



# UL 1453

## STANDARD FOR SAFETY

### Electric Booster and Commercial Storage Tank Water Heaters

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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.

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## UL 1453

### Standard for Electric Booster and Commercial Storage Tank Water

#### Heaters

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

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## 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 <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>				Minimum thickness					
Maximum width <sup>b</sup>		Maximum length <sup>c</sup>		Maximum width <sup>b</sup>		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 <sup>d</sup>	(0.51) <sup>d</sup>	0.023 <sup>d</sup>	(0.58) <sup>d</sup>
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 <sup>d</sup>	(0.66) <sup>d</sup>	0.029 <sup>d</sup>	(0.74) <sup>d</sup>
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)				

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> 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.

<sup>d</sup> 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 <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>				Minimum thickness	
Maximum width <sup>b</sup>	Maximum length <sup>c</sup>	Maximum width <sup>b</sup>	Maximum length	Maximum length	Inch	(mm)	
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)			
3.0 (7.6)	Not limited	7.0 (17.8)	Not limited	Not limited	0.023 <sup>d</sup>	(0.58) <sup>d</sup>	
3.5 (8.9)	4.0 (10.2)	8.5 (21.6)	9.5 (24.1)	9.5 (24.1)			
4.0 (10.2)	Not limited	10.0 (25.4)	Not limited	Not limited	0.029	(0.74)	
5.0 (12.7)	6.0 (15.2)	10.5 (26.7)	13.5 (34.3)	13.5 (34.3)			
6.0 (15.2)	Not limited	14.0 (35.6)	Not limited	Not limited	0.036	(0.91)	
6.5 (16.5)	8.0 (20.3)	15.0 (38.1)	18.0 (45.7)	18.0 (45.7)			
8.0 (20.3)	Not limited	19.0 (48.3)	Not limited	Not limited	0.045	(1.14)	
9.5 (24.1)	11.5 (29.2)	21.0 (53.3)	25.0 (63.5)	25.0 (63.5)			
12.0 (30.5)	Not limited	28.0 (71.1)	Not limited	Not limited	0.058	(1.47)	
14.0 (35.6)	16.0 (40.6)	30.0 (76.2)	37.0 (94.0)	37.0 (94.0)			
18.0 (45.7)	Not limited	42.0 (106.7)	Not limited	Not limited	0.075	(1.91)	
20.0 (50.8)	25.0 (63.5)	45.0 (114.3)	55.0 (139.7)	55.0 (139.7)			
25.0 (63.5)	Not limited	60.0 (152.4)	Not limited	Not limited	0.095	(2.41)	
29.0 (73.7)	36.0 (91.4)	64.0 (162.6)	78.0 (198.1)	78.0 (198.1)			
37.0 (94.0)	Not limited	87.0 (221.0)	Not limited	Not limited	0.122	(3.10)	
42.0 (106.7)	53.0 (134.6)	93.0 (236.2)	114.0 (289.6)	114.0 (289.6)			
52.0 (132.1)	Not limited	123.0 (312.4)	Not limited	Not limited	0.153	(3.89)	
60.0 (152.4)	74.0 (188.0)	130.0 (330.2)	160.0 (406.4)	160.0 (406.4)			

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> 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.

<sup>d</sup> 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 <sup>a</sup>	Resistance to ignition		Electrical				End product tests <sup>d</sup>			
		Maximum hot wire (HWI) <sup>b</sup> PLC <sup>c</sup>	Maximum high current (HAI) <sup>b</sup> PLC <sup>c</sup>	Minimum dielectric strength, volts <sup>b</sup>	Maximum high voltage track rate (HVTR) <sup>b</sup> PLC <sup>c</sup>	Maximum comparative tracking index (CTI) <sup>b</sup> PLC <sup>c</sup>	Volume resistivity <sup>b</sup> 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

<sup>a</sup> 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.

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

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

<sup>d</sup> Tests are to be conducted in accordance with UL 746C.

**Table 6.5**  
**Polymeric outer jacket**

Part	Impact test <sup>a</sup>	Burning characteristics		Moisture resistance <sup>d</sup>
		Maximum flame spread index <sup>b</sup>	Minimum flammability classification <sup>c</sup>	
Outer jacket, indoor only				
A. Less than 10 square feet (0.93 m <sup>2</sup> ) 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 <sup>2</sup> ) 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

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> 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.

<sup>d</sup> 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

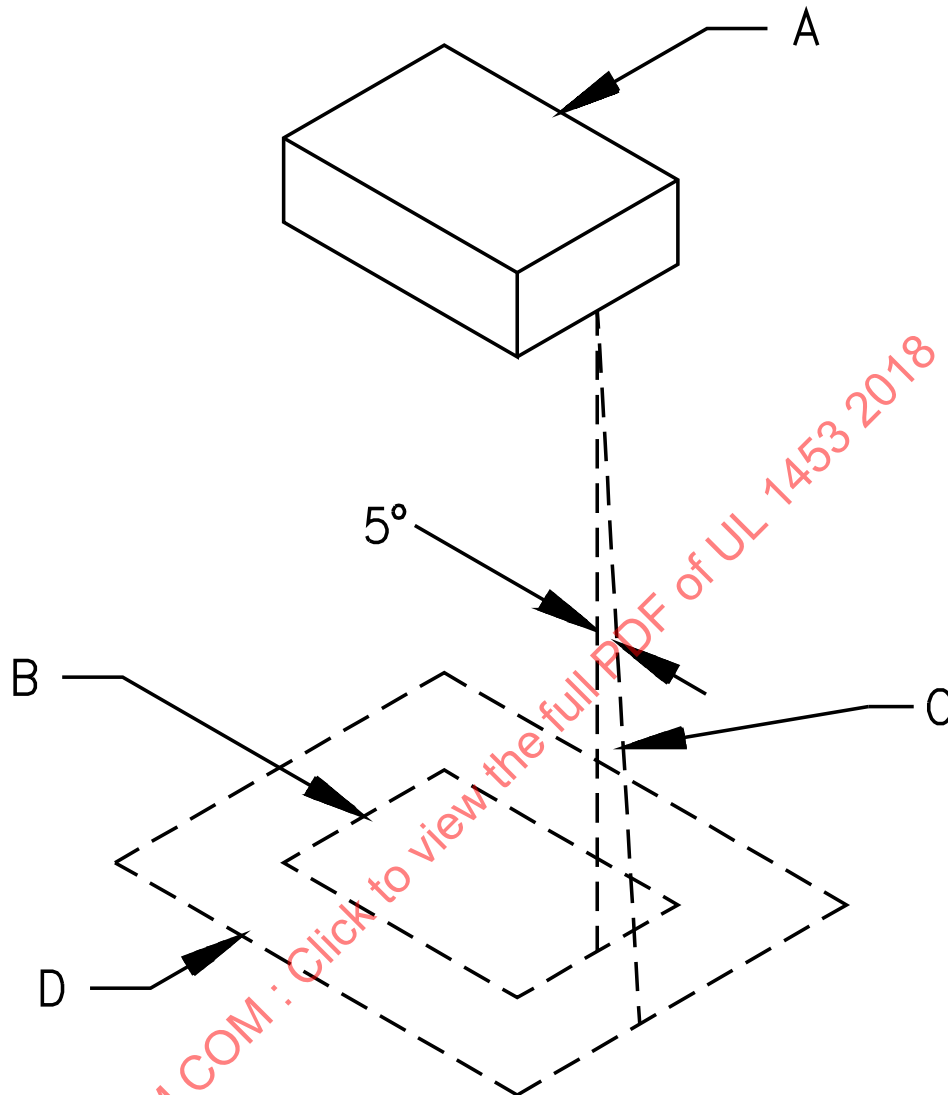
6.3.1 The enclosure of a water heater shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the water heater is supported.

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.

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**Figure 6.1**  
**Location and extent of barrier**



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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.