with other more acceptable insulating materials or if located and guarded so that the risk of mechanical injury and absorption of moisture is reduced. When it is necessary to investigate a material to determine whether it is acceptable, consideration is to be given to its mechanical strength, dielectric withstand properties, insulation resistance, heat resistant qualities, the degree to which it is enclosed or guarded, and any other features having a bearing on the risk of fire, electric shock, and injury to persons involved, in conjunction with conditions of actual service. All of these factors are to be considered with respect to thermal aging.

19.3 In the mounting or supporting of a small fragile insulating part, screws or other fasteners shall not be so tight as to cause cracking or breaking of these parts with expansion and contraction.

20 Thermal Insulation

20.1 General

20.1.1 Thermal insulation in contact with wiring shall be nonabsorbent and resistant to combustion.

20.1.2 Thermal insulation in direct contact with a live part shall be glass wool or equivalent material that is nonconductive, nonabsorbent, resistant to combustion, and that has been shown by investigation to be intended for such use.

20.1.3 Thermal insulation that is not rigid shall be mounted or supported to prevent it from sagging. Adhesive material employed for mounting thermal insulation shall retain its adhesive qualities for any temperature to which the adhesive is subjected under conditions of intended use.

20.1.4 *Deleted.*

20.2 Polymeric foam

20.2.1 If polymeric foam is used as thermal insulation:

a) The foam shall be completely enclosed by an outer jacket in accordance with 6.1.5 or 6.1.6, as applicable. If the foam has a flame spread classification greater than 25 as shown by the Standard Test for Surface Burning Characteristics of Building Materials, UL 723, it shall be completely enclosed by metal in accordance with 6.1.5;

b) All enclosure fastening means shall be mechanically secured;

c) The foam shall not be in contact with the internal wiring of the water heater;

d) The foam shall be located no less than 2 inches (50.8 mm) from any electrical component, such as a thermostat or heating element; and

e) The foam shall be rated for the temperatures involved as specified in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

Exception No. 1: As an alternative to (a), polyvinyl chloride, polyethylene, or the equivalent shall be used in place of enclosure metal at a plumbing connection when the opening at the connection does not exceed three times the diameter of the pipe.

Exception No. 2: With respect to (c), the foam shall not be in contact with internal wiring unless the entrance and exit wiring holes are sealed with PVC grommets or sealing compound.

Exception No. 3: With regard to (c) and (d), the foam shall not be in contact with internal wiring and the electrical components shall not be located less than 2 inches from the foam unless:

a) The foam has a flame class rating of HF-1 or HF-2 in accordance with the Appendix A included with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; or

b) No fire occurs as a result of the electrical disturbance test described in Section 53, Electrical Disturbance Evaluation of Foam Thermal Insulation.

Exception No. 4: With regard to (e), a foam is not required to be temperature rated as specified in UL 746B if it is not subjected to temperatures exceeding the temperature requirements documented by the foam manufacturer.

21 Overcurrent Protective Devices

21.1 A water heater rated more than 48 amperes and employing resistance heating elements shall have the heating elements on subdivided circuits. Each subdivided load shall not exceed 48 amperes and shall be protected at no more than 60 amperes.

Exception: A water heater employing a resistance type immersion electric heating element contained in a vessel marked with an appropriate ASME symbol may be subdivided into circuits not exceeding 120 amperes and protected at no more than 150 amperes.

21.2 The overcurrent protective devices required by 21.1 shall be provided by the manufacturer as an integral part of the water heater or shall be provided by the manufacturer as a separate assembly for independent mounting for use with the water heater. If the overcurrent protective devices are provided as a separate assembly, the water heater and the overcurrent protection assembly shall be marked as indicated in 57.22 and 57.23, respectively.

21.3 The screw shell of a plug fuseholder shall be connected toward the load.

21.4 Unless the heater is intended to be connected to a branch circuit rated at 20 amperes or less, overcurrent protection of no more than 20 amperes shall be provided in each ungrounded conductor by a circuit breaker or fuse complying with the requirements for branch circuit protection. Such overcurrent protection shall be independent of a heating element and shall be provided as part of the water heater:

a) For each general use receptacle circuit;

b) For each transformer primary circuit; and

c) For each lampholder circuit, other than as indicated in 21.6.

21.5 The overcurrent protection mentioned in 21.1, 21.2, and 21.4 shall be of a type rated for branch circuit protection. A cartridge fuse used for this purpose shall be a Class CC, G, H, J, K, RK, T, or equivalent fuse meeting the requirements for branch circuit protection. A plug fuse shall be used only in circuits of 125 volts maximum.

21.6 A neon pilot lamp that is integral with the lampholder is not required to have overcurrent protection of 20 amperes or less.

21.7 Fuseholders shall comply with one of the following, as applicable:

a) The Standard for Fuseholders – Part 1: General Requirements, UL 4248-1;

b) The Standard for Fuseholders – Part 4: Class CC, UL 4248-4;

c) The Standard for Fuseholders – Part 5: Class G, UL 4248-5;

d) The Standard for Fuseholders – Part 6: Class H, UL 4248-6;

e) The Standard for Fuseholders – Part 8: Class J, UL 4248-8;

f) The Standard for Fuseholders – Part 9: Class K, UL 4248-9;

g) The Standard for Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse, UL 4248-11;

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h) The Standard for Fuseholders – Part 12: Class R, UL 4248-12; or

i) The Standard for Fuseholders – Part 15: Class T, UL 4248-15.

21.8 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

21.9 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

22 Lampholders

22.1 A lampholder shall be constructed and installed such that uninsulated live parts other than the screw shell are not exposed to contact by persons removing or replacing lamps in routine service.

Exception: This requirement does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the water heater by means of a tool.

22.2 A lampholder shall not be supplied as part of a water heater unless the water heater is intended for use only on a supply circuit operating at 250 volts or less to ground, having a grounded conductor, and the screw shell is electrically connected to the grounded conductor. Such a water heater shall be marked as indicated in 58.9 and 58.10.

Exception: This requirement does not apply to a lampholder for a pilot light or indicating lamp that requires the use of tools for replacement.

22.3 A cord connected water heater employing a lampholder in accordance with 22.2 shall be provided with a polarized attachment plug.

22.4 A lampholder shall comply with the Standard for Lampholders, UL 496.

23 Switches and Control Devices

23.1 A switch or other control device provided as part of a water heater shall have a current and voltage rating no less than that of the circuit (load) it controls.

23.2 The current rating of a switch that controls a solenoid, magnet transformer, or other inductive load is to be at least twice the rated full load current of the component it controls unless the switch has been investigated and found to be acceptable for the control of an inductive load at least equal to the full load current of the component.

23.3 A switch employed in a water heater shall be located or guarded so that it is not subjected to mechanical damage during intended use.

23.4 A switching device that interrupts the main water heater or control power supply circuit or both shall, when open, disconnect all ungrounded conductors of that circuit.

23.5 A switch or other means of control such as a sequencing device intended to permit the use of a limited number of elements at one time shall be so located or of such a type that the user cannot readily change the connections to permit the use of more elements than intended.

23.6 A switch that controls a medium base lampholder of other than a pilot or indicating light shall be rated for use with tungsten-filament lamps.

23.7 As applicable, switches shall comply with the Standard for Enclosed and Dead Front Switches, UL 98, the Standard for General-Use Snap Switches, UL 20 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

23.8 Controllers shall comply with the following, as applicable:

a) The Standard for Industrial Control Equipment, UL 508;

b) The Standard for Switchgear and Controlgear, Low-Voltage – Part 1: General Rules, UL 60947-1;

c) The Standard for Switchgear and Controlgear, Low Voltage – Part 4-1: Contactors and Motor-Starters-Electromechanical Contactors and Motor-Starters, UL 60947-4-1; or

d) The Standard for Switchgear and Controlgear, Low-Voltage – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2.

23.9 Programmable Controllers shall comply with the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2. In addition, if the programmable controller is used to provide the Temperature Limiting Control and/or the Temperature Regulating Control, it shall comply with 24.4 and 25.5, respectively.

24 Temperature-Limiting Controls

24.1 A water heater shall be equipped with a factory installed direct or indirect acting manually reset temperature-limiting control in addition to any other operating control utilized for regulation purposes and shall prevent the water in the upper 25 percent of the tank from attaining a temperature higher than 99°C (210°F), as described in 43.2.2 – 43.2.3.

24.2 An electro-mechanical control shall comply with the Standard for Limit Controls, UL 353, or the water heater limiting control requirements in the Standard for Temperature-Indicating and Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

24.3 An electronic temperature-limiting control with switched outputs that only relies on hardware circuitry to limit the temperature within the limits specified in 24.1 shall comply with the requirements of;

a) The Standard for Limit Controls, UL 353, or the water heater limiting control requirements in the Standard for Temperature-Indicating and Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements; and

b) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 with no single or second order points of failure permitted.

24.4 An electronic temperature-limiting control that relies on software to limit the temperature within the limits specified in 24.1 shall comply with the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998.

24.5 With respect to 24.2 – 24.4, a temperature-limiting control shall have no more than a 2.8°C (5°F) initial variation from rated operating temperature and shall have no more than a 5.5°C (10°F) or 5 percent variation, whichever greater, from initial operating temperature after the Operation Tests of the Standard for Limit Controls, UL 353 or the Endurance Test of the Standard for Temperature Indicating and Regulating Equipment, UL 873, as applicable. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

24.6 As an alternate to 24.2 – 24.4, temperature-limiting (thermal cutout) controls can be investigated to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9 utilizing the declarations specified in Table 24.1.

Table 24.1
Temperature-limiting (Thermal cutout, protective) control parameters

[a] UL 60730-1, Table 1 item number	Information	Control requirement
6	Purpose of control	Manually Reset Thermal Cut-Out
7	Type of load controlled	AC heater load
26	Number of Manual cycles (M)	6000: 1000 with load 5000 without load
29	Type of disconnection or interruption	Micro-Disconnection (B)
39	Type 1 or Type 2 action	Type 2.B
40	Additional features	Manual Reset, D, J or H Action
41	Manufacturing Deviation, maximum	±2.8°C (±5°F)
42	Drift	Not vary from the as-received temperature by more than 5 percent of the Fahrenheit setpoint temperature, or by more than 5.5°C (10°F), whichever is the greater.
48	Operating value	99°C (210°F) setpoint
49	Pollution degree	Pollution degree 2[f]
52	The minimum parameters of any heat dissipater (heat sink) not provided with an electronic control but essential to its correct operation	Must be specified
53	Output waveform if other than sinusoidal	Must be specified
58a	Required protection/immunity from mains borne perturbations, magnetic and electromagnetic disturbances	Required[b]
60	Surge immunity	IEC 61000-4-5 installation Class 3. Overvoltage category III[c]
69	Software Class	C[d,e]
74	External load and emission control measures to be used for test purposes	Must be specified
91	Fault reaction time	Must be specified
92	Class or classes of control function(s)	C[e]

Table 24.1 Continued on Next Page

Table 24.1 Continued

[a] UL 60730-1, Table 1 item number	Information	Control requirement
[a] This table should be used as a correlation for the parameters specified for the Standard for Temperature-Indicating and -Regulating Equipment, UL 873 and the Standard for Limit Controls, UL 353 evaluations. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements. [b] For the purpose of the tests specified in the Electromagnetic compatibility (EMC) requirements – immunity, Annex H, Section 26 of the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, the products covered by this Standard should be considered as: a) Installation Class 3 for indoor use, or 4 for outdoor use (See the Explanatory notes for surge immunity test, Annex R, of UL 60730-1); b) Overvoltage Category III applies for permanently-connected equipment. For cord-connected equipment, Overvoltage Category II applies; c) Test Level 3. [c] Overvoltage Category III applies for permanently-connected equipment. For cord-connected equipment, Overvoltage Category II applies. [d] Does not apply to electromechanical controls or controls with protection implemented in hardware only – see Item 92. [e] Applies to closed (non-vented) water heaters. For water heaters open to the atmosphere (vented), Class B may be applied. [f] Pollution Degree 2 applies except when the manufacturer declares Pollution Degree 3 due to exposure of condensation or water to the control during normal operation.		

24.7 A temperature-limiting control shall interrupt each ungrounded conductor of the heating element circuit. The interruption may be by direct or indirect means.

24.8 A temperature-limiting control shall be connected in the ungrounded conductor of a 2-wire, 120 volt direct acting or control circuit that has one side grounded.

Exception: A direct acting temperature-limiting control may be used in a line voltage circuit provided it opens all ungrounded heating element circuit conductors.

24.9 If a control circuit is supplied by a transformer, one side of the secondary winding of the transformer shall be grounded and the secondary shall be 150 volts or less.

Exception: It is the intent of the requirements in 24.8 and 24.9 that a short circuit or combination of short circuits to ground will not render the temperature-limiting control inoperative. A safety control arrangement, other than described in 24.8 and 24.9, may be considered acceptable if it accomplishes the intent of the requirements.

24.10 A temperature-limiting control shall be operative whenever the water heater is connected to the branch circuit power supply.

24.11 Components including contactors and sequence controllers that are operated by the temperature-limiting control shall be rated for 100,000 cycles of operation and shall be arranged to result in the direct opening of that circuit, whether the switching mechanism is integral with the sensing element or remote from the element.

24.12 A manually reset temperature-limiting control shall operate at a temperature above the predetermined temperature limit allowed by an automatic temperature-limiting control that may be provided.

24.13 A component, such as a relay, switch or the like, shall not be wired in conjunction with the limit control such that malfunction of a component may result in the control circuit being bypassed or defeated.

24.14 The temperature-limiting control circuit shall be designed such that a malfunction of any component in the temperature-regulating or other operating control circuit will not adversely affect the operation of the safety limit control circuit.

25 Temperature-Regulating Controls

25.1 A temperature-regulating control shall be provided to regulate the output water temperature to a maximum of 90°C (194°F) under conditions of intended normal operation.

25.2 An electro-mechanical temperature-regulating control shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873 or the Standard for Limit Controls, UL 353. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

25.3 An electro-mechanical temperature-regulating control shall be 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 ±5.6°C (±10°F).

25.4 An electronic temperature-regulating control with switched outputs that relies on hardware circuitry only to regulate or maintain the temperature within the limits specified in 25.1 shall comply with the requirements of:

a) The Standard for Limit Controls, UL 353, or the water temperature regulating control requirements of the Standard for Temperature-Indicating and Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements; and

b) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, with no single points of failure permitted.

The temperature-regulating control shall be 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 ±5.6°C (±10°F).

25.5 An electronic temperature-regulating control that relies on software to regulate or maintain the temperature within the limits specified in 25.1 shall comply with the requirements for software Class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

25.6 As an alternate to 25.2 – 25.5, temperature-regulating (operating) controls can be investigated to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9 utilizing the declarations described in Table 25.1.

Table 25.1
Temperature-regulating (operating) control parameters

[a] UL 60730-1, Table 1 item number	Information	Control requirement
6	Purpose of control	Thermostat
7	Type of load controlled	AC heater (resistive load) AC Pump (motor load)
27	Number of Automatic cycles (A)	30,000
29	Type of disconnection or interruption	Micro-Disconnection (B) Electronic Disconnection (Y)
39	Type 1 or Type 2 action	Type 2.B or 2.Y (see Item 29 above)
40	Additional features	Automatic reset
41	Manufacturing Deviation, maximum	±3.9°C (±7°F)
42	Drift	Not vary from the as-received temperature by more than 5 percent of the Fahrenheit setpoint temperature, or by more than 5.5°C (10°F), whichever is the greater.
48	Operating value	85°C (185°F) maximum setpoint normal operation
49	Pollution degree	Pollution degree 2[e]
52	The minimum parameters of any heat dissipater (heat sink) not provided with an electronic control but essential to its correct operation	Must be specified
53	Output waveform if other than sinusoidal	Must be specified
58a	Required protection/immunity from mains borne perturbations, magnetic and electromagnetic disturbances	Required[b]
60	Surge immunity	IEC 61000-4-5 installation Class 3. Overvoltage category III[c]
69	Software Class	B[d]
74	External load and emission control measures to be used for test purposes	Must be specified
91	Fault reaction time	Must be specified
92	Class or classes of control function(s)	B

[a] This table should be used as a correlation for the parameters specified for the Standard for Temperature-Indicating and -Regulating Equipment, UL 873 and the Standard for Limit Controls, UL 353 evaluations. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

Table 25.1 Continued on Next Page

Table 25.1 Continued

[a] UL 60730-1, Table 1 item number	Information	Control requirement
[b] For the purpose of the tests specified in the Electromagnetic compatibility (EMC) requirements – immunity Annex H, Section 26 of the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, the products covered by this Standard should be considered as: a) Installation Class 3 for indoor use, or 4 for outdoor use (See the Explanatory notes for surge immunity test, Annex R of UL 60730-1); b) Overvoltage Category III applies for permanently-connected equipment. For cord-connected equipment, Overvoltage Category II applies; c) Test Level 3. [c] Overvoltage Category III applies for permanently-connected equipment. For cord-connected equipment, Overvoltage Category II applies. [d] Does not apply to electromechanical controls or controls with protection implemented in hardware only – see Item 92.		

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Table 25.1 Continued

[a] UL 60730-1, Table 1 item number	Information	Control requirement
[e] Pollution Degree 2 applies except when the manufacturer declares Pollution Degree 3 due to exposure of condensation or water to the control during normal operation.		

25.7 If a temperature-regulating control installed as part of the water heater has a marked or displayed OFF position, the control shall directly or indirectly disconnect the heating elements that it controls from the ungrounded heating element circuit conductors, and shall not respond to temperature when placed in the OFF position.

25.8 A commercial storage tank water heater temperature-regulating control shall be set before leaving the factory to a control position corresponding to a setting of 60°C (140°F) or less. 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 C or F.

26 Terminals and Sensing Elements of Temperature-Regulating and Temperature-Limiting Controls

26.1 The bulb, capillary tubing, or other sensing element of a temperature-limiting control that is depended upon to reduce the risk of fire, electric shock, or injury to persons, or of a temperature-regulating control that regulates the output water temperature, shall be located or shielded so that it is not subjected to mechanical damage during field installation or subsequent use of the water heater.

26.2 Water heaters that require partial disassembly or that are constructed to permit rearrangement of internal parts at the time of installation shall afford components referenced in 26.1 protection from mechanical damage during field installation or subsequent use of the water heater.

27 Materials in Contact with Water

27.1 General

27.1.1 A nonmetallic material in contact with water shall conform to the requirements of the National Sanitation Foundation Standard for Plastics Piping Components and Related Materials, NSF No. 14 with regard to toxicity, taste, color, solubility, and odor; and shall have a specific gravity greater than 0.94.

27.1.2 Lead shall not be used as an intentional ingredient for any material in contact with water in a water heater.

27.2 Dip tubes

27.2.1 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.

27.2.2 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 no more than 1/4 inch (6.4 mm).

27.2.3 A nonmetallic dip tube shall comply with the tests described in Section 44, Nonmetallic Dip Tube Tests.

28 Spacings

28.1 The spacings in a water heater shall be no less than those indicated in Table 28.1 and 28.2 – 28.8.

28.2 The spacings specified in Table 28.1 do not apply to the inherent spacings of a component part of a water heater. Such spacings are judged under the requirements for the component.

Table 28.1
Minimum acceptable spacings

Parts involved	0 – 250 Volts				251 – 600 Volts			
	Through air		Over surface		Through air		Over surface	
	Inch	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)
Between a live part and the enclosure	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)
Between uninsulated live parts of opposite polarity; and between a rigidly mounted uninsulated live part and a dead metal part which is exposed to contact by persons or which may be grounded[a]	1/8	(3.18)	1/4	(6.35)	1/4	(6.35)	3/8	(9.6)
[a] If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction is to be such that the minimum spacing will be maintained under all operating conditions.								

28.3 At closed-in points only, such as the screw-and-washer construction of an uninsulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable on a water heater rated 250 volts or less. Within a thermostat, other than at contacts, the spacing between uninsulated live parts on opposite sides of the contacts shall be no less than 1/32 inch (0.8 mm) through air and 3/64 inch over the surface of insulating material, and the construction shall be such that the spacings are maintained permanently.

28.4 Whether through air or over the surface, a closed-in spacing is considered to be that in the enclosed space formed by a live conductor passing through an opening in dead metal, as well as through an insulating washer on each side of the metal. The assembly is secured firmly in place, usually by a nut threaded on the live conductor on each side of the exterior of the assembly.

28.5 An insulating lining or barrier of fiber or similar material employed where spacings would otherwise be sufficient shall be no less than 1/32 inch (0.8 mm) in thickness, and shall be so located or of such material that it is not adversely affected by arcing.

Exception: Fiber no less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing no less than 50 percent of the spacing required for air alone.

28.6 Unless protected from mechanical abuse during assembly and intended functioning of the water heater, a barrier of mica shall be 0.010 inch (0.25 mm) or more in thickness.

28.7 Spacings in a low voltage safety control circuit shall comply with the requirements in 28.1 – 28.6.

28.8 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service may be less than indicated in Table 28.1 for parts of a low voltage circuit.

29 Grounding

29.1 A permanently connected water heater shall be provided with a field wiring terminal or lead for connection of an equipment grounding conductor. The terminal or lead shall be constructed in accordance with 11.3. Sheet-metal screws shall not be used:

a) To connect grounding conductors to enclosures; nor

b) To provide for the connection of the branch circuit equipment grounding conductor.

29.2 In a water heater intended to be permanently connected to the power supply, all exposed dead metal parts that may become energized and all dead metal parts within the enclosure that are exposed to contact during any servicing operation and that may become energized shall be conductively connected:

a) To the enclosure at the point of connection of the wiring system; and

b) To the equipment grounding terminal or lead.

29.3 For a cord connected water heater, the power supply cord or cord set shall have an equipment grounding conductor.

29.4 An equipment grounding conductor of a flexible power supply cord shall be:

a) Provided with insulation having an outer surface that is green with or without one or more yellow stripes;

b) Connected to the grounding blade of an attachment plug of the grounding type;

c) Conductively connected to all exposed dead metal parts that may become energized and all dead metal parts within the enclosure that are exposed to contact during any servicing operation and that may become energized; and

d) Conductively connected to the enclosure of the water heater.

29.5 With reference to the requirements in 29.2 and 29.4, the following dead metal parts are not considered as being likely to become energized:

a) A small metal part – such as an adhesive attached foil marking, a screw, a handle, or the like – that is:

1) On the exterior of the enclosure and separated from all electrical components by grounded metal; or

2) Electrically isolated from all electrical components.

b) A panel, a cover, or other metal part that is isolated from all electrical components, including wiring, by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture resistant insulating material no less than 1/32 inch (0.8 mm) thick and secured in place.

c) A panel, a cover, or other metal part that does not enclose uninsulated live parts and that is electrically isolated from other electrical components.

d) A door or the like that may only become energized through a grounded part.

29.6 Servicing, as mentioned in 29.2 and 29.4, is considered to include repair of the water heater by qualified service personnel as well as by the user.

29.7 With reference to the requirements in 29.4 (c) and (d), the connection shall be made by a screw or other means not likely to be removed during servicing not involving the power supply cord. Solder alone shall not be used for making this connection.

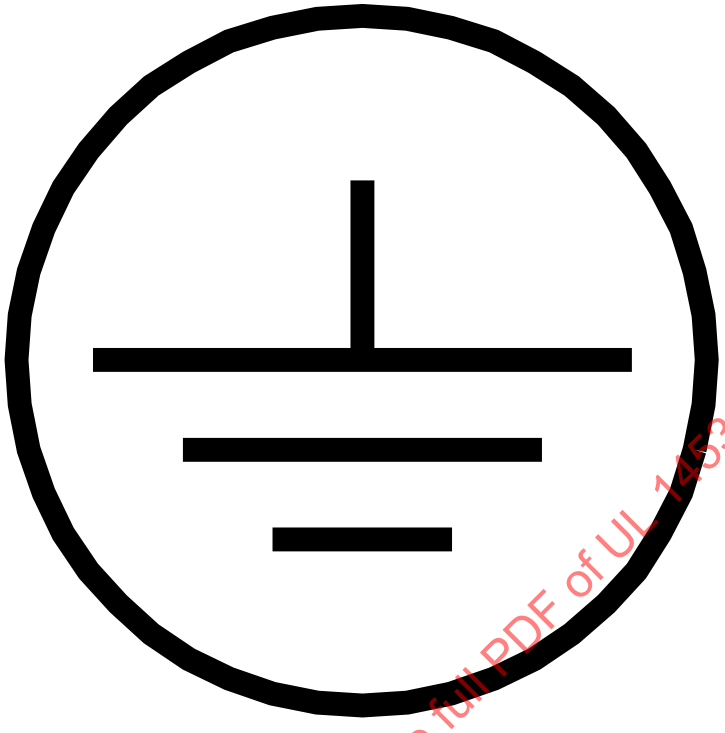
29.8 A field wiring terminal intended solely for connection of an equipment grounding conductor shall be capable of securing a conductor of the size indicated in 29.12.

29.9 The surface of a lead visible in a wiring compartment in which field connections are made, and intended for the connection of an equipment grounding conductor, shall be green with or without one or more yellow stripes, and no other lead shall be so finished.

29.10 The requirements in 29.9 relating to color coding for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

29.11 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is slotted, hexagonal shaped, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked ″G″, ″GR″, ″GROUND″, ″GROUNDING″, the grounding symbol illustrated in Figure 29.1, or by a marking on an attached wiring diagram. See 59.7. The wire binding screw or pressure wire connector shall be located inside the terminal compartment and in a manner that will make it unlikely to be removed during routine servicing of the water heater.

Figure 29.1
Grounding symbol



29.12 The size of a conductor or strap employed to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device to which the equipment is connected.

Exception: An equipment grounding conductor no smaller than 18 AWG (0.82 mm^2) copper and no smaller than the circuit conductors that is an integral part of a flexible cord assembly may be used to ground cord connected equipment if the equipment is protected with an attachment plug-cap rated at 15 or 20 amperes.

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

Exception: An internal connector for bonding non-current carrying parts for grounding continuity purposes (excluding a field installed grounding conductor or the grounding conductor of a supply cord) may employ a quick connect terminal of the dimensions specified in Table 29.1, provided the connector is not likely to be displaced and provided the heater is limited to use on a circuit having a branch circuit protective device specified in Table 29.1.

Table 29.1
Size of quick connect terminals

Connector size, inch (mm)	Rating of protective device, amperes
0.020 x 0.187 x 1/4 (0.51 x 4.75 x 6.4)	20
0.032 x 0.187 x 1/4 (0.81 x 4.75 x 6.4)	20
0.032 x 0.205 x 1/4 (0.81 x 5.21 x 6.4)	20
0.032 x 1/4 x 5/16 (0.81 x 6.4 x 7.9)	60

29.14 Grounding and bonding equipment used to comply with this Section and other applicable requirements of this standard shall comply with the Standard for Grounding and Bonding Equipment, UL 467.

30 Motors

30.1 General

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

30.1.2 Conformance to 30.1 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

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

30.1.4 The requirement in 30.1.3 will necessitate the use of a barrier of nonflammable material under an open type motor unless:

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

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

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor shorted, permanent split capacitor type; or

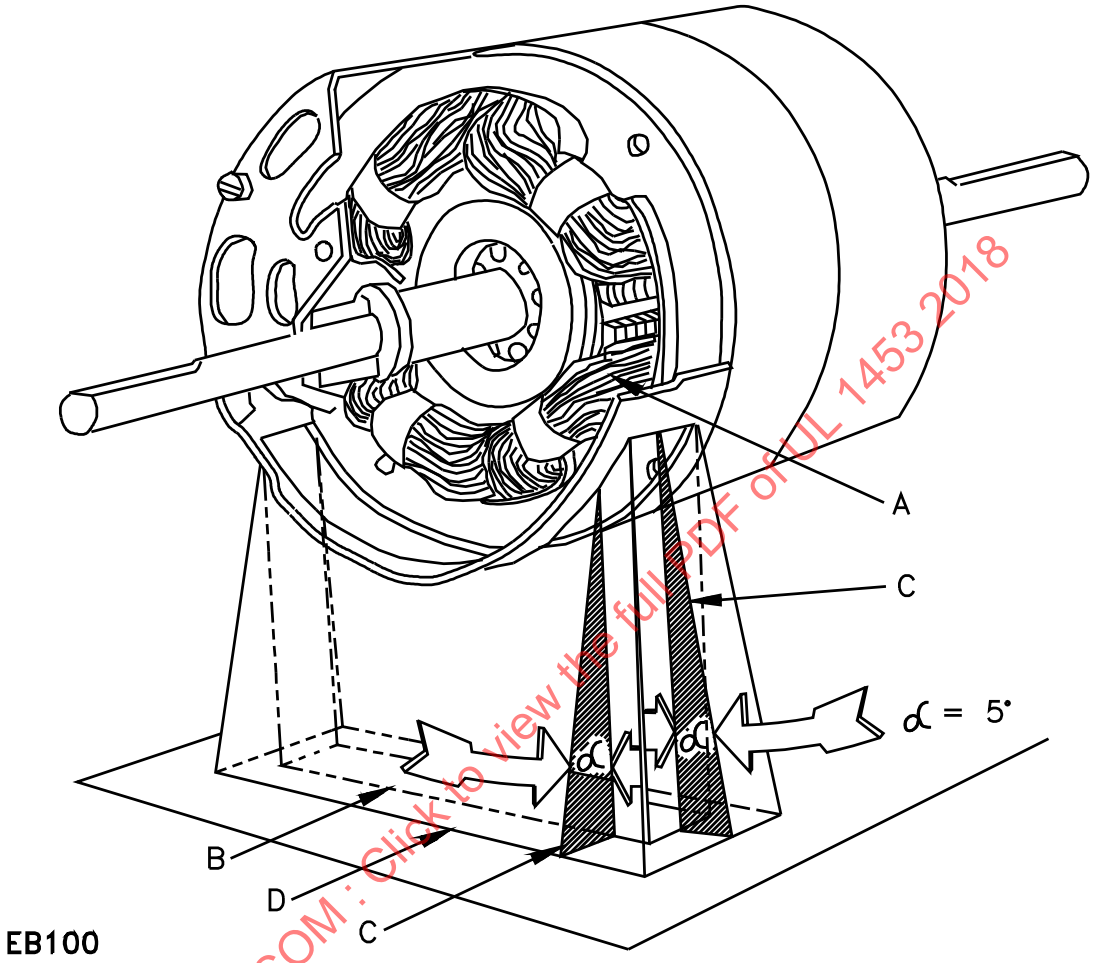
c) The motor is provided with a motor protector in accordance with 30.2 that will prevent the temperature of the motor windings from becoming more than 125°C (275°F) under the maximum load below which the motor will run without causing the protector to cycle and from becoming more than 150°C (302°F) with the rotor of the motor locked.

d) The motor complies with the requirements for impedance-protected motors see 30.2.5 and the motor winding will not exceed a temperature greater than 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

30.1.5 The barrier mentioned in 30.1.4 shall be horizontal, and have an area not less than that described in that illustration. Openings for drainage, ventilation, and the like, may be employed in the barrier provided that such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 30.1

LOCATION AND EXTENT OF BARRIER



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding if it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding which is partially shielded by the motor enclosure or equivalent.

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

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

1) tangent to the motor winding;

2) 5 degrees from the vertical; and

3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is to be that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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

30.1.7 Motors shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

30.1.8 Capacitors shall comply with the Standard for Capacitors, UL 810.

30.2 Motor overload protection

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

30.2.2 In no case shall interruption of the circuit to a motor by the overcurrent or thermal protective device result in a risk of fire, electric shock, or injury to persons during operation of the equipment.

30.2.3 Automatic-reset type protective devices shall not be used if the automatic reclosing of the circuit to the motor by the device may result in a risk of fire, electric shock, or injury to persons during operation of the equipment.

30.2.4 All single-phase motors shall be protected by one or more of the following:

a) A separate device responsive to motor current and rated or set to trip at not more than the percentage of the motor nameplate full-load current rating as specified in Table 30.1.

b) A separate overload device, which combines the functions of overload and overcurrent protection and is responsive to motor current. Such a device shall be set at values not greater than the percentages of the motor nameplate full-load current rating as specified Table 30.1.

c) A thermal protective device or impedance protection complying with the Standard for Thermally Protected Motors, UL 1004-3 or the Standard for Impedance Protected Motors, UL 1004-2. If a motor protective electronic circuit relies on software as a protective component, that part of the software providing the required motor protection shall comply with software Class 1 in the Standard for Software in Programmable Components, UL 1998 or software Class B in Annex H of the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. |

d) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2.

Exception: Impedance protection may be accepted for motors which are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under the performance requirements of this standard.

e) A protective device integral with the motor that complies with the Standard for Thermally Protected Motors, UL 1004-3. A motor intended to move air only, by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor, is required to have locked-rotor protection only.

f) Protective electronic circuits integral to the motor that comply with the Standard for Electronically Protected Motors, UL 1004-7.

g) Protective electronic circuits that comply with 30.2.6.

h) Other protection that is shown by test to be equivalent to the protection specified in (a) to (g).

30.2.5 In reference to 30.2.4 (a) and (b), if the percentage protection specified in Column A of Table 30.1 does not correspond to the percentage value of an overload device of a standard size, the device of the next higher size may be used. However, the device of the next higher size shall provide protection no higher than that indicated in Column B of Table 30.1.

Table 30.1
Overload relay size

	Maximum percentage protection	
	A	B
Motor with a marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 40°C (72°F)	125	140
Any other motor	115	130

30.2.6 Except as indicated in 30.2.4 (c) and (f), a protective electronic circuit providing motor protection shall comply with one of the following:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, that part of the software providing the required motor protection shall comply with the Standard for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1.

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 as well as the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. If software is relied upon to perform a safety function, it shall be considered software Class B.

Exception: A protective electronic circuit providing motor protection is not required to comply with UL 991 or UL 60730-1 if there is no risk of fire, electric shock or casualty hazard during abnormal testing with the protective electronic circuit rendered ineffective. The need for software to comply with UL 1998 or UL 60730-1 can be based on the actual construction and operation of the motor within the equipment. This could include a consideration of the protective electronic circuit being provided with independent redundant protective devices.

30.2.7 With reference to 30.2.6, the factors outlined in Table 30.2 shall be considered when judging the acceptability of a protective electronic circuit.

Table 30.2
Factors for judging protective electronic circuits

1	Conducting failure-mode and effect analysis (FMEA) for the protective circuits and functions.
2	Electrical supervision of critical components resulting in the control becoming permanently inoperative and disconnecting power.
3	Temperature ranges as follows: **Indoor Equipment:** 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F) **Outdoor Equipment:** minus 35.0 ±2°C (minus 31.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F)
4	Cycling test duration: 14 days
5	Endurance test duration: 100,000 cycles
6	Radio-frequency electromagnetic field immunity: A. To conducted disturbances[a] – test level 3 B. To radiated electromagnetic fields – field strength of 3 V/m
7	Humidity exposure: **Indoor Equipment:** 21.1 – 26.7°C (70 – 80°F) and minimum 50 percent relative humidity **Outdoor Equipment:** minimum 98 percent relative humidity
8	Electrical fast transient/burst immunity: **Outdoor Equipment:** test level 4 **For all equipment other than outdoor use:** test level 3
9	Surge immunity[a]: **Outdoor Equipment:** – installation Class 4 **For all equipment other than outdoor use:** installation Class 3
10	Electrostatic Discharge[a] with a Severity Level of 3 having contact discharge at 6 kV to accessible metal parts andAir discharge at 8 kV to accessible parts of insulating material
[a]The noted factors are exempt from being considered when requirements from the Standard forTests for Safety-Related Controls Employing Solid-State Devices, UL 991 are applied.	

30.2.8 Three-phase motors shall be protected by:

a) Three properly rated overcurrent units, each complying with the applicable requirements of 30.2.4 through 30.2.7; or

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

31 Low-voltage transformers – General

31.1 Except as specified in 31.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer.

31.2 A transformer that directly supplies a Class 2 circuit [see 5.3(b)] shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

REDUCTION OF RISK OF INJURY TO PERSONS

32 Reduction of Risk of Injury to Service Personnel

32.1 An uninsulated live part that may require examination, adjustment, servicing, or maintenance while energized shall be located, guarded, or enclosed to reduce the likelihood of unintentional contact by service personnel performing service functions that are performed while the water heater is energized.

32.2 Certain electrical components within the overall assembly shall be located so that space is provided for working on these components while the water heater is energized, and shall provide a reasonable degree of protection for service personnel performing service functions of a mechanical nature on an energized water heater. Such service functions do not in themselves require exposure of a live part, but it is commonly necessary to perform these functions while the water heater is energized.

32.3 Mechanical service functions that have to be performed while the water heater is energized include: adjusting water control valves, adjusting the setting of temperature or pressure controls, resetting control trip mechanisms, operating manual switches, or the like. A factory set and sealed control is not considered to be adjustable.

32.4 The requirement in 32.1 is not applicable to a mechanical service function that is not normally performed while the water heater is energized, such as opening of drain plugs.

32.5 An adjustable or resettable electrical control or a manual switching device may be located or oriented with respect to an uninsulated live part so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the intended direction of access if an uninsulated live part is:

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.

This requirement applies only to uninsulated live parts involving a risk of electric shock.

32.6 An uninsulated part shall be guarded to reduce the possibility of contact by service personnel if an uninsulated part is one that:

a) Involves a risk of electric shock or operates at an alternating current potential greater than 30 volts or a direct current potential greater than 60 volts; and

b) Service personnel must reach over, under, across, or around to perform any servicing, and that is made accessible by opening or removing a cover, door, panel, or other closure on or within the water heater.

32.7 If the guards mentioned in 32.6 must be removed during servicing of the parts that they are designed to cover, the guards shall be constructed and arranged so that they can be removed and replaced with minimum effort.

32.8 A component or control assembly that may be rotated or otherwise displaced for service is acceptable if it is located, guarded, or enclosed as required by 32.1.

32.9 Arrangement of components or guarding, other than required by 32.6 – 32.8, is acceptable if the reduction of risk of injury to service personnel required by 32.1 is provided.

32.10 The electrical components referred to in 32.2, 32.8, and 32.9 include the following: fuses, adjustable or resettable overload relays, manual or magnetic motor controllers, magnetically operated relays, adjustable or resettable pressure or temperature controllers, manual switching devices, and clock timers. Such components in a low voltage circuit shall comply with the requirements in 32.1 in their relation to uninsulated live parts in a line voltage circuit.

32.11 Under certain conditions some of the components referred to in 32.10 are not required to be accessible for service; for example, a magnetically operated relay that is inaccessible for service while energized because it is located behind a subbase or the equivalent and is not visible when the access panel or panels are removed.

32.12 With reference to the requirements in 32.1, 32.2, 32.5 – 32.6, and 32.10, the following are not considered to be uninsulated live parts: coils of controllers, relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps and at least 1/32 inch (0.8 mm) thick; terminals and splices with acceptable insulation; and insulated wire.

32.13 An electrical component in a water heater shall be located so that access for servicing or replacement is not restricted.

32.14 The need to lift or remove a heavy part, or to reach to arm's length to remove a heavy part, is not acceptable. A large panel that must be removed for replacement of a heating element or similar operation shall be provided with handles. If a hung door is divided horizontally into two parts because of its size, a means shall be provided to hold the upper door out of the way of service personnel when the lower door is open.

33 Enclosures and Guards

33.1 An enclosure, opening, frame, guard, knob, handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons during intended use and maintenance.

34 Switches and Controls

34.1 A device that automatically starts a water heater, such as a timer, an automatically reset overload protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting does not result in a risk of injury to persons.

34.2 A switch shall be located and protected so that it is not unintentionally operated during intended use.

34.3 The OFF position of a switch other than a momentary contact type shall be such that the operator can determine by visual inspection that the water heater is off.

35 Surface Temperature

35.1 During the temperature test required by Section 45, Temperature Tests, a temperature on a surface of a water heater that can be contacted by the user shall be no more than the values specified in Table 45.2.

36 Pressure Vessels and Parts Subject to Pressure

36.1 Unless the tank of a water heater is marked with an appropriate ASME symbol and has a marked working pressure no less than the marked maximum working pressure of the water heater, it shall be subjected to the test described in Section 46, Hydrostatic Pressure Test.

37 Temperature and Pressure Relief Devices

37.1 A combination temperature-pressure relief valve shall be factory supplied. The valve temperature setting shall be no more than 99°C (210°F) and the pressure relief setting shall be no higher than the marked working pressure of the water heater.

37.2 For a water heater employing a tank that is marked as indicated in 35.1, a combination temperature-pressure relief valve shall have a minimum relieving capacity of 3500 Btu (3.7 MJ) per kilowatt input and shall be marked with the ASME code symbol ″V″ or ″HV″ in accordance with the applicable section of the 1986 ASME Boiler and Pressure Vessel Code.

37.3 A valve may be shipped unattached to a water heater for mounting in the field if:

a) The valve is shipped in the same overall shipping container with the water heater;

b) Instructions for mounting the valve are included; and

c) The water heater has provision, such as a threaded boss, to permit the valve to be properly mounted.

37.4 A temperature and pressure relief device shall be connected directly in the upper 6 inches (152 mm) of the tank and shall be installed in a separate threaded opening located so that it is readily accessible for inspection and repair.

PERFORMANCE

38 General

38.1 For the tests described in Section 40 – 53, the test voltage shall be a value determined in accordance with the appropriate (a) – (c) below or a voltage adjusted to cause rated and marked wattage input, whichever is higher. The test voltage for a water heater:

a) Having a single voltage rating within the range of 110 – 120 volts, 220 – 240 volts, 254 – 277 volts, or 440 – 480 volts shall be the maximum voltage of the range;

b) Having a single voltage rating not within a range specified in (a) shall be the marked voltage rating; or

c) Marked for a range of voltages shall be the maximum voltage of the specified range.

39 Test Installation for Alcove or Closet

39.1 For the temperature test described in Section 45, Temperature Tests, a water heater intended for use in an alcove or closet is to be installed in an enclosure, as described in 39.3 – 39.5 and illustrated in Figures 39.1 and 39.2, in the as-received condition, with clearances in integral inches (or integral mm) as specified 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 assembly to the ceiling specified by the manufacturer. A water heater intended to be installed less than 3 feet (914 mm) from any adjacent wall or ceiling is to be tested in an alcove or closet.

Figure 39.1
Alcove installation

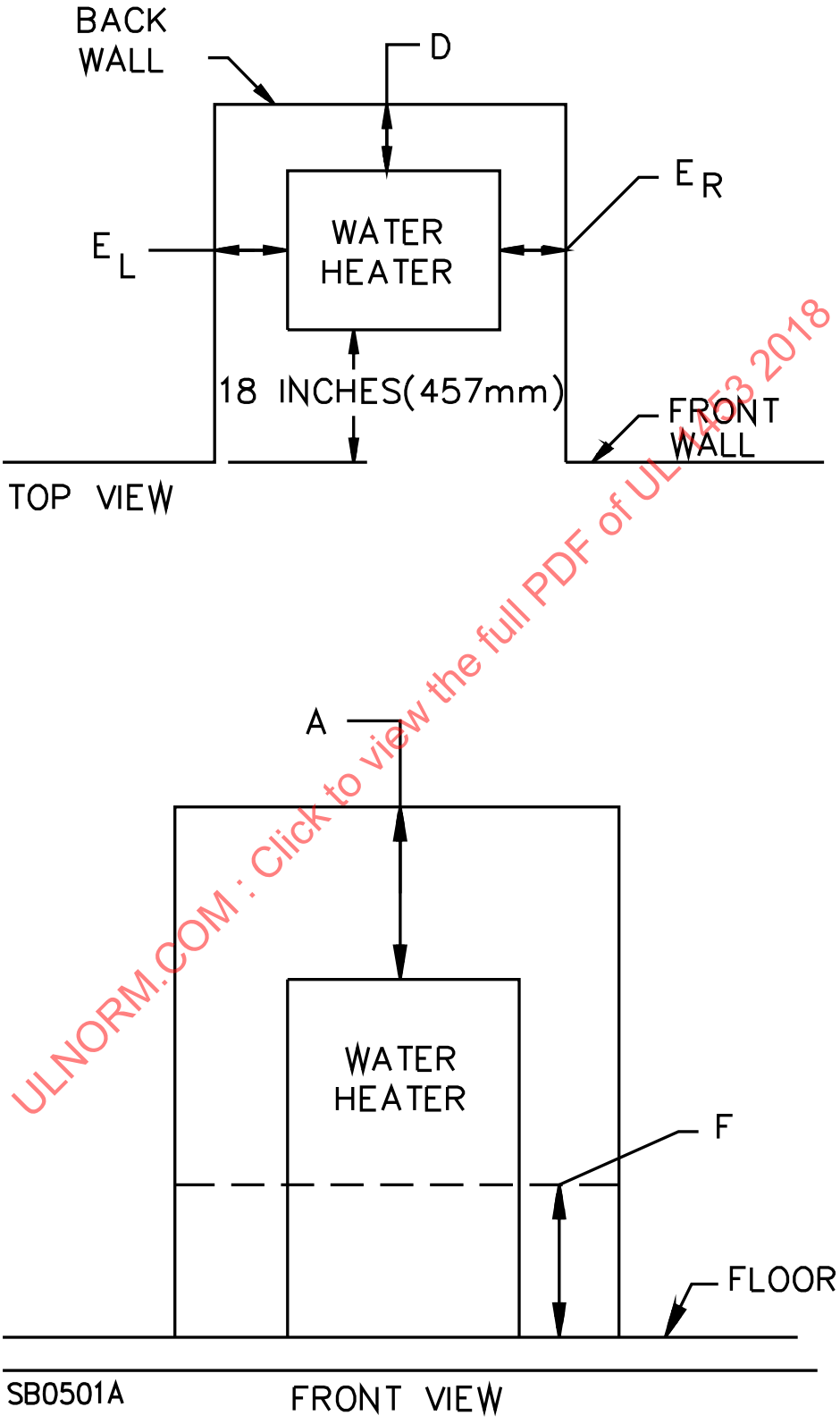
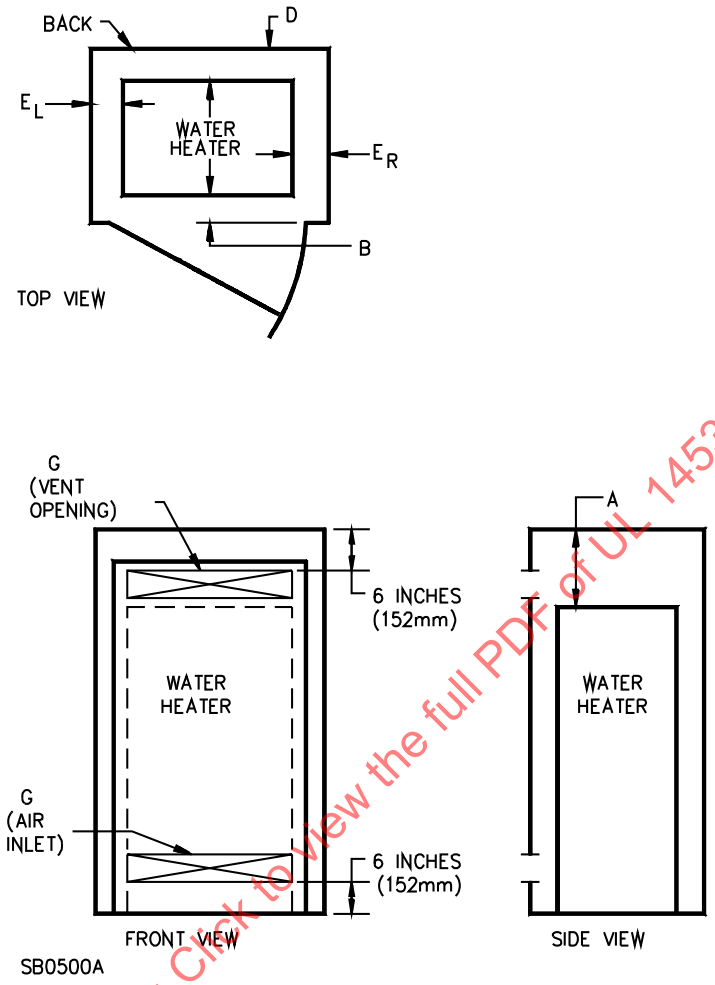


Figure 39.2
Closet installation



Description of dimensions, symbols, and abbreviations.

A – Clearance above top of water heater.

B – Clearance from front of water heater. Prefix ″C″ to numeral indicates suitability for closet or alcove installations; prefix ″A″, suitability for alcove installation but not for closet.

D – Clearance from back of water heater.

E_L – Clearance from left side of water heater.

E_R – Clearance from right side of water heater.

F – Indicates type of flooring; any numeral indicates minimum clearance below suspended units to combustible floor.

G – Total minimum free area in square inches (square cm) of closet ventilating openings.

39.2 The walls and ceiling of the enclosure are to be made of nominal 1 inch (25.4 mm) thick wood boards or 3/4 inch (19.1 mm) thick plywood. The walls are to be vertical and at right angles to each other. The interior surface of the walls and ceiling are to be finished in flat black paint. All joints of the enclosure are to be sealed. The floor is to be made of material as recommended by the manufacturer in the installation instructions. If the manufacturer recommends flooring of combustible material, the floor is to be made of 3/4 inch (19.1 mm) thick plywood or equivalent, finished in flat black paint.

39.3 A floor of an enclosure intended to be made of or surfaced with wood, compressed paper, plant fibers, or other combinations of materials having equal or greater flammability, even though flame proofed, fire retardant, or plastered, is considered to be made of a combustible material.

39.4 For alcove installation, the water heater is to be installed in an enclosure that is open at the front of the water heater as illustrated in Figure 39.1. The wall, opposite the open side of the enclosure, is to be located 48 inches (1.2 m), 36 inches (0.9 m), or 24 inches (0.6 m) from the front of the water heater, as recommended by the manufacturer for installation.

39.5 For closet installation, a door is to be provided as part of the enclosure. The door is to be located away from the front of the water heater at a distance no more than the minimum specified in the installation instructions. If ventilating openings are provided, each opening is to be located as shown in Figure 39.2 and the height of each opening is to be one-half the width of the opening as specified in the installation instructions.

40 Leakage Current Test

40.1 The leakage current of a cord connected water heater rated for a nominal 250 volts or less supply shall be tested in accordance with 40.3 – 40.9. The results are acceptable if the leakage current does not exceed 0.75 milliampere.

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

40.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible and from one surface to another where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered to reduce the risk of electric shock as specified in 6.4.2 – 6.4.4. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to present a risk of electric shock.

40.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil with an area of 10 by 20 centimeters (3.94 by 7.87 inches) in contact with the surface. Where the surface is less than 10 by 20 centimeters (3.94 by 7.87 inches), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the water heater.

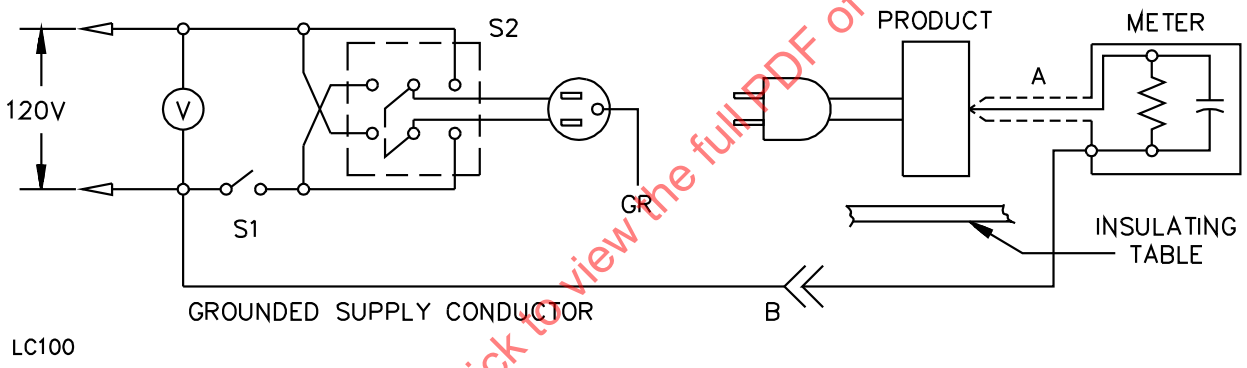
40.5 The measurement circuit for leakage current shall be as illustrated in Figure 40.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

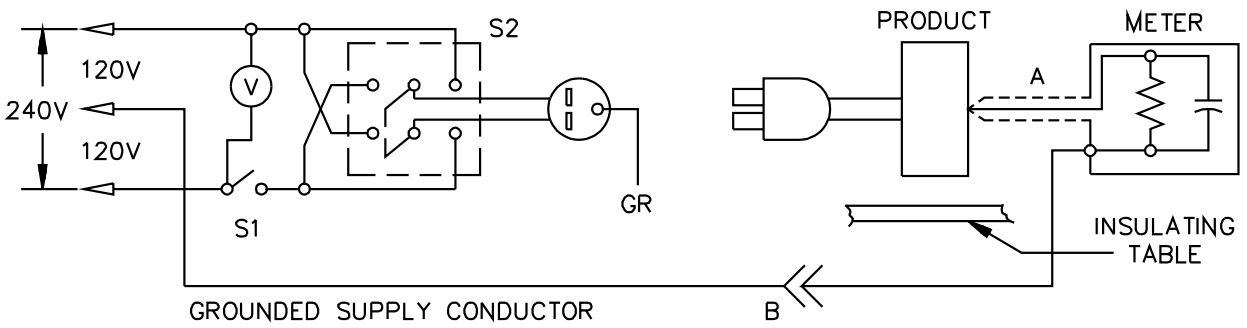
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.75 milliampere, the measurement is to have an error of no more than 5 percent.

Figure 40.1
Leakage current measurement circuits

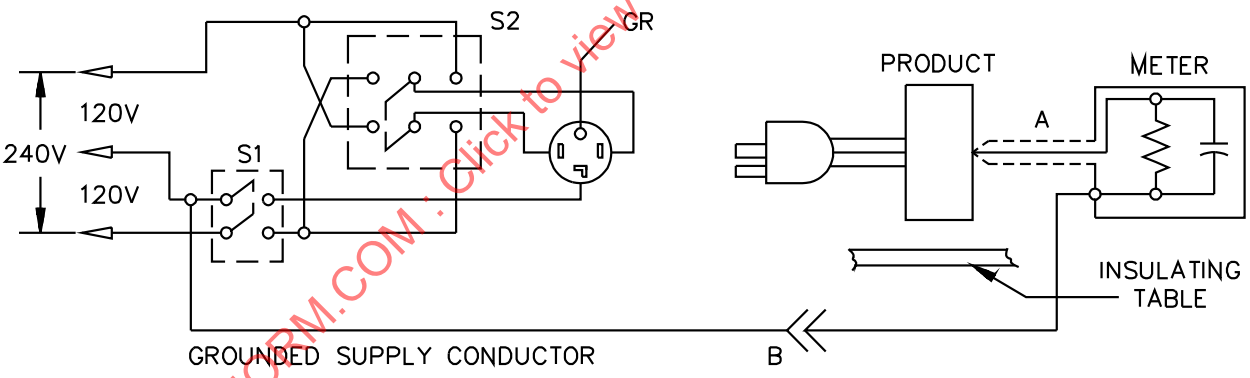


Appliance intended for connection to a 120 volt power supply.



LC200

Appliance intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.



LC300

Appliance intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

A – Probe with a shielded lead.

B – Separated and used as clip when measuring currents from one part of the appliance to another.

40.6 Unless the meter defined in 40.5 is being used to measure leakage from one part of an appliance to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

40.7 A sample water heater is to be prepared and conditioned for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location and installation, and the like of the production unit.

b) The grounding conductor is to be open at the attachment plug and the test unit isolated from ground.

c) The sample is to be conditioned in an ambient temperature of 21 – 27°C (70 – 81°F) and approximately 50 percent relative humidity for no less than 8 hours.

d) The test is to be conducted at the ambient conditions specified in (c).

e) The supply voltage is to be adjusted to the value specified in 38.1.

f) A water heater is to be filled with water.

40.8 The test sample is to be installed so that all parallel ground paths, such as through the fill and drain lines, will be eliminated.

40.9 The leakage current test sequence, with reference to the measuring circuits in Figure 40.1, is to be as follows:

a) With switch S1 open, the water heater is to be connected to the measurement circuit. Leakage current is to be measured using both positions of switch S2. All manual switching devices are to be operated in their intended manner, and leakage currents are to be measured using both positions of switch S2.

b) With the water heater switching devices in their normal operating positions, switch S1 is to be closed, energizing the water heater, and within 5 seconds the leakage current is to be measured using both positions of switch S2. All manual switching devices are then to be operated in their intended manner, and leakage currents are to be measured using both positions of switch S2.

c) The water heater manual switching devices are then to be returned to their normal operating positions and the unit allowed to run until thermal equilibrium, as described in 45.1.4, is obtained. Leakage current is to be monitored continuously. Both positions of switch S2 are to be used in determining this measurement. Thermal equilibrium may involve cycling caused by an automatic control. This cycling is to be observed with switch S2 in both positions.

d) If the water heater employs a single pole switch, monitoring of leakage current is to continue until the leakage current stabilizes or decreases after the water heater is turned off.

40.10 Usually a sample will be carried through the complete leakage current test program as covered in 40.9 without interruption for other tests. With the concurrence of those concerned, the leakage current tests may be interrupted to conduct other nondestructive tests.

41 Grounding Continuity Test

41.1 The resistance of the grounding path between all dead metal parts that are likely to become energized and the equipment grounding terminal, or point of attachment of the wiring system, shall be no more than 0.10 ohm.

41.2 With reference to 41.1, the resistance may be determined by any convenient method. If unacceptable results are recorded, either a direct or alternating current equal to the current rating of the maximum branch circuit overcurrent protective device that may be employed with the water heater is to be passed from the equipment grounding terminal to the dead metal part, and the resulting drop in potential is to be measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

42 Input Test

42.1 The input to a water heater shall be no more than 105 percent of its marked rating.

42.2 The input is to be measured with the water heater at the operating temperature attained under conditions of maximum load, and while connected to a supply circuit having the value specified in 38.1.

43 Temperature-Regulating and Temperature-Limiting Control Operation Tests

43.1 Temperature-regulating controls

43.1.1 A temperature-regulating control shall regulate the output water temperature to an upper limit of 90°C (194°F).

43.1.2 With respect to 25.1 and 43.1.1, the water heater is to be operated as described in 43.1.3 and the temperature of the water at the water outlet is to be monitored as water is drawn off immediately following the second opening of all thermostats.

43.1.3 Unless a water heater involves unusual features of design or construction, it is to be assumed that temperatures have become constant when it has been operated as follows. After a full tank of water has been heated to the temperature at which all of the thermostats open, one-fourth of the water is to be drawn off and replaced promptly with cold water. The water heater is to be allowed to heat again until all of the operating thermostats open, at which time the output water temperature is to be measured.

43.2 Temperature-limiting controls

43.2.1 A temperature-limiting control shall limit the water temperature to no higher than 99°C (210°F) when tested as described in 43.2.2.

43.2.2 With respect to 24.1 and 43.2.1, the water heater is to be tested as follows. After a tank full of water has been heated to the temperature at which all of the thermostats open, one-fourth of the water is to be drawn off and replaced promptly with cold water. Immediately after the first closure of any thermostat, the thermostats are to be short-circuited as described in 43.2.3, and operation is to be continued until all temperature-limiting controls open. Immediately thereafter, hot water is to be drawn off and its temperature is to be measured at the hot water outlet. Usually this procedure gives an accurate measurement of the temperature of the water in the upper 25 percent of the tank, but unusual conditions may necessitate use of a probe or thermocouple within the tank.

43.2.3 The thermostats are to be short-circuited as follows:

a) If the thermostat carries the heating load:

1) The thermostat is to be short-circuited in a heater incorporating only one thermostat.

2) Two thermostats are to be short-circuited simultaneously in a heater incorporating two or more thermostats; or

b) If the thermostat or thermostats control the coil of a magnetic contactor, all regulating thermostats in any one magnetic contactor coil circuit are to be short-circuited.

44 Nonmetallic Dip Tube Tests

44.1 Deformation and weight loss

44.1.1 A nonmetallic dip tube is to have a linear deformation not in excess of 1/2 inch (12.7 mm), a total lateral deformation not in excess of 1-1/2 inches (38.1 mm), and undergo no weight loss when tested in accordance with the requirements of 44.1.2 – 44.1.4.

44.1.2 Twelve 51-inch (1.30-m) long samples of each kind and section of dip tube are to be submitted for these tests. Each sample is to be cut to a length of 49 inches (1.24 m) and the weight of each tube is to be determined by use of a laboratory grade measuring device with a full scale not to exceed 3 times the weight of the sample.

44.1.3 Weight loss and linear deformation is to be determined by suspending the samples as they would be in service for 48 hours in water maintained at 93°C (199°F). These samples are then to be cooled to room temperature, any surface water is to be removed, and the length and weight determined and compared with the original results. The results are acceptable if there is no weight loss, and if the length of the samples is within the range of 48-1/2 – 49 inches (1.23 – 1.24 m).

44.1.4 Lateral deformation is to be determined by installing one end of each sample in a fixture (as it would be by a tank inlet fixture) and measuring the distance between the position of the center line of the free end and the extended center line of the fixture. Following immersion for 48 hours in water maintained at 93°C (199°F), the samples are to be cooled to room temperature, any surface water is to be removed, and the lateral deformation measured. The total lateral deformation of each sample is acceptable if it is within the limits of a circle having a radius of 1-1/2 inches (38.1 mm) measured from the extended center line of the fixture.

44.2 Resistance to crushing

44.2.1 A nonmetallic dip tube shall be subjected to transverse loading under a weight of 870 grams as described in 44.2.2 – 44.2.5.

44.2.2 Ten 2 inch (51 mm) long samples of each kind and section of dip tube are to be subjected to this test. The test apparatus is illustrated in Figure 44.1.

Figure 44.1
Heat deformation tester

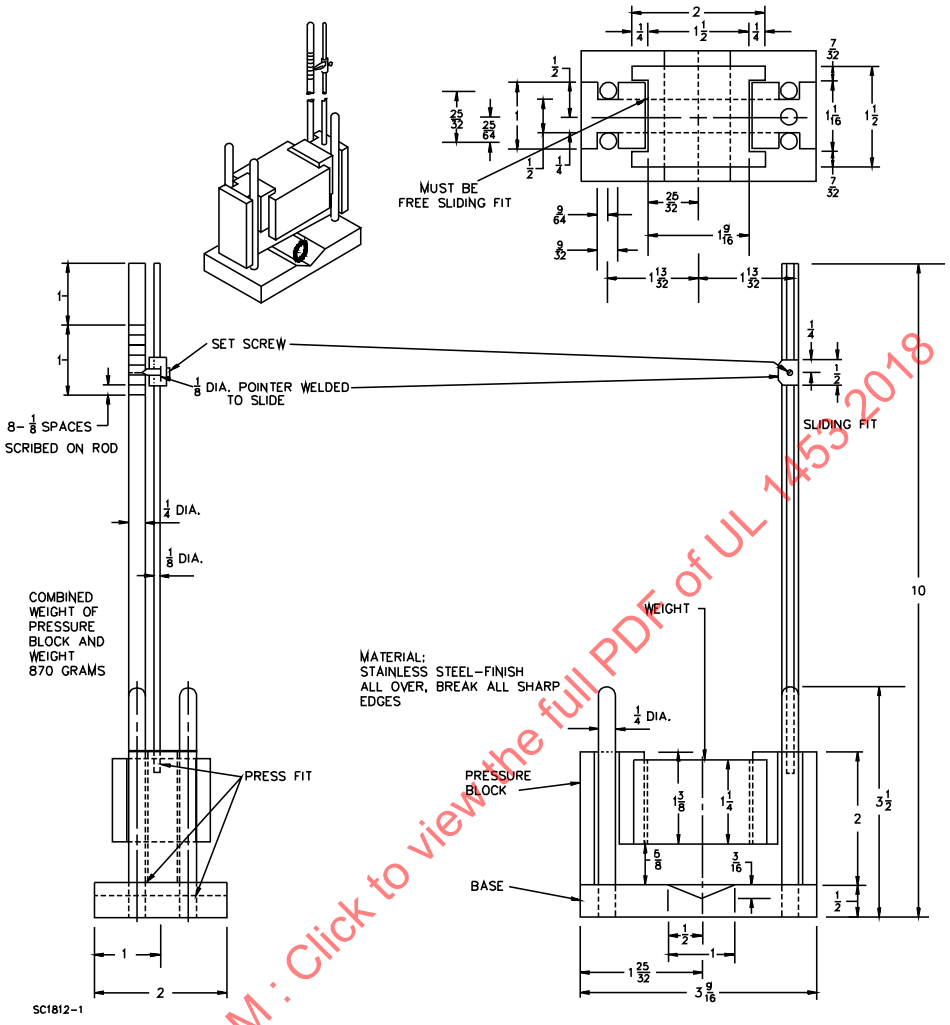


TABLE OF SI EQUIVALENTS FOR FIGURE 44.1

inch	(mm)	inches	(mm)
1/8	(3.2)	1-1/16	(27)
9/64	(3.6)	1-1/4	(31.8)
3/16	(4.8)	1-3/8	(34.9)
7/32	(5.6)	1-13/32	(35.7)
1/4	(6.4)	1-1/2	(38.1)
9/32	(7.1)	1-9/16	(39.7)
25/64	(9.9)	1-25/32	(45.2)
1/2	(12.7)	2	(50.8)
5/8	(15.9)	3-1/2	(88.9)
25/32	(19.8)	3-9/16	(90.5)
1	(25.4)	10	(254)

44.2.3 The scale on the test apparatus shown in Figure 44.1 is to be set at zero with a sample of the tube to be tested in place in the ″V″ trough beneath the pressure block. The sample is then to be removed and the test apparatus placed in a 1 liter glass beaker filled with ethylene glycol, glycerin or a similar liquid to a depth that will cover the pressure block when at the zero scale setting. The glass beaker is then to be placed over a hot plate and heated until the temperature of the liquid and test apparatus, as determined by a thermometer placed in the beaker with its bulb on the base of the test apparatus, has reached 107 – 110°C (225 – 230°F). The temperature is then to be held constant for the duration of the test.

44.2.4 The pressure block is then to be raised and the sample of the dip tube to be tested placed in the ″V″ trough below the block. The block is then to be lowered without impact onto the dip tube sample and the time recorded. At the end of a 24 hour period the distance of travel of the indicator on the scale is to be recorded, the test sample removed, and the test repeated on the remaining test samples.

44.2.5 The results are acceptable if the average deformation of the samples does not exceed 1/4 inch (6.4 mm) and the rate of deformation is to be uniform. Immediate deformation of any test sample upon application of the test load is to be considered as noncompliance of the lot submitted for test.

44.3 Collapse

44.3.1 A nonmetallic dip tube shall not collapse under the conditions of test described in 44.3.2 – 44.3.6.

44.3.2 The internal diameter of a 49 inch (1.24 m) long sample of each style and kind of dip tube is to be determined before the conditioning described in 44.3.3 – 44.3.6.

44.3.3 The sample is to be installed in the hot water outlet of a typical water heater. A quick acting valve is to be installed at the outer connection of the storage vessel. The minimum cross-sectional area through this valve is to be equal to or greater than that of an ANSI B36.10, Schedule 40, 1/4 inch pipe having an internal diameter of 0.364 inch (9.25 mm). A flow restricting device, adjusted or constructed so as to maintain a flow rate of 5 gallons (18.9 L) per minute during the test period, is to be connected to the inlet of the heater.

44.3.4 A mercury thermometer graduated to 0.5°C (1°F) or a thermocouple for connection to a potentiometer is to be installed in the storage vessel within the top 6 inches (152 mm) of the tank. A water pressure regulator is to be located between the inlet connection to the storage vessel and the water supply line and adjusted so that, at a steady flow rate of 5 gallons (18.9 L) per minute, the pressure at the inlet connection will be 40 pounds per square inch (276 kPa).

44.3.5 The storage vessel is to be filled and the test water heater placed in operation, with the thermostat, if any, bypassed. When the temperature indicated by the thermometer or thermocouple in the top of the storage vessel is 107 – 110°C (225 – 230°F), the quick acting valve is to be opened and water allowed to flow until the outlet water temperature is the same as the inlet water temperature.

44.3.6 The dip tube is then to be removed from the test heater and examined. Any indication of reduction in internal diameter in excess of 1/8 inch (3.2 mm) from the original diameter is to be considered as noncompliance with this provision.

45 Temperature Tests

45.1 General

45.1.1 A water heater shall be tested under conditions of maximum normal load. The results are acceptable if the temperature at any point does not:

a) Constitute a risk of fire;

b) Adversely affect any material employed in the water heater; or

c) Exceed the temperature rises specified in Table 45.1.

45.1.2 All values in Table 45.1 are based on an assumed ambient temperature of 25°C (77°F). The tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). For the tests, the ambient measuring thermocouple is to be placed centrally 24 inches (610 mm) in front of the water heater and 24 inches above the test enclosure floor.

Table 45.1
Maximum acceptable temperature rises

	Material or component	°C	(°F)
1.	Any point within a terminal box or wiring compartment of a water heater in which field installed conductors are to be connected, including such conductors themselves, unless the water heater is marked in accordance with 57.14	35	(63)
2.	Any point on a surface adjacent to a water heater, including the surface on which the water heater is mounted or supported, and specified points on test surfaces and enclosures at designated clearances from the water heater; metal surfaces of a water heater at point of contact with the test surfaces and surfaces of a water heater that are recessed within the test enclosure	65	(117)
3.	Fuses other than Classes CC, G, J, T	65	(117)
4.	Classes CC, G, J, T fuses	85	(153)
5.	Fiber employed as electrical insulation	65	(117)
6.	Wood or other combustible material	65	(117)
7.	Class 105 insulation systems on a relay, a transformer, a solenoid, and the like		
	Thermocouple method	65[a]	(117[a])
	Resistance method	85	(153)
8.	Class 130 insulation systems on a relay, a transformer, a solenoid, and the like		
	Thermocouple method	85[a]	(153[a])
	Resistance method	105	(189)
9.	Phenolic components used as electrical insulation or where deterioration of the compound would result in a risk of fire, electric shock, or injury to persons[b]	125	225
10.	Insulated wire or cord	25°C less than its established temperature rating[c]	(45°F) less than its established temperature rating[c]
11.	Sealing compound	d	d
12.	Copper or copper-base alloy conductors:		
	A. Tinned or bare strands having:		

Table 45.1 Continued on Next Page

Table 45.1 Continued

Material or component	°C	(°F)
1. A diameter less than 0.015 inch (0.38 mm)	125	(225)
2. A diameter of 0.015 inch or more	175	(315)
B. Plated with nickel, gold, silver, or a combination of these metals	225	(405)
13. Termination of copper conductors and pressure terminal connectors unless both are tinned, nickel coated, silver plated or otherwise protected	125	(225)
14. Capacitor		
A. Electrolytic type	65[e]	(117[e])
B. Other types	65[f]	(117[f])

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher than the maximum indicated by the following amount:

Item	Additional Temperature Rise	
7	15°C	(27°F)
8	20°C	(36°F)

provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

[b] The limitation on phenolic composition does not apply to a compound that has been investigated and found to be acceptable for a higher temperature.

[c] Inside a water heater, the temperature rises on a wire or cord may be greater than the specified maximum rise provided that the insulation on each individual conductor is protected by supplementary insulation, such as braid, wrap, tape, or close fitting tubing, that is rated for the temperature and type of insulation involved.

[d] Unless the sealing compound is a thermosetting material, the maximum acceptable temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined by the Test for Softening Point by Ring-and-Ball Apparatus, ASTM E28..

[e] For other than an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be no more than 65°C (117°F).

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

45.1.3 To determine whether a water heater complies with the requirements in 45.1.1, it is to be operated continuously, in accordance with 45.2.1, until constant temperatures have been reached.

45.1.4 Thermal equilibrium or constant temperature is considered to exist when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test but no less than 5 minute intervals, indicate no change.

45.1.5 Temperatures are to be measured by thermocouples consisting of wires no larger than 24 AWG (0.21 mm^2) and no smaller than 30 AWG (0.05 mm^2). The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements for Special Tolerances Thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature″ tables in the Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

45.1.6 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material of which the temperature is being measured. In most cases, thermal contact will result from securely taping or cementing the thermocouples in place. If a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

45.1.7 Usually the temperature of a coil is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting in these devices, such as a coil immersed in sealing compound, or if the coil wrap includes thermal insulation or more than two layers – 1/32 inch (0.8 mm) maximum – of cotton, paper, rayon, or like material, the resistance method is to be used.

45.2 Continuous operation

45.2.1 With reference to 45.1.3, a water heater is to be operated continuously:

a) As described in 45.2.2 – 45.2.5, for a water heater having only one heating element; or

b) As described in either 45.2.2 – 45.2.5 or in 45.2.6 – 45.2.8, for a water heater having more than one heating element.

45.2.2 During continuous operation, electrically operated thermal controls, including the temperature-regulating control but not including the manual temperature-limiting control, are to be shunted out of the circuit.

45.2.3 A water heater is to be connected to a water supply source. The water flow is to be adjusted such that the output water temperature is maintained at 90.0 ±2.8°C (194.0 ±5.0°F). The water heater is to be operated until thermal equilibrium is reached, at which time temperatures are to be recorded and the test is to be terminated.

45.2.4 For other than a booster water heater, a cold water supply source is to be used. The temperature of the cold water supply is to be that at which the water is obtained from the city water main.

45.2.5 For a booster water heater, the temperature of the water supply source is to be 60.0 ±2.8°C (140.0 ±5.0°F).

45.2.6 In the alternative method of continuous operation referred to in 45.2.1(b) and described in 45.2.7 and 45.2.8, electrically operated controls, other than the automatic temperature-regulating control and the manually reset temperature-limiting control, are to be shunted out of the circuit.

45.2.7 The water heater is to be connected to a water supply source as described in 45.2.4, and is to be operated as described in 43.1.2.

45.2.8 After the water heater has been operated as described in 43.1.2, sufficient heating elements are to be shunted out of the circuit to maintain a constant water temperature of 90.0 ±2.8°C (194.0 ±5.0°F). The remaining heating elements are to be connected to their rated voltage. At any convenient voltage, a current equal to rated current of the remaining circuits is to be applied to the circuits and to any other contactors provided. The coils of the contactors are to be connected directly to a supply of their rated voltage. The water heater is to be operated until thermal equilibrium is reached, at which time temperatures are to be recorded and the test is to be terminated.

45.3 Surface temperature

45.3.1 During the temperature test required by 45.1.1, a temperature on a surface of a water heater that may be contacted by the user shall be no more than the value specified in Table 45.2. If the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Table 45.2
Maximum acceptable temperatures of surfaces exposed to user contact

Location	Composition of surface[a]			
	Metal		Nonmetallic	
Handles or knobs that are likely to be grasped	60°C	(140°F)	85°C	(185°F)
Surfaces, other than a heating function surface, subject to unintentional contact	70°C	(158°F)	95°C	(203°F)

[a] A handle, knob, or the like made of a material (other than metal) that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is considered to be a nonmetallic part.

46 Hydrostatic Pressure Test

46.1 A water heater that is required to be tested in accordance with 35.1 shall withstand for 15 minutes without leakage or visible permanent distortion a hydrostatic pressure of 300 pounds per square inch (2068 kPa), or two times the marked working pressure, whichever is greater.

46.2 The pressure is to be increased from atmospheric pressure to the test pressure at a rate of approximately 20 pounds per square inch (138 kPa) per second.

46.3 Leakage at a gasket during the hydrostatic pressure test is acceptable unless it occurs at a pressure 40 percent or less of the required test pressure value.

47 Enclosure Strength Test

47.1 In accordance with item (c) of the Exception to 6.2.3, a water heater with an enclosure thinner than specified in Tables 6.1 and 6.2 shall be subjected to a static load of 50 pounds-force (222.5 N) as described in 47.2. The results are acceptable if, during or after the application of the force, there is no reduction of electrical spacings below the minimum acceptable values specified in Section 28, Spacings, and no live parts are made accessible to contact by the probe illustrated in Figure 6.2.

47.2 The force of 50 pounds (222.5 N) is to be applied through contact with the rounded end of a metal rod in a direction parallel to the longitudinal axis of the rod. The rod diameter is to be 1/2 inch (12.7 mm), and the rounded end is to be shaped to a 1/4 inch (6.4 mm) radius hemisphere. The enclosure is to be tested on all surfaces thinner than specified in Tables 6.1 and 6.2.