UL 2523

STANDARD FOR SAFETY

Solid Fuel-Fired Hydronic Heating Appliances, Water Heaters, And Boilers

UL Standard for Safety for Solid Fuel-Fired Hydronic Heating Appliances, Water Heaters, And Boilers, UL 2523

First Edition, Dated December 22, 2009

Summary of Topics

These revisions to ANSI/UL 2523 are being issued to address:

Temperature rise vs, absolute temperature values in Table 55.1

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. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated February 9, 2018.

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UL 2523

Standard for Solid Fuel-Fired Hydronic Heating Appliances, Water Heaters, And Boilers

Prior to the first edition, the requirements for the products covered by this standard were included in the Outline of Investigation for Solid Fuel-Fired Water Heaters And Boilers, SU 2523.

First Edition

December 22, 2009

This ANSI/UL Standard for Safety consists of the First Edition including revisions through March 16, 2018.

The most recent designation of ANSI/UL 2523 as an American National Standard (ANSI) occurred on March 16, 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 apply to factory built manually and/or automatically fueled solid fuel-fired hydronic heating appliances, water heaters and boilers, as defined in Section 5, Glossary, intended to be fixed non-moveable appliances.

1.2 The appliances are intended to burn solid fuels, such as wood, coal, or any other biomass fuel, as specified by the manufacturer.

1.3 The appliances are provided with an integral chimney and termination or intended for connection to chimneys for residential type and building heating appliances or for building heating appliances in compliance with the Standard for Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances, NFPA 211, and intended for installation in compliance with the National Electrical Code, ANSI/NFPA 70; and the International Mechanical Code (ICC), International Residential Code (ICC) and the Uniform Mechanical Code (IAPMO), as applicable.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component.

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 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 apply.

5.2 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary air, secondary air, or both. It may be either manually or automatically operated.

5.3 APPLIANCE FLUE – The passages within the product that conduct the products of combustion (flue gases) through the product.

5.4 BOILER – A closed vessel in which water or some other liquid is heated or in which steam is generated or superheated, under pressure or vacuum, by direct application of heat.

5.5 BOILER, HIGH PRESSURE STEAM – A boiler in which steam is generated at a pressure higher than 15 psig (103 kPa).

5.6 BOILER, HIGH TEMPERATURE WATER – A boiler intended for operation at a pressure exceeding 160 psig (1103 kPa) or at a temperature exceeding 250°F (121°C) or both.

5.7 BOILER, HOT WATER – A boiler that furnishes hot water at a pressure not exceeding 160 psig (1103 kPa) and at a temperature not exceeding 250°F (121°C).

5.8 BOILER, LOW PRESSURE STEAM – A boiler in which steam is generated at a pressure not exceeding 15 psig (103 kPa).

5.9 CHIMNEY CONNECTOR – The pipe that connects a fuel-burning product to a chimney.

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

5.11 COMBUSTIBLE, NONCOMBUSTIBLE PRODUCTS – These terms, as used in this standard, are defined in the Standard Glossary of Terms Relating to Chimneys, Vents, and Heat-Producing Appliances, NFPA 97.

5.12 CONTROL, LIMIT – An automatic control responsive to changes in pressure or temperature and intended to limit the operation of the controlled equipment.

5.13 CONTROL, SAFETY – Any automatic control, such as a relay or switch, used in conjunction with other auxiliary equipment to form a safety control system that is relied upon to reduce the risk of fire, electric shock, or injury to persons.

5.14 CONTROL, THERMOSTATIC DAMPER – An automatic control responsive to changes in temperature. Usually acts through direct mechanical linkage to reduce or increase the supply of air needed for combustion, thereby regulating the combustion rate and limiting the operation of the product when the product is burning solid fuel.

5.15 DAMPER – A valve or plate that regulates draft or flow of flue gases or inlet combustion air. May be either manually or automatically operated.

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

5.17 ELECTRICAL CIRCUITS :

a) Circuit – A circuit involving a potential of not more than 600 volts and having circuit values in excess of those of a low-voltage circuit.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak or direct current) and supplied by a NEC Class 2 transformer, or by a battery, or by a battery and fixed impedance, or by a transformer and fixed impedance each of which, as a unit, is either in compliance with requirements for a Class 2 transformer or is otherwise limited to a maximum output of 100 volt-amperes. A circuit derived by connecting resistance in series with a high-voltage circuit as a means of limiting the voltage and current is not considered a low-voltage circuit.

c) Isolated Limited Secondary Circuit – A circuit of limited energy output derived from a isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and open-circuit secondary voltage rating not exceeding 1000 volts.

5.18 GRATE – A metal frame provided by the manufacturer for supporting the fuel within an appliance.

5.19 HEARTH – The floor area within the fire chamber of an appliance.

5.20 HYDRONIC HEATING APPLIANCE – An appliance that maintains a constant atmospheric internal working pressure and is designed to heat a liquid, such as water, that is circulated between a heating load and the heating source (appliance).

5.21 INDIRECT-FIRED VENTED PRODUCT – A product in which the products of combustion and the medium being heated (circulating air, for example) are segregated by the walls of the fire chamber and flues; it is provided with an integral chimney termination or a flue collar to accommodate a chimney connector.

5.22 RADIATION SHIELD – A separate panel or separate panels interposed between heating surfaces and adjacent objects for the purpose of reducing heat transmission by radiation.

5.23 RADIATOR – Auxiliary heat transfer surfaces within the casing, connected between the combustion chamber and the flue collar.

5.24 SAFETY SHUTDOWN – The means to interrupt the combustion air and automatic fuel supply of a solid fuel fired appliance, resulting in extinguishment of the combustion process of the fuel.

5.25 THERMOSTAT – An automatic control actuated by temperature change to maintain temperatures between predetermined limits.

5.26 WATER HEATER – A vessel in which water is heated by the combustion of fuels and is withdrawn for external use, including all controls and devices necessary to prevent water temperatures from exceeding 210°F (99°C), with an internal maximum working pressure of less than 160 psi (1103 kPa) and storage water volume not in excess of 120 gallons (454 L).

CONSTRUCTION

ALL APPLIANCES

6 General

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

6.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may result in operation of the equipment in a manner that involves a risk of fire, electric shock, or injury to persons.

7 Corrosion Protection

7.1 Iron and steel parts shall be protected against corrosion by painting, galvanizing, plating or other equivalent means if the malfunction of such unprotected part would be likely to result in a hazardous condition.

Exception: Cast-iron parts, cast-aluminum parts and ASME coded pressure vessels are not required to be protected against corrosion.

7.2 An evaluation of any condensation that may collect in the flue gas ductwork or components shall be undertaken to determine the pH content. The pH content is to be measured as undiluted condensate. An initial condensate sample is to be taken upon a cold start and additional samples are to be taken to be representative of all firing conditions that produce condensate. The pH measurement is to be performed in accordance with the Standard Test Method for pH of Aqueous Solutions With the Glass Electrode, ASTM E70. If the pH is greater than or equal to 3.0, no further evaluation of the effects of the condensate is required. If the pH concentration is less than 3.0, the venting system of the appliance shall be evaluated in accordance with the Standard for Venting Systems for Gas Burning Appliances, Categories II, III, and IV, UL 1738.

8 Protection of Users and Service Personnel

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

Exception: A moving part is not required to comply with 8.1 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

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

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

b) Resetting control trip mechanism;

c) Operating manual switches; or

d) Adjusting air shutters or air-flow dampers.

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

8.3 The requirements of 8.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

8.4 Adjustable or resettable electrical control or manual switching devices may be located or oriented with respect to uninsulated live parts, so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the normal direction of access if uninsulated live parts or moving parts that may involve a risk of injury to persons are:

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

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

8.5 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized, not including voltage measurements, shall be located and mounted with respect to other components and grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to a risk of electric shock from adjacent uninsulated live parts or to unintentional contact from adjacent moving parts that may involve a risk of injury to persons.

8.6 Accessibility and protection from a risk of fire, electric shock, or injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through the access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement:

a) The components are located with respect to the access opening in the cabinet so that the farthest component in the control assembly is not more than 14 inches (356 mm) from the plane of the access opening.

b) Uninsulated live parts outside the control assembly projected clear space (except for live parts within a control panel) or unguarded moving parts that may involve a risk of injury to persons are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the

smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

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

d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

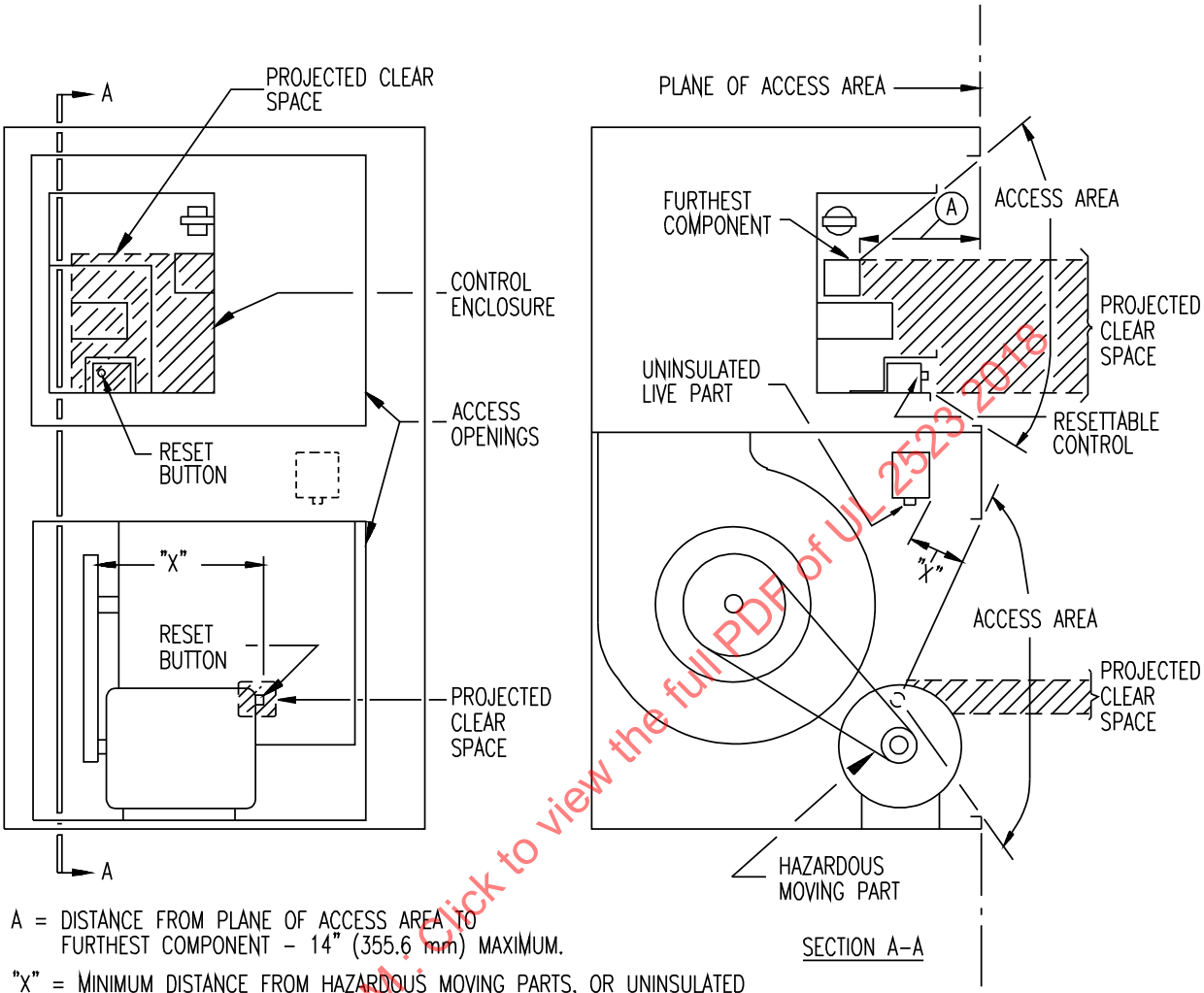
e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure shall be located so that:

1) There is unimpeded access to these components through the access opening in the outer cabinet; and

2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded.

Also see Figure 8.1.

Figure 8.1
Accessibility and protection



A = DISTANCE FROM PLANE OF ACCESS AREA TO FURTHEST COMPONENT – 14" (355.6 mm) MAXIMUM.

"X" = MINIMUM DISTANCE FROM HAZARDOUS MOVING PARTS, OR UNINSULATED LIVE PARTS TO ACCESS AREA = 6" (152.4mm) MINIMUM.

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8.7 Components in a low-voltage circuit shall comply with the requirements of 8.5 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

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

a) Coils of controllers;

b) Relays and solenoids;

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

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wires.

8.9 Moving parts such as fan blades, blower wheels, pulleys, belts, and the like, which may cause injury shall be enclosed or guarded (See 8.13 for requirements pertaining to automatically fed appliances). If the removal of doors, panels, or shields will expose such moving parts;

a) The opening or removal of the door, panel, or shield shall require the use of tools;

b) An interlocking device shall shut off the mechanism; or

c) A warning marking shall be displayed as described in 72.10.

Exception: A moving part is not required to comply with 8.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

8.10 The distance from an opening in a required guard or enclosure to the moving part mentioned in 8.9 shall be in accordance with Table 8.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

Table 8.1
Dimensions of openings

Minor dimensions of opening		Minimum distance from opening to moving part	
inches[a]	(mm)	inches[a]	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)
2	(50.8)	14-1/2	(369)
over 2	(over 50.8)	30	(762)

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

8.11 A moving part shall not be considered when evaluating for compliance with 8.1 and 8.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

8.12 The fuel hopper of an automatically fueled appliance shall be constructed such that fuel or fuel residue cannot enter areas within the appliance electrical enclosure or come into contact with exterior surfaces of the fire chamber. Fuel hopper sections shall be fastened together securely such that they do not rely solely on a sealing compound or tape for tightness.

8.13 The fuel hopper of an automatically fueled appliance shall have a lid or door with a direct interlock to the fuel feed auger motor so that the auger is disabled when the hopper is opened.

8.14 If provided, the hopper lid/door seal gasketing shall be attached to the lid/door, or the design and construction shall be such that damage to the gasketing during normal operation and filling of the hopper is prevented.

8.15 When components require removal, for example, during periodic maintenance, such removal shall not render the gasket or seal incapable of forming a suitable seal when the components are reassembled with a gasket or seal replacement.

9 Enclosures

9.1 General

9.1.1 Uninsulated live high-voltage parts shall be enclosed or guarded to prevent unintentional contact by persons during normal use of the appliance.

9.1.2 Among the factors taken into consideration when evaluating the acceptability of an enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

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

For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal and chemical aging, in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

9.1.3 The enclosure shall reduce the likelihood of the emission of molten metal, burning insulation, flaming particles, or the like through openings onto combustible material, including the surface on which the equipment is mounted.

9.1.4 Where the design and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 9.1 or 9.2 whichever applies, may be employed.

Table 9.1
Minimum thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing				Minimum thickness, inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Metal coated	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(MSG)		(GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.32	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		33.0	(83.8)	Not limited		0.060	(1.53)	0.063	(1.61)
25.0	(63.5)	31.0	(78.7)	35.0	(89.0)	43.0	(109.2)	(15)		(15)	
25.0	(63.4)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)

Table 9.1 Continued on Next Page

Table 9.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing				Minimum thickness, inches (mm)	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated	Metal coated
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(MSG)	(GSG)
29.0	(73.7)	36.0	(91.4)	41.0	(104.0)	51.0	(129.5)	(14)	(14)
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080 (2.04)	0.084 (2.13)
35.0	(89.0)	47.0	(119.4)	54.0	(137.1)	66.0	(167.6)	(13)	(13)
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093 (2.36)	0.097 (2.46)
42.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)	(12)
52.0	(135.1)	Not limited		80.0	(203.2)	Not limited		0.108 (2.74)	0.111 (2.80)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)	(11)
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123 (3.12)	0.126 (3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)	(10)

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is a 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 which are not supported along one side, e.g., side panels of boxes, the length of the unsupported side shall be lifted to the dimensions specified unless the side in question is provided with a flange at lease 1/2 inch (12.7 mm) wide.

Table 9.2
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	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(AWG)	
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(22)	
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)	(20)	
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)	(18)	
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)	(16)	
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)	(14)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(12)	
25.0	(63.4)	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)	(10)	
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)	(8)	
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)	(6)	

Table 9.2 Continued on Next Page

Table 9.2 Continued

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	(mm)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	(AWG)	

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

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

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

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

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

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

9.1.5 Electrical parts within the outer cabinet are not required to be individually enclosed if the assembly conforms with all of the following:

a) Their design and location with respect to openings in the outer cabinet will not result in the emission of flame or molten metal through openings in the cabinet or if it can be shown that failure of the component would not result in a risk of fire;

b) There are no openings in the bottom of the compartment in which the part is located which would permit dropping of molten metal, and the like, onto combustible material;

c) The part is not in proximity to combustible material other than electrical insulation;

d) The part is not located closer than 5 inches (127 mm) to the outer cabinet unless the thickness of sheet metal is in compliance with Table 9.1;

e) The part is not located in an air-handling compartment;

f) The thickness of the outer cabinet is not less than two-gage thicknesses thinner than indicated in Table 9.1 for the maximum dimensions of the cabinet enclosure.

g) The part is not subject to unintentional contact by persons. See Protection of Users and Service Personnel, Section 8.

9.1.6 The requirements of 9.1.5 apply only to parts of high-voltage circuits as defined by 5.17.

9.1.7 All intended mounting positions of the unit shall be considered when evaluating compliance to 9.1.3.

9.1.8 Cabinet compartments housing gas piping and controls shall be ventilated.

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

9.1.10 The thickness of a sheet metal enclosure shall be as indicated in Tables 9.1 and 9.2.

Exception: When the design and location of components and the strength and rigidity of the outer cabinet warrant, an individual enclosure thinner than specified in Tables 9.1 and 9.2 is able to be employed.

9.1.11 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) (No. 20 MSG) if uncoated steel, not less than 0.034 inch (0.86 mm) (No. 20 GSG) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

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

9.1.13 Terminal housings of motors, to which connections are to be made in the field, shall be of metal and shall be sized in accordance with the National Electrical Code, NFPA 70.

9.1.14 A junction box partially formed by another part such as a fan scroll or a motor casing shall fit such that:

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

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

9.1.15 The criteria for evaluating an opening in an electrical enclosure are given in the following items and the related figures:

a) An opening that does not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:

1) A probe, as illustrated in Figure 9.1, cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe, as illustrated in Figure 9.2, cannot be made to touch enamel insulated wire when inserted through the opening.

b) An opening that permits entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 9.3.

Figure 9.1
Probe for uninsulated live metal parts

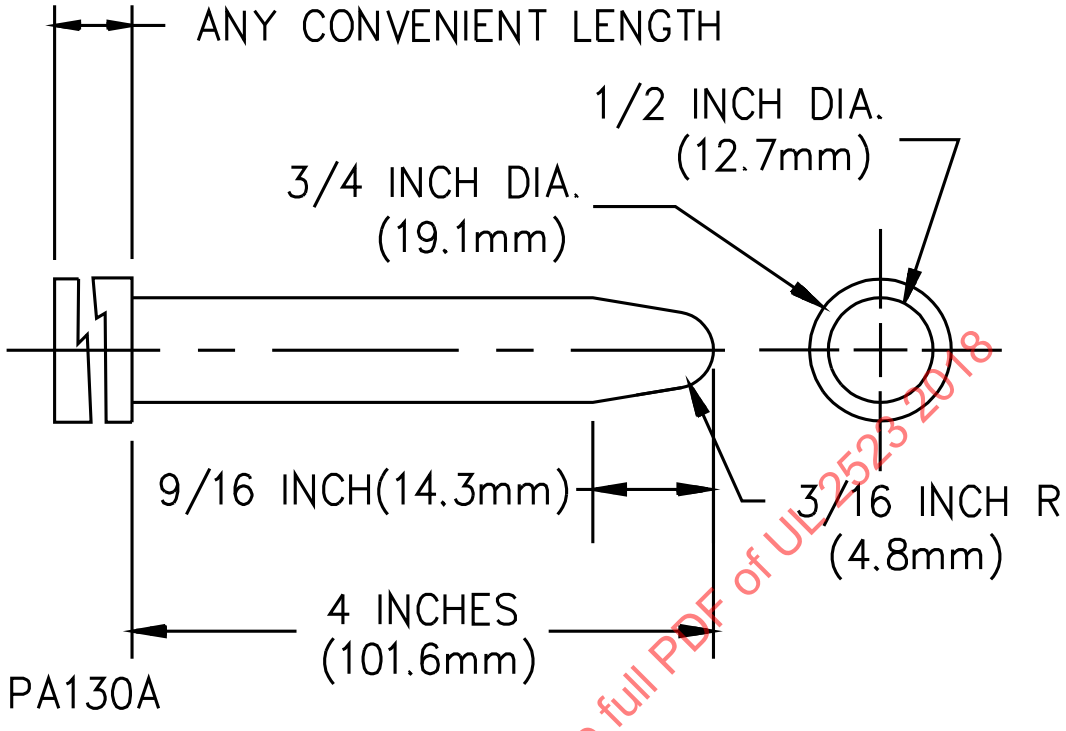


Figure 9.2
Probe for film-coated wire

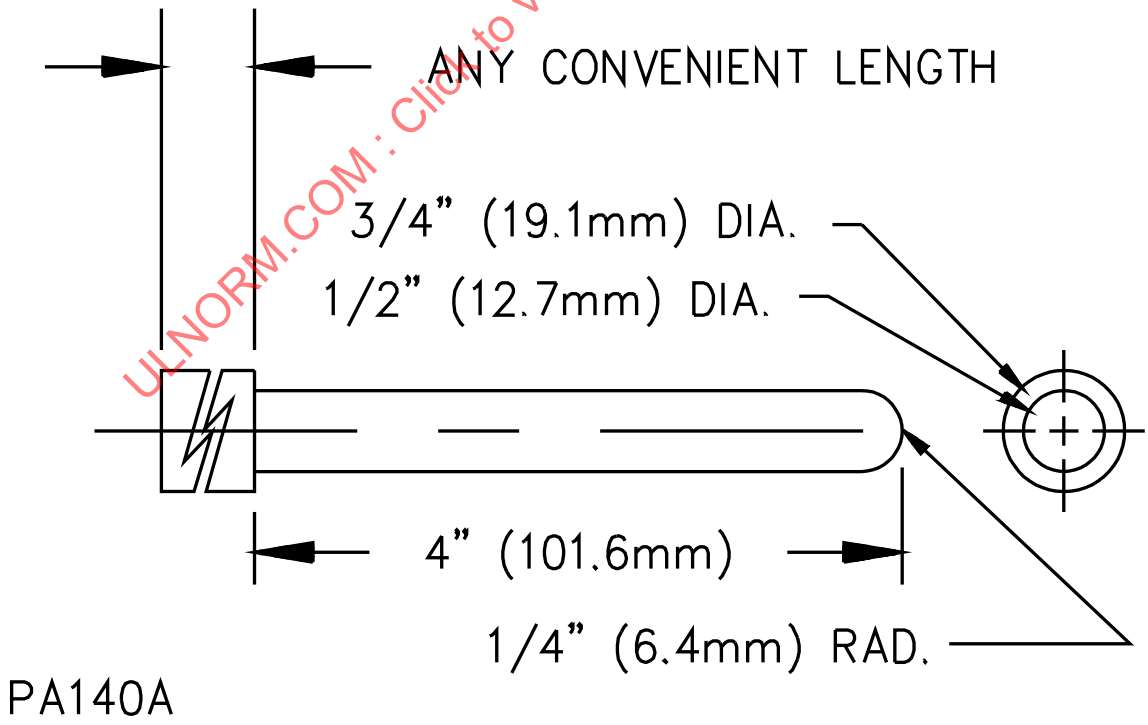
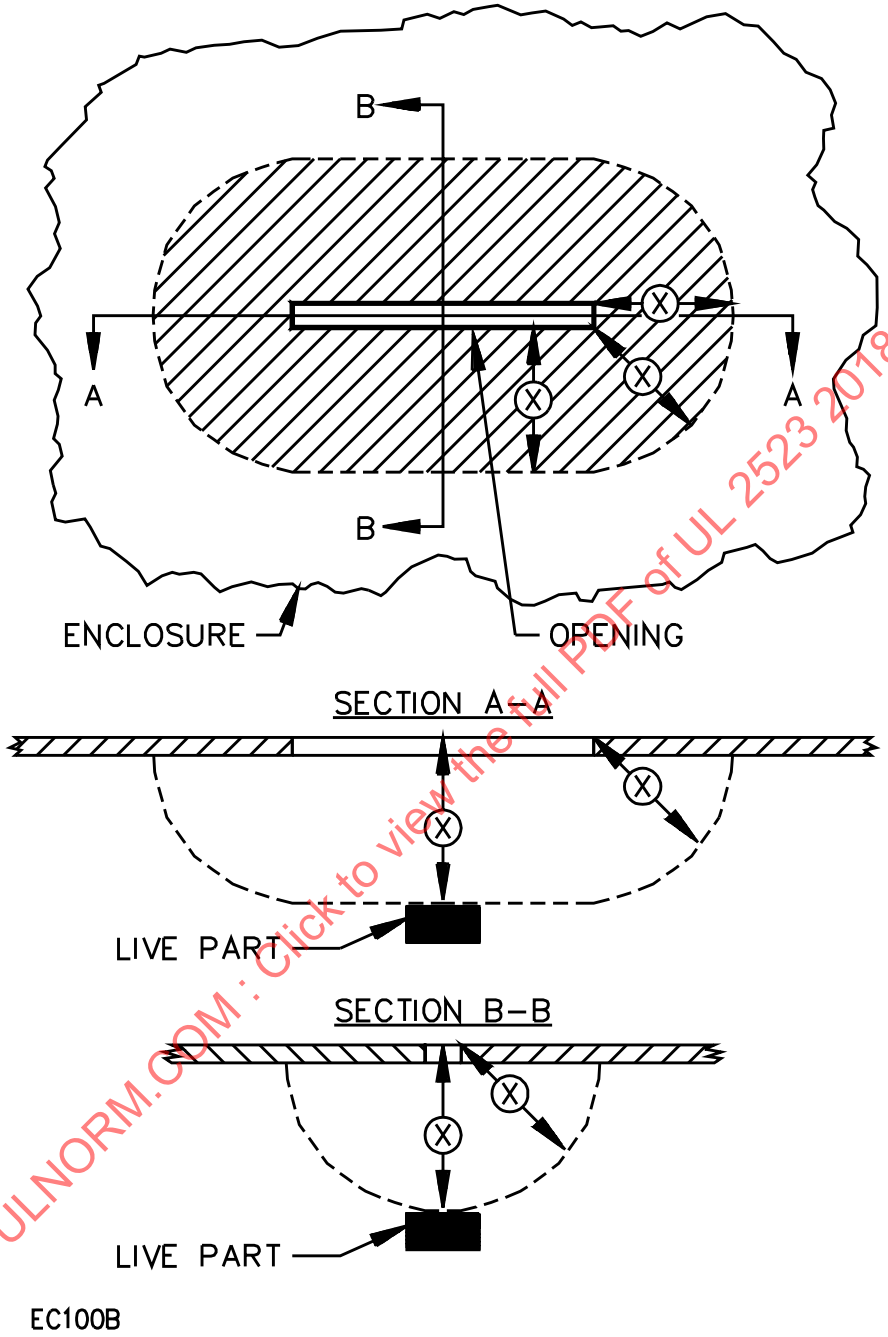


Figure 9.3
Opening in enclosure



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

a) Less than X inches (mm) from the perimeter of the opening, as well as

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

9.1.16 During the examination for conformance with the requirements in 9.1.15, a part of the enclosure which may be removed with the use of tools is to be removed.

9.2 Accessibility of uninsulated live parts and film-coated wire

9.2.1 During the examination of a product to determine whether it complies with the requirements concerning accessibility of uninsulated live parts and film-coated wire:

a) A part of the enclosure that may be opened or removed by the user without using a tool, (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed;

b) Insulated brush caps are not required to be additionally enclosed;

c) The probes shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure; and

d) The probes shall be used as measuring instruments to evaluate the accessibility provided by an opening, and not as instruments to evaluate the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

9.2.2 The criteria for evaluating an opening in an electrical enclosure are given in (a) – (b) and the related figures:

a) An opening that does not permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if:

1) A probe as illustrated in Figure 9.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 9.2 cannot be made to touch film-coated wire when inserted through the opening.

b) An opening that permits entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 9.3.

9.3 Doors and covers

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

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

9.3.3 The assembly incorporating overcurrent protective devices shall be arranged so that fuses can be replaced and manual-reset devices can be reset, as applicable, without removing parts other than a service cover or panel and a cover or door enclosing the device. See 9.3.7.

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

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

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

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

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

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

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

c) Fuses in low-voltage circuits.

9.3.8 Hinged covers, where required, shall not depend solely upon screws or other similar means requiring the use of tools to hold them closed, but shall be provided with a catch or spring latch.

9.3.9 A spring latch, a magnetic latch, a dimple or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open, is an acceptable means for holding the door in place as required in 9.3.8.

9.3.10 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction which affords equivalent protection, such as a fuse enclosure within an outer enclosure, or a combination of flange and rabbet, is acceptable.

9.3.11 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (41.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

9.3.12 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

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

b) 0.027 inch (0.68 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimensions.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

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

9.4 Field wiring system connection

9.4.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be attached.

9.4.2 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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

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

9.4.4 effective June 22, 2012

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

9.4.5 effective June 22, 2012

10 Field Wiring

10.1 General

10.1.1 Provision shall be made for connection of a wiring system that would be suitable for power supply in accordance with the National Electrical Code, NFPA 70.

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

10.1.3 The connections shall be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made. A component intended for use as the cover of an outlet box or compartment may serve as a cover.

10.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that indicated in Table 10.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 10.1
Size of junction boxes

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

10.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 10.2.

Table 10.2
Trade size of conduit in inches[a]

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	1	1	1-1/4	1-1/4
4	(21.1)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1-1/4	1-1/4	1-1/2	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
0	(53.5)	1-1/4	1-1/2	2	2	2-1/2
2/0	(67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107.2)	2	2	2-1/2	2-1/2	3

Table 10.2 Continued on Next Page

Table 10.2 Continued

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6

[a] This table is based on the assumption that all conductors are of the same size and there are no more than six conductors in the conduit. If more than six conductors are 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.

10.1.6 Wiring exterior to an appliance assembly between the blower, automatic fueling assembly, or similar, and a limit control, a regulating control, or a motor controller, that can be done readily with a wire enclosed in conduit or with metal-clad cable in accordance with the National Electrical Code, NFPA 70, need not be furnished by the manufacturer as part of the appliance assembly if adequate instructions for installing such wiring are furnished with each appliance. See 11.1.4.

10.1.7 A box or enclosure, included as part of the assembly and in which a branch circuit supplying power to the appliance is to be connected, shall not require that it be moved for normal care of the unit. This requirement does not apply to separate limit controls and stack switches, where permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

10.1.8 A box or enclosure in which field installed conductors are to be connected as indicated in 10.1.5 – 10.1.7 and 10.1.9 shall be so located that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors does not exceed that specified for a wire having a 140°F (60°C) temperature rating when the assembly is tested in accordance with these requirements.

10.1.9 Except as otherwise permitted by 11.1.4, wiring to be done in the field between the assembly and devices not attached to the appliance or between separate devices which are field installed and located, shall conform to these requirements if done with a 140°F (60°C) rated wire enclosed in suitable conduit or metal-clad cable.

10.1.10 The wiring of the appliance may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 10.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product is not more than 6 feet (1.83 m);

b) No circuit conductor protected by an overcurrent-protective device rated at more than 20 amperes is included; and

c) The conduit is no larger than 3/4 inch trade size, or the fittings for the conduit are identified as providing grounding.

10.2 Leads and terminals

10.2.1 Wiring terminals or leads not less than 6 inches (152 mm) long for connection of field-wiring conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the marked rating of the assembly shall be provided.

10.2.2 Leads may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead results in a risk of fire, electric shock, or injury to persons.

10.2.3 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring which may cause the lead to separate from its termination or result in damage to the lead from sharp edges. Each lead shall be capable of withstanding a pull of 10 pounds (44.5 N) for 1 minute without damage to the assembly.

10.2.4 An identified (grounded) terminal or lead shall not be electrically connected to a single-pole manual switching device which has an OFF position or to a single-pole overcurrent (not thermal) protective device.

10.2.5 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. An open slot-type connector shall not be used unless it is constructed to reduce the likelihood of disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

10.2.6 Field wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are prevented from turning or shifting in position if such motion results in reduction of spacings to less than those required. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent means.

10.2.7 Conductors intended for connection to a grounded neutral line shall be identified, that is, finished a white or gray color. All other current-carrying conductors visible to the installer shall be finished in colors other than white, gray, or green. A terminal for connection of a grounded conductor shall be identified by a metallic-plated coating, substantially white in color and shall be readily distinguishable from other terminals, or it shall be identified in some other manner, such as on an attached wiring diagram.

10.2.8 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire-binding screws or pressure terminal connectors, located in the same compartment as the splice or visible to the installer, unless the screws or connectors are rendered unusable for field wiring connections or the leads are insulated at the unconnected ends.

10.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 10.2.6, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

10.2.10 A wire binding screw at a high-voltage wiring terminal for field connection shall not be smaller than No. 10 (4.8 mm major diameter).

Exception No. 1: A No. 8 (4.2 mm major diameter) screw may be used for the connection of a conductor not larger than 14 AWG (2.1 mm^2).

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

10.2.11 A terminal plate for a wire binding screw shall be of metal not less than 0.030 inch (0.76 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm^2); and in either case there shall be not less than two full threads in the metal.

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

10.2.13 A wire binding screw shall thread into metal.

11 Internal Wiring

11.1 General

11.1.1 The wiring of high-voltage circuits shall conform to the requirements in this Section.

11.1.2 Wiring shall be done with insulated conductors having current carrying capacity, voltage, and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be not smaller than 18 AWG (0.82 mm^2).

11.1.3 Except as indicated in 11.2.2, the wiring for each device assembly circuit shall be furnished by the manufacturer as part of the appliance. If the appliance is not assembled and wired at the factory, such wiring shall be furnished as harness with each boiler and be arranged to facilitate attachment when the boiler is assembled; and a pictorial diagram showing the exact arrangement of the wiring shall be included with each appliance.

11.1.4 If insulated conductors rated for use at temperatures in excess of 140°F (60°C) are required, such wiring shall be furnished as part of the assembly and the devices to be connected by such wiring shall be factory-located on the equipment.

11.2 Methods

11.2.1 Electrical wiring to a part which must be moved for normal maintenance and servicing shall be arranged so that the part may be moved without breaking soldered connections or disconnecting conduit. Conductors to be disconnected from terminals of such part shall terminate in eyelets or connectors. If the wiring to a part which functions also as an access plate or cover, that is, a transformer closing the access to the nozzle assembly, is not readily detachable, the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any allowable movement of such part shall not unduly twist, bend, or pull the wiring.

11.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 11.2.15.

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

a) It is not practical to do the wiring in accordance with 11.2.2;

b) The cord is not required to be bent, twisted, or otherwise displaced to render normal maintenance and service; and

c) The length of cord exterior to the assembly is not more than 4 inches (102 mm) and strain relief is provided.

11.2.3 Group A of Table 11.1 includes some wiring materials suitable for use if enclosed as indicated in 11.2.2.

Table 11.1
Typical wiring materials

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire Size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
A	FEH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, T, THW, XHHW, MTW, THWN, TW, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFHH-3 or thermoplastic appliance wiring material.	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.3)	3/64	(1.2)
		6	(13.3)	4/64	(1.6)
		4	(21.2)	4/64	(1.6)
		3	(25.7)	4/64	(1.6)
		2	(33.6)	4/64	(1.6)
		1	(42.4)	5/64	(2.0)
		1/0	(53.5)	5/64	(2.0)
		2/0	(67.4)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.0)	5/64	(2.0)

Table 11.1 Continued on Next Page

Table 11.1 Continued

Group	Type of wire, cord, or appliance wiring material with insulation thickness shown at the right corresponding to wire sizes indicated	Wire Size		Insulation thickness	
		AWG	(mm^2)	Inch	(mm)
B	SO, ST, SJO, SJT, S, SE, SJ, SJOO, SJTO, SJTOO, SOO, STO, STOO, or appliance wiring material with thermoplastic or neoprene insulation	18	(0.82)	4/64	(1.8)
		16	(1.3)	4/64	(1.6)
		14	(2.1)	5/64	(2.0)
		12	(3.3)	5/64	(2.0)
		10	(5.3)	5/64	(2.0)
		8	(8.3)	6/64	(2.4)
		6	(13.3)	8/64	(3.2)
Thermoplastic wiring materials, as referenced in group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.82 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.3 mm^2), are considered equivalent to the wiring material referenced in group B, when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type suitable for the purpose from the standpoint of dielectric properties, heat resistance, moisture-resistance, flammability, and the like.				

11.2.4 Flexible metal conduit, shall not be smaller than 3/8 inch (9.5 mm) electrical trade size. This does not apply to parts of components, such as conduit protecting flame sensor leads.

11.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (914 mm) where flexibility is necessary.

11.2.6 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in risk of fire, electric shock, or injury to persons.

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

11.2.8 A splicing device, such as a fixture-type splicing connector, pressure wire connector, and the like, may be employed if the device has insulation suitable for the voltage to which it is subjected. Thermoplastic tape wrapped over a sharp edge is not acceptable.

11.2.9 Each splice shall be enclosed by being installed in a junction box, control box, or other compartment in which high-voltage wiring materials may be employed.

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

11.2.11 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which wiring materials, as specified in Group A of Table 11.1, may be employed. Splices in enclosed machinery compartments shall be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

11.2.12 At all points where conduit or metal tubing terminates, the conductor shall be protected from abrasion. If metal-clad cable is used, an insulating bushing or its equivalent shall be provided between the conductors and the metal cladding, and the connector or clamp shall be of such design that the insulating bushing or its equivalent will be visible for inspection.

11.2.13 A wireway shall be such that the interconnection of sections and fittings provides a rigid mechanical assembly and ensure electrical conductivity. The interior of the wireway shall be free from burrs and sharp corners or edges which might cause damage to the insulation on wires.

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

11.2.15 Cords or appliance wiring material as referenced in Group B of Table 11.1 may be employed if the wiring is enclosed by a casing or compartment conforming to all of the following:

a) There are no openings in the bottom, unless a U-shaped channel or trough is located under the wiring and the wires do not project through the plane of the top of the trough or channel;

b) If the appliance is for installation only on noncombustible flooring, the bottom of such compartment may be open provided all sides of the compartment extend to the floor level;

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

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

e) Combustible material, other than electrical insulation, located within the casing or compartment is separated from such wiring material.

11.2.16 With reference to 11.2.15(e), plastic materials shall be classified as Type V-0, V-1, V-2, 5V, HF-1, or HF-2 in accordance with requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

11.2.17 Cords and other wiring material permitted in accordance with 11.2.15 shall be arranged to avoid being physically damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

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

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

11.2.20 To provide an acceptable unbushed opening in sheet metal, not requiring a bushing, usually requires roll or extrusion of the metal around the opening, or both, or the insertion of a grommet conforming to 11.2.18.

11.3 Short-circuit protection

11.3.1 Conductors of motor circuits having two or more motors, one or more of which are thermal or overcurrent protected and wired for connection to one supply line shall withstand the conditions of a short-circuit test without creating a risk of fire or electric shock. See Short-Circuit Test, Section 57.2.

Exception: Conductors that conform to the following are considered acceptable without test:

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

b) Conductors that are 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length provided that the circuit will be protected by a fuse or HACR Type circuit breaker rated 60 amperes or less as specified on the product nameplate or provided as part of the product and acceptable for branch-circuit protection. This applies to any of the wiring materials specified in this standard, including those enclosed those enclosed in raceways; or

c) Conductors that serve as jumper leads between controls providing the length of the leads does not exceed 3 inches (76 mm) or the conductors are located in a control panel.

11.3.2 Factory wiring of a low-voltage safety circuit may be done with SP-2 cord having all-neoprene insulation, SPT-2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness, or power limited circuit cable, if such wiring is located in a cavity or compartment of an appliance and is adequately shielded from harm.

12 Separation of Circuits

12.1 Unless provided with insulation for the highest voltage involved, insulated conductors of different internal wiring circuits shall be separated by barriers or shall be segregated; and shall also be so separated or segregated from uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

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

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

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

b) Uninsulated live parts of any other circuit; and

c) Any uninsulated live parts whose short-circuiting permits operation of the appliance that results in a risk of fire, electric shock, or injury to persons except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that conductors having insulation at least equivalent to those referenced in group A of Table 11.1 are or will be installed when wired in accordance with the National Electrical Code, NFPA 70.

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

a) The number of openings in the enclosure does not exceed the minimum required for proper wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 12.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) More than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit shall be investigated, in accordance with the requirements of this section.

12.5 To determine if an appliance complies with the requirements of 12.3, it is to be wired as it would be in service and in doing 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 into the wiring compartment.

12.6 If a barrier is used to provide separation between the wiring of different circuits or between operating parts and field installed conductors, it shall be of metal or insulating material and shall be held in place.

12.7 A metal barrier shall have a thickness at least as great as that required by Table 9.1 or 9.2, whichever applies, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

12.9 The output of a transformer device supplying a circuit classified as a Class 2 low-voltage circuit and provided as a part of the equipment shall not be interconnected with the output of another such transformer device unless the voltage and current measurements at the output terminals of the interconnected devices are within the values for a single Class 2, 30 volt, or less, transformer device.

12.10 Two or more transformer devices supplying circuits classified as Class 2, low-voltage circuits provided as a part of the appliance shall be treated as two separate circuits each having its own separate wiring compartment, and the output of each circuit shall be marked to warn that the separation shall be maintained.

13 Bonding for Grounding

13.1 Exposed or accessible noncurrent carrying metal parts which may become energized, and which may be contacted by the user or by service personnel during service operations likely to be performed when the appliance is energized, shall be electrically connected to the point of connection of an equipment ground.

13.2 Except as indicated in 13.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping valves, and the like, shall be bonded for grounding if they may be contacted by the user or serviceman.

13.3 Metal parts, as described below, are not required to be grounded:

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

b) Isolated metal parts, such as magnet frames and armatures, and small assembly screws, which are separated from wiring and uninsulated live parts;

c) Panels and covers which do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover; or

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

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

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

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

13.7 A separate bonding conductor shall be of material rated for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

a) Be protected from mechanical damage, such as by being located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

13.8 The bonding shall be by a positive means, such as by clamping, riveting, a bolted or screwed connection, or by welding, soldering, or brazing with materials having a softening or melting point greater than 850°F (454°C). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel.

13.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 13.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. The effect of assembling and disassembling, for maintenance purposes, such a clamping device shall be considered with respect to the likelihood of the clamping device being reassembled in its intended position.

13.10 Where the bonding means depend on screw threads, two or more screws or two full threads of a single screw engaging metal is considered in compliance with 13.8.

13.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 13.12 – 13.14, it shall be considered acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 13.1 twice the current equal to the rating of the branch-circuit overcurrent device required to protect the equipment; and

b) During a short-circuit test in series with a fuse of proper rating. See Short-Circuit Test, Section 44.

Table 13.1
Duration of current flow, bonding-conductor test

Rating of overcurrent device, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

13.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 13.11, the size of the conductor or strap shall be in accordance with Table 13.2.

Table 13.2
Bonding wire conductor size

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

[a] Or equivalent cross-sectional area.

13.13 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component(s) within the enclosure.

13.14 If more than one size of branch-circuit overcurrent device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

13.15 The following are considered to constitute means for connection to a ground:

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

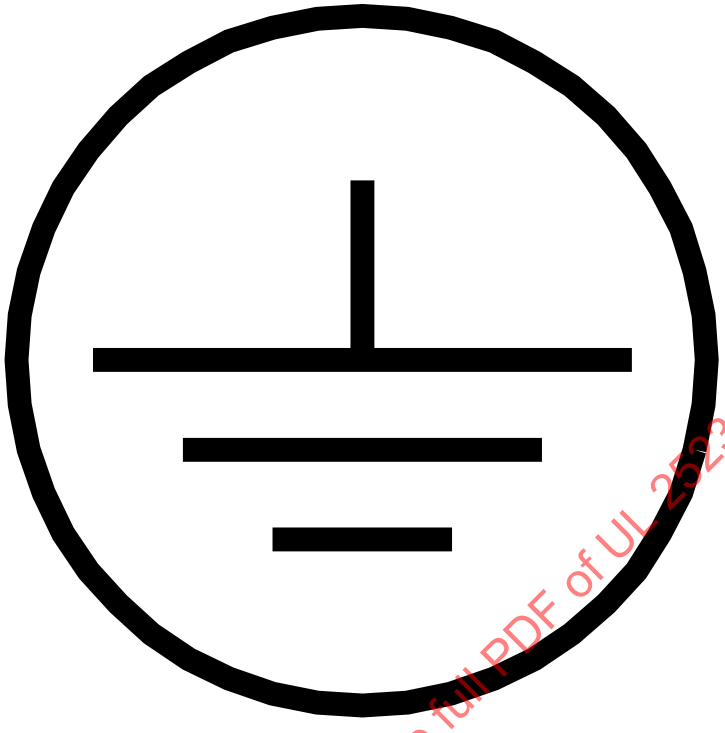
b) In equipment intended to be connected by a nonmetal-enclosed wiring system, for example, metal-clad cable – An equipment grounding terminal or lead.

13.16 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application, in accordance with the National Electrical Code, NFPA 70.

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

13.18 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by being marked ″G″,″GR″,″GROUND″,″GROUNDING″, by the symbol in Figure 13.1, or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be so located that it is unlikely to be removed during normal servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors and if it could be mistaken for the neutral of a grounded supply, a marking shall be additionally provided indicating ″EQUIPMENT GROUND″ and/or identifying the connector by a green color.

Figure 13.1
Grounding symbol



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

14 Mounting of Electrical Components

14.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 14.2 and 14.3.

14.2 The requirement that a switch be prevented from turning may be waived if all of the following conditions are met:

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

b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;

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

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

14.3 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the required values.

14.4 The means for preventing turning shall consist of more than friction between surfaces. A toothed lock washer which provides both spring take-up and an interference lock is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

14.5 Uninsulated live parts shall be so secured to the base or mounting surface that they are prevented from turning or shifting in position if such motion results in a reduction of spacings below the acceptable values.

15 Motors and Motor Overload Protection

15.1 Each motor shall be protected by an integral thermal protector or by an overcurrent protective device or combinations thereof.

15.2 ″Overcurrent protective device″ as referred to in 15.1 means those that conform to the requirements of the National Electrical Code, NFPA 70, as follows:

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

1) Motors with marked service factor not less than 1.15, 125 percent;

2) Motors with a marked temperature rise not over 72°F (40°C), 125 percent; and

3) All other motors, 115 percent.

For a multispeed motor, each winding connector shall be considered separately and the motor shall be protected at all speeds.

b) If the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, or magnetic or thermal overload protective devices, the next higher size or rating may be used, but not higher than the following percent of motor full-load current rating:

1) Motors with a marked service factor not less than 1.15, 140 percent;

2) Motors with a marked temperatures rise not over 72°F (40°C), 140 percent; and

3) All other motors, 130 percent.

15.3 An integral thermal protective device shall comply with the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Thermally Protected Motors, UL 1004-3.

15.3 revised October 17, 2011, effective June 22, 2012. UL 1004-3 will replace Part III of UL 2111 effective September 15, 2014.

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

15.5 Three-phase motors shall be provided with overcurrent protection as follows:

a) Three properly rated overcurrent devices shall be employed; or

b) Thermal protectors, 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.

15.6 Motors such as direct-drive fan motors which are not normally subjected to overloads, and which are determined to be adequately protected against overheating due to locked-rotor current by a thermal or overcurrent protective device, may be accepted under the requirement for overcurrent protection provided it is determined that the motor will not overheat under actual conditions of use.

15.7 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 does not overheat under the performance requirements of this standard.

15.8 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.

15.9 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the short-circuit test in 57.2.

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

15.11 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 or the discharge of fuel that may result in a risk of fire or injury to persons. If a burner depends solely upon an electrical valve to stop the flow of fuel to the burner, the interruption of the circuit to the motor by the protective device shall also cause the interruption of the circuit to the valve.

15.12 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.

15.13 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.

15.14 Conformance to 15.13 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and shall be determined with the motor applied to the assembly.

15.15 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.

15.16 The requirement in 15.15 will necessitate the use of a barrier of nonflammable material under an open type motor unless any of the following are met:

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

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

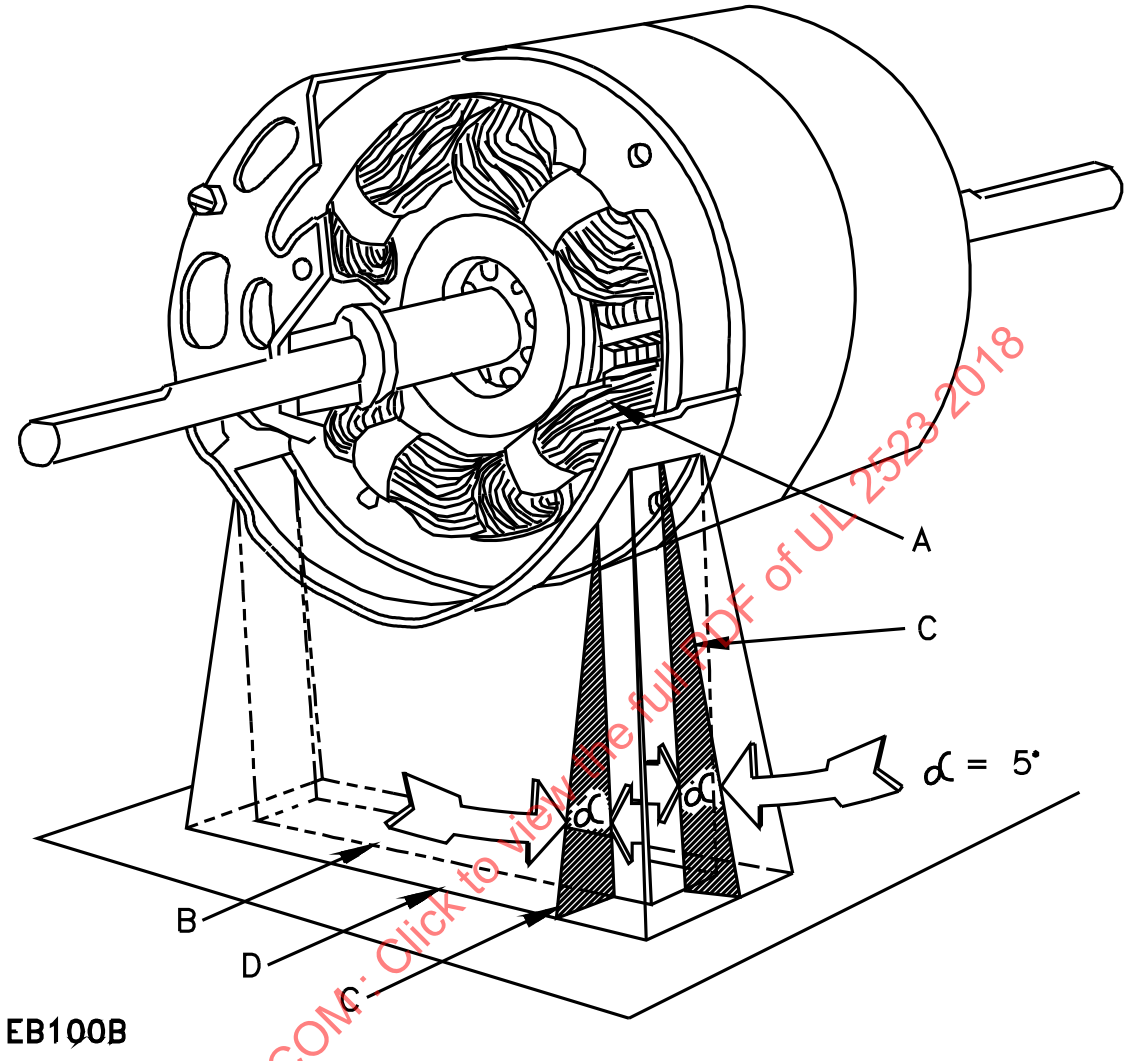
4) Capacitor shorted, permanent split capacitor type;

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

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

15.17 The barrier mentioned in 15.16 shall be horizontal, located as indicated in Figure 15.1, and have an area not less than that described in the figure. 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 15.1
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.

16 Overcurrent Protection of High-Voltage Control-Circuit Conductors

16.1 General

16.1.1 For the purpose of the requirements in 16.2.1 – 16.4.2, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 17, for additional requirements.

16.2 Direct-connected high-voltage control circuit

16.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 72.17.

16.3 Tapped high-voltage control circuits

16.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the burner on the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 16.3.3 – 16.4.2.

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

16.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 16.1.

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

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 57.2.13.

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

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

a) This protection is in accordance with the requirements specified in Overcurrent Protection of Transformers, Section 17, and

b) The rating of the device does not exceed the applicable value specified in Table 16.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 16.1
Overcurrent protective device rating for control circuit conductors

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

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C (140° F) conductors in Table 310-17 of National Electrical Code, ANSI/NFPA 70.

[c]300 percent of value specified for 60°C (140° F) conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70.

16.4 Overcurrent-protective devices

16.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 16.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 72.15.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 16.1.

16.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 16.3.3; and

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

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

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 57.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 72.16.

17 Overcurrent Protection of Transformers

17.1 High-voltage transformers

17.1.1 A transformer, other than as described in 17.2.1 and 17.2.2, is considered to be a high-voltage transformer and shall comply with the requirements for ignition transformers in the Standard for Specialty Transformers, UL 506 and/or the requirements for Power Transformers in the Standard for Dry-Type General Purpose and Power Transformers, UL 1561, as applicable.

17.2 Low-voltage transformers

17.2.1 Except as specified in 17.2.3, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 5.17.

17.2.2 A transformer that directly supplies a Class 2 circuit [see 5.17(b)] shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and 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).

17.2.3 Overcurrent protection in the primary circuit of a transformer need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 17.2.1, as applicable.

17.2.4 Overcurrent protection in the secondary circuit of a transformer shall be provided as part of the appliance. If a fuse is used, the appliance shall be marked in accordance with 72.15.

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

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 17.2.1, as applicable, and

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

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

Exception: If a transformer supply is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 57.1. The product shall be marked in accordance with 72.16.

18 Switches and Controllers

18.1 A controller(s) for controlling the loads involved shall be provided for all assemblies incorporating more than one motor intended for connection to the same power supply.

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

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

18.3 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly shall be marked in accordance with 72.2 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

18.4 A controller or switch shall be rated for the load that it controls. The load controlled is to include any load external to the assembly for which connections in the controller or switch circuit are provided.

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

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

18.7 The locked-rotor load of a motor is based on six times the full-load current rating of the motor if alternating current, and ten times the full-load current rating if direct current.

18.8 If the marked maximum fuse size of the appliance does not exceed the maximum size for protecting the motor of the smallest rating, two or more motors each having individual running overcurrent protection may be connected to the same power supply if it can be determined that a fuse of the marked size will not open under the most severe conditions of service that might be encountered.

19 Capacitors

19.1 A motor starting or running capacitor shall be housed within an enclosure or container that protects the plates against mechanical damage and that prevents the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 19.2 and 19.3, the container shall be of metal providing strength and protection not less than that of uncoated steel 0.020 inch (0.51 mm) thick.

19.2 The individual container of a capacitor may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the device assembly, and provided that such box, case, or the like, is acceptable for the enclosure of current-carrying parts.

19.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts in accordance with Table 16.1.

19.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 57.2.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 57.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

20 Electrical Insulating Materials

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

20.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

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

21 Spacings – High-Voltage Circuits

21.1 Except as noted in 21.2 – 21.4, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 21.1.

Table 21.1
Minimum spacings

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

[a] See 20.3.

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

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

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

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

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

21.3 The spacing requirements in Table 21.1 do not apply to the inherent spacings of a component which is evaluated on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, shall be those indicated.

21.4 All uninsulated live parts connected to different circuits, except subdivided or branch circuits of the same voltage from the same feeder, shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated in 21.1 – 21.3 and shall be evaluated on the basis of the highest voltage involved.

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

22 Spacings – Low-Voltage Circuits

22.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons shall comply with 22.2 – 22.4.

22.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 21.4.

22.3 The spacing between wiring terminals regardless of polarity, and between the wiring terminal and a dead metal part (including the enclosure and fittings for the connection of conduit) which may be grounded when the device is installed shall be not less than 1/4 inch (6.4 mm).

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

22.5 The spacings in low-voltage circuits that do not contain devices such as indicated in 22.1 are not specified.

23 Control Applications

23.1 A safety-control circuit shall be two-wire, one side grounded, having a nominal voltage of 120. A safety control or protective device shall interrupt the ungrounded conductor.

23.2 It is the intent of the requirement in 23.1 that a short circuit or combination of short circuits to ground does not render a safety control or protective device inoperative. Safety control circuit arrangements other than described in 23.1 may be considered if they accomplish the intent of this requirement.

23.3 The control circuit shall be constructed so that a safety control or protective device cannot be rendered ineffective by short-circuit(s) to ground. Safety-control-circuit arrangements other than described in 23.1 shall provide equivalent protection.

23.4 The requirement of 23.1 does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

23.5 A control circuit shall be arranged so that it may be connected to a power supply branch circuit that can be protected against overcurrent at not more than the value appropriate for the rating of the electrical components included in the circuit.

23.6 All safety controls shall be accessible.

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

23.8 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective.

23.9 Where so specified, safety shutdown may be provided either by employing manual reset type limit controls or it may be effected remotely by utilizing the manual reset feature of another control, such as the low water control. For systems where the reset feature is remote from the limit control, means shall be provided to indicate the limit control has operated when it causes safety shutdown.

23.10 Deleted effective June 22, 2012

23.11 The control circuit of a blower intended for use with a limit or regulating control which functions to interrupt or reduce the air for combustion by opening an electrical circuit shall be arranged to permit the limit or regulating control to be wired into the circuit so as to effect the direct opening of that circuit, whether the switching mechanism is integral with the sensing element or remote from same.

23.12 The purpose of the requirement in 23.11 is to prevent interposing in the limit-control circuit with other controls, the failure of which may result in a condition the limit control is intended to prevent.

BOILERS

24 Assembly

24.1 A boiler assembly shall be factory-built as a group assembly and shall include all the essential components necessary for its normal function when installed as intended. A boiler assembly may be shipped as two or more major subassemblies. The boiler pressure vessel shall be constructed, equipped, inspected, tested, and marked in accordance with the ANSI/ASME Boiler and Pressure Vessel Code, Section I, Power Boilers or Section IV, Heating Boilers, or in accordance with Part 5: Heating Boilers for Solid Fuels, Hand and Automatically Stocked, Nominal Heat Output of up to 300 kW - Terminology, Requirements, Testing and Marking, EN303-5, as required by local jurisdiction.

24.2 A boiler assembly, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. See 24.3. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the intended installation or operation of the boiler assembly, shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other, without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

24.3 To be in accordance with 24.2, major subassemblies of a boiler assembly are deemed to be the burner and the heat exchanger sections of a cast iron sectional boiler including its base, combustion chamber, casing, and safety controls. A wiring harness may be packaged with one of the major subassemblies.

24.4 A radiation shield or baffle employed to prevent excessive temperature shall be assembled as part of the boiler assembly; or be part of a subassembly that must be attached to the boiler assembly for its normal operation; or be designed so that the boiler assembly cannot be assembled for operation without first attaching a required shield or baffle in its proper position.

24.5 A boiler assembly shall be such that, for any normal installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to prevent abnormal temperatures is not required.

24.6 A boiler assembly shall afford convenient operation by the user of those parts requiring attention or manipulation in normal usage.

25 Accessibility for Servicing

25.1 A boiler assembly shall be built to allow cleaning of parts such as heating surfaces in contact with combustion products, without major dismantling of the boiler assembly or removal of parts required by 24.2 to be factory-assembled.

25.2 The removal of access panels, caps, plugs, or the like, specifically designed to permit ready removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 25.1.

25.3 Sufficient and reasonable accessibility shall be afforded for cleaning, inspection, repair, and replacement of all controls, and safety devices when the boiler assembly is installed as recommended by the manufacturer. The disposition of parts in the assembly removed for normal care shall be such that their restoration, following removal, does not necessitate their realignment to secure their proper relationship with other parts of the assembly. Special facilities required for normal care to be done by the operator shall accompany the boiler assembly to the user.

26 Casing

26.1 The outer casing or jacket shall be made of steel or equivalent material, braced, reinforced or formed so that it is not likely to be damaged through handling in shipment, installation, and use. Sheet metal casings shall be made of steel at least 0.020 inch (0.51 mm) (No. 24 MSG) thick if uncoated, or 0.023 inch (0.58 mm) (No. 24 GSG) if galvanized, or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

26.2 Access panels that need to be removed for normal service and accessibility shall be constructed to permit removal and replacement repeatedly without causing damage or impairing any required insulating value.

26.3 A removable panel through which air is drawn for combustion shall be so constructed as to prevent it from being attached in a manner that may cause abnormal performance of the boiler assembly.

26.4 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same boiler when interchange may allow abnormal operation of the boiler assembly.

26.5 The casing of a boiler assembly for installation on combustible flooring shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor.

27 Radiation Shields or Liners

27.1 A radiation shield or liner shall be so constructed, formed, and supported as to ensure proper positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the boiler assembly is tested in accordance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the boiler assembly is tested under these requirements.

27.2 Thermal insulation which is not adequately self-supporting shall be applied to solid surfaces in a manner so as to prevent sagging. The insulating value of the material shall be unimpaired when the boiler assembly is tested under these requirements.

27.3 An adhesive for attaching insulating material shall retain its adhesive qualities at any temperature the adhesive may attain when the unit is tested under these requirements and at 0°F (minus 17.8°C).

28 Combustion Chamber

28.1 A combustion chamber and flueway shall be constructed of cast iron, sheet steel, or of a material equivalent in mechanical properties and corrosion resistance. Plain carbon sheet steel, if used, shall be at least 0.042 inch (1.07 mm) (No. 18 MSG) thick.

28.2 Combustion chamber or fire box lining material, if used, shall be durable, adequately held in place, and accessible for replacement with equivalent lining material.

29 Baffles

29.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be constructed and disposed in a manner to provide for reasonable life and shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI 1010 hot-rolled sheet steel having a minimum thickness of 0.042 inch (1.07 mm) (No. 18 MSG) unless its deterioration will not cause excessive temperatures when the boiler assembly is tested in accordance with these requirements.

29.2 A flue baffle shall be accessible for cleaning. A flue baffle which is removable for cleaning shall be such as to facilitate its removal and permit replacement only in its intended position.

30 Flue Collar

30.1 A flue collar shall be constructed and arranged to permit the secure attachment of the chimney connector to the boiler assembly.

31 Flue Dampers, Draft Regulators, and Air Shutters

31.1 An adjustable flue damper shall be equipped with minimum and maximum operating stops. The minimum operating stop for such damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

31.2 An automatically operated flue damper shall be designed to maintain a proper damper opening at all times and be arranged to prevent starting of the appliance unless the damper is in the intended position for starting.

31.3 An automatically operated flue damper shall be counterbalanced to assume an open position in the event of breakage or failure of its operating means. Operating parts shall be located or shielded to avoid interference with their movement and to prevent injury to the operator in case of breakage.

31.4 A device to be equipped with a barometric draft regulator shall be designed so as not to require the regulator to be installed in a false ceiling, in a different room, or in any manner that permits a difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

31.5 A double swing barometric draft regulator shall incorporate means which act to cause the automatic fuel supply, to be shut off in the event flue gas spillage continues for a duration exceeding 60 seconds.

31.6 An adjustable flue damper shall not be used in connection with a device equipped with a draft regulator.

31.7 A thermostatic damper control relied upon to limit maximum temperatures shall comply with the Standard for Limit Controls, UL 353.

31.8 If a combustion-air damper or shutter or fan motor must be operated and controlled by means of a limit or thermostatic damper control to limit maximum temperatures, the entire operating mechanism, including the damper or shutter, crank arms, chains, connecting rods, and associated linkages, shall be located and guarded to reduce risk of tampering or physical damage. Electrical circuits shall be arranged to directly open the damper or fan-motor circuit.

31.9 An air shutter shall be capable of being adjusted readily to any desired setting and be provided with means for reducing the risk of a change in setting.

31.10 An air shutter shall provide for a reasonably smooth surface between the shutter and the matching face.

31.11 Sheet metal air shutters shall be of a thickness not less than 0.0254 inch (0.645 mm). If sheet metal air shutters are of a thickness less than 0.0508 inch (1.29 mm), they shall have the outer edges turned at right angles or be otherwise properly reinforced.

31.12 An air shutter shall (by its design or assembly and selection of materials) be guarded against sticking or corroding in position. Screws or bolts used for attaching or adjustment shall be of corrosion resistant material.

32 Controls

32.1 Application

32.1.1 Safety controls shall conform with the requirements in Control Applications, Section 23.

32.2 Operating controls

32.2.1 A boiler assembly shall be provided with operating limit controls that regulate the combustion process so as not to exceed the rated operating temperature or pressure as specified in 32.2.2 – 32.2.4.

32.2.2 A steam boiler shall be provided with at least one steam pressure actuated limit control that shuts down the combustion process when the steam pressure in the boiler reaches a preset maximum operating pressure. This requirement does not preclude the use of additional operating controls, if required.

32.2.3 A water boiler shall be provided with at least one temperature actuated limit control to that will shut down the combustion process when the temperature of the water in the boiler reaches a preset operating temperature. This requirement does not preclude the use of additional operating controls, if required.

32.2.4 An operating limit control is not required to be factory-installed provided the wiring diagram and instructions furnished with the boiler indicate that an operating control of an appropriate type and setting is to be furnished by the installer. See 73.3.

32.2.5 An operating limit control shall comply with 32.3.7 – 32.3.9.

32.3 Limit controls

32.3.1 A boiler shall be provided with high limit controls that operate to shut down the combustion process and cause safety shutdown in case of a low water condition and excessive temperature or excessive pressure, as specified in 32.3.2 – 32.3.5 and 32.6.1. The high limit controls shall be in addition to any operating controls specified in 32.2.1 – 32.2.4.

32.3.2 With respect to 32.3.1, safety shutdown may be provided either by employing manual reset type limit controls or it may be affected remotely by utilizing the manual reset feature of another control, such as the low water control. For systems where the reset feature is remote from the limit control, means shall be provided to indicate the limit control has operated when it causes safety shutdown.

32.3.3 Fixed-setting hot-water temperature limit controls shall be marked with the operating temperature, and steam-pressure controls shall be marked with the operating pressure of their fixed points. Adjustable setting hot-water temperature limit controls shall have their temperature range marked, and steam-pressure controls shall have their pressure range marked.

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

32.3.5 The purpose of the requirement in 32.3.4 is to avoid interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to prevent. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the safety circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls or to interrupt a multiphase circuit.

32.3.6 The limit control for a boiler for alcove or closet installation shall be factory-located on the assembly or its location shall be factory-predetermined.

32.3.7 An electro-mechanical limit control shall comply with the Standard for Limit Controls, UL 353, or the requirements for protective electrical controls in the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

32.3.8 An electronic limit control with switched outputs that only relies on hardware circuitry to limit the temperature within the limits specified in 32.3, 32.4, 32.5, and 32.6, as applicable, shall comply with the requirements of:

a) The Standard for Limit Controls, UL 353; and

b) The Standard for Tests for Safety-Related Controls Employing Solid- State Devices, UL 991, with no single points of failure permitted, or the Type 2 Protective Control requirements per the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

32.3.9 An electronic limiting control that relies on software to limit the temperature within the limits specified in 32.3, 32.4, 32.5, and 32.6, as applicable, shall comply with the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998, or software Class C in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1A.

32.3.10 A limiting control circuit shall be designed such that a malfunction of any component in the operating control circuit does not adversely affect the operation of the safety limit control circuit.

32.4 Liquid level limit controls

32.4.1 A water boiler shall be provided with at least one low water cut-off or combination low water cut-off and water feed control that operates to open the combustion circuit and cause safety shutdown before the water falls below the lowest permissible level as specified in 32.4.2.

Exception: A water tube or coil type boiler that requires forced water circulation to guard against excessive temperatures (see 32.6.1), may employ a water flow sensing device instead of a low water cut-off.

32.4.2 Low pressure and high pressure steam boilers shall be provided with at least two low water cut-offs or combination low water cut-off and water feed controls. Both controls shall be wired electrically so that operation of either control causes fuel cut-off to the burner before the water level falls below the lowest visible part of the gage glass. However, one control shall be set to operate at a lower water level than the other. The control set lower shall cause safety shutdown, requiring a manual reset to restore burner operation.

Exception: A boiler that does not exceed any of the following limits may be provided with only one low water cut-off:

a) Maximum working pressure – 100 psig (689.5 kPa);

b) Maximum inside diameter of shell – 16 inches (406.4 mm);

c) Maximum heating surface – 20 square feet (1.86 m^2); or

d) Gross volume, exclusive of casing and insulation – 5 cubic feet (0.142 m^2). See 32.4.3.

32.4.3 With reference to the Exception to 32.4.2, the gross volume is considered to be the volume of a rectangular or cylindrical enclosure into which all the pressure parts of the boiler could be fitted in their final assembly including gas passages that are integral with the assembled pressure parts. Projecting nozzles or fittings need not be considered in this volume.

32.5 Pressure limit controls

32.5.1 Each low pressure and high pressure steam boiler shall be provided with a pressure operated control that operates to shut off the combustion process and cause safety shutdown in case of excessive steam pressure in the boiler. The control settings shall be in accordance with 32.5.2 and 32.5.3, as appropriate.

32.5.2 The maximum setting of a limit control on a low-pressure steam boiler shall limit the steam pressure in the boiler to 15 psig (103 kPa). On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop. Such a boiler is marked with ASME Code Symbol ″H″.

32.5.3 The limit control for a high pressure steam boiler shall limit the steam pressure in the boiler to the maximum allowable working pressure of the boiler. On a control having an adjustable setpoint, the maximum setting shall be limited by a fixed stop. Such a boiler is marked with ASME Code Symbol ″S″.

32.6 Temperature limit controls

32.6.1 A water boiler shall be provided with at least one temperature-operated limit control that operates to shut off the combustion process and cause safety shutdown before the water temperature in the boiler exceeds the maximum rated operating temperature. For a low pressure hot water boiler safety shutdown shall occur to prevent the water temperature in the boiler from exceeding 250°F (121°C).

32.7 Installation of external controls and fittings

32.7.1 If a low water cutoff is installed external to a low pressure or a high pressure steam boiler utilizing a water column, the connecting piping and fittings to the column shall not be smaller than 1-inch NPS and no shutoff valves of any type shall be placed in the piping between the boiler and the cutoff. A cross or equivalent fitting shall be used in the piping connections at every right angle to facilitate cleaning and inspection.

32.7.2 A low water cutoff that embodies a separate chamber shall incorporate a vertical drainpipe and a blowoff valve not smaller than 3/4-inch NPS, located at the lowest point of the chamber or water-equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the low water cutoff can be tested for operation.

32.7.3 A low water cutoff or a combination cutoff and water feed control for a low pressure steam boiler may be installed in the tapped openings provided for attachment of a water gage glass directly to the boiler. For such installation, the connections shall be made with nonferrous ″T″ or ″Y″ fittings for the low water cutoff connections. The ends of any nipples used shall be hollowed to full size of the internal diameter.

32.7.4 For a hot water heating boiler, the low water cutoff may be installed external to the boiler. Under low water conditions, the chamber in which the cutoff is located shall drain so as to maintain the same water level as in the boiler, and if flow occurs in the chamber, it will be in the upward direction.

32.7.5 A water feed control shall be constructed and installed so that the water inlet valve cannot feed water into the boiler through a float chamber of a low water cutoff or through the connections of such float chamber.

32.7.6 A steam pressure limit control shall be installed on the boiler without any shutoff valve between the limit control and the boiler.

32.7.7 Each steam pressure limit control shall be protected with a siphon or equivalent means of maintaining a water seal between the steam and the inlet to the control. The size of the siphon shall not be less than 1/4-inch NPS. Tubing of adequate temperature and pressure rating and of equivalent inside diameter may be substituted for pipe.

32.7.8 If a steam pressure limit control that incorporates a mercury switch is mounted on a siphon, the loop of the siphon shall be in a plane that is 90 degrees (1.57 rad) from the plane of the mercury switch.

32.7.9 The steam pressure connections to the steam pressure limit control shall not be:

a) Smaller than 1/4-inch NPS, if the pipe is of nonferrous material;

b) Smaller than 1/2-inch NPS, for ferrous materials up to 5 feet (1.52 m) in length; or

c) More than 1-inch NPS for ferrous materials over 5 feet in length. Tubing of adequate temperature and pressure rating and of equivalent internal diameter may be substituted for pipe.

HYRDRONIC HEATING APPLIANCES AND WATER HEATERS

33 Assembly

33.1 An solid fuel hydronic heating appliance and water heater shall be factory built as a single complete assembly or a group of subassemblies and shall include all of the essential components necessary for its function when installed as intended. A hydronic heating appliance and water heater may be shipped as two or more major subassemblies.

33.2 Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or more subassemblies, that must bear a definite relationship to each other for the intended operation of the heater, shall be:

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

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

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

a) Assembled as part of the hydronic heating appliance and water heater;

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

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

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

33.5 A hydronic heating appliance and water heater shall be constructed so that parts requiring attention or manipulation during typical use can be easily operated.

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

34 Accessibility for Servicing

34.1 A hydronic heating appliance and water heater shall be constructed so that parts, such as interior surfaces of the combustion chamber, heating surfaces in contact with combustion products, can be cleaned without major dismantling of the hydronic heating appliance and water heater or removal of parts required by Section 33, Assembly, to be factory assembled.

34.2 The removal of an access panel, blower, cap, plug, or the like, specifically constructed to permit removal and replacement for servicing and the detachment of the chimney connector is not considered major dismantling with regard to the requirement in 34.1.

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

35 Base

35.1 A hydronic heating appliance and water heater shall be provided with a base or frame that supports the heater. The base or frame shall be constructed of steel or equivalent material.

36 Casing

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

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

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

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

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

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

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

37 Radiation Shields

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

38 Insulation Materials

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

39 Combustion Chamber

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

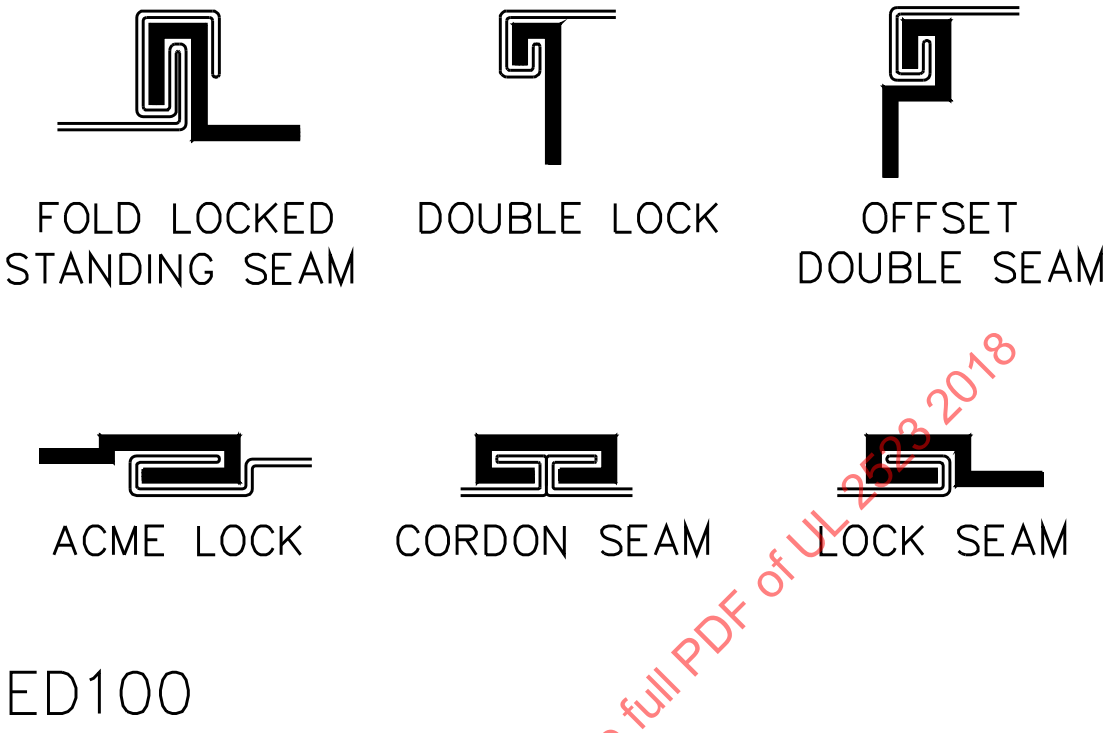
39.2 A combustion chamber lining material shall be durable, secured in place, and accessible for replacement with equivalent material.

40 Heating Surface Joints

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

40.2 Examples of acceptable lock-seams are illustrated in Figure 40.1.

Figure 40.1
Types of acceptable lock-seams



41 Baffles

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

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

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

42 Air Shutters and Flue Collars

42.1 An air shutter shall be capable of being adjusted readily to any desired setting and be provided with means for reducing the risk of a change in setting.

42.2 An air shutter shall provide for a reasonably smooth surface between the shutter and the matching face.

42.3 Sheet metal air shutters shall be of a thickness not less than 0.0254 inch (0.645 mm). If sheet metal air shutters are of a thickness less than 0.0508 inch (1.29 mm), they shall have the outer edges turned at right angles or be otherwise properly reinforced.

42.4 An air shutter shall (by its design or assembly and selection of materials) be guarded against sticking or corroding in position. Screws or bolts used for attaching or adjustment shall be of corrosion resistant material.

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

43 Materials in Contact with Water

43.1 General

43.1.1 A nonmetallic material in contact with water shall comply with the requirements of the NSF International Standard for Plastic Piping System Components and Related Materials, ANSI/NSF No. 14.

43.2 Dip tubes

43.2.1 If applicable, 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.

43.2.2 A dip tube shall have a specific gravity greater than 0.94 and, when the specific gravity is less than 1.0, the dip tube shall be held in place by a positive means that limits any vertical displacement to no more than 1/4 inch (6.4 mm).

43.2.3 A nonmetallic dip tube shall comply with the tests described in Non-Metallic Dip Tube Test – Water Heaters, Section 58.

43.3 Polymeric storage tank liner

43.3.1 If applicable, a polymeric liner provided in a storage tank shall have a water vapor transmission (WVT) rate of less than 5 when measured in accordance with the Test Methods for Water Vapor Transmission of Materials, ASTM E96.

44 Water-Storage Vessels

44.1 A water-storage vessel shall be constructed to withstand the applicable hydrostatic test specified in the Hydrostatic Test on Water-Storage Vessels, Section 59, without rupture, leakage, or visible permanent distortion, or the water-storage vessel shall carry one of the following symbols of the ASME Boiler and Pressure Vessel Code:

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

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

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

Exception: This requirement does not apply to a hydronic heating appliance, of which the opening, vent, or similar mechanical system(intended to provide constant atmospheric internal pressure of the tank) shall be the equivalent of a 3/4 inch (19.05 mm) pipe size opening.

44.2 The working pressure of a water-storage vessel that does not carry one of the symbols of the ASME Boiler and Pressure Vessel Code, specified in 44.1 shall not be higher than 50 percent of the hydrostatic-test pressure specified in Section 59, Hydrostatic Test on Water-Storage Vessels – Water Heater.

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

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

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

a) Shall be located:

1) In the top of the tank; or

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

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

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

d) Shall accommodate a 3/4 inch (19.05 mm) or larger trade-size pipe.

Exception: This requirement does not apply to a hydronic heating appliance, of which the opening, vent, or similar mechanical system(intended to provide constant atmospheric internal pressure of the tank) shall be the equivalent of a 3/4 inch (19.05 mm) pipe size opening.

45 Controls

45.1 Application

45.1.1 Safety controls shall conform with the requirements in Control Applications, Section 32.

45.2 Limit control

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

Exception: A hydronic heating appliance, which is not automatically fueled is excluded from the requirements of Section 45.2 due to the inherently temperature and pressure restrictive design of the appliance.

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

45.2.2.1 Components including contactors and sequence controllers that are operated by the automatic fuel-shutoff system 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.

45.2.3 A water heater shall be equipped with an automatically reset shutoff system that will not reset at a water temperature above 120°F (49°C).

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

45.2.5 The automatic-shutoff system shall have no operating parts in common with the temperature-regulating device or control mentioned in 45.3.1, but a common mounting bracket or a common enclosure may be employed for both devices.

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

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

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

45.2.9 A limit control shall be provided with a fixed stop that complies with the Water Heater Limit Control Test, Section 53.

45.2.10 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, or the requirements for protective electrical controls in the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

45.2.10 revised October 17, 2011, effective June 22, 2012. UL 873 will be withdrawn October 19, 2016.

45.2.11 An electronic limiting control with switched outputs that only relies on hardware circuitry to limit the temperature within the limits specified in 45.2.1 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, and;

b) The Standard for Tests for Safety-Related Controls Employing Solid- State Devices, UL 991, with no single points of failure permitted, or the Type 2 Protective Control requirements per the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

45.2.11 revised October 17, 2011, effective June 22, 2012. UL 873 will be withdrawn October 19, 2016.

45.2.12 An electronic limiting control that relies on software to limit the temperature within the limits specified in 45.2.1 shall comply with the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998, or software Class C in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1A.

45.2.13 The 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.

45.3 Water-temperature regulating control

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

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

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

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

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

45.3.5 An electro-mechanical temperature-regulating control shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, the Standard for Limit Controls, UL 353, or the requirements for operating electrical controls in the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

45.3.5 revised October 17, 2011, effective June 22, 2012. UL 873 will be withdrawn October 19, 2016.

45.3.6 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 45.3.1 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; and

b) The Standard for Tests for Safety-Related Controls Employing Solid- State Devices, UL 991, with no single points of failure permitted, or the Type 2 Operating Control requirements per the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2, Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

45.3.6 revised October 17, 2011, effective June 22, 2012. UL 873 will be withdrawn October 19, 2016.

45.3.7 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 ±10°F (±5.6°C).

45.3.8 An electronic temperature-regulating control that relies on software to regulate or maintain the temperature within the limits specified in 45.3.1 shall comply with the requirements for software Class 1 in accordance with the Software in Programmable Components, UL 1998, or software Class B in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1A.

PERFORMANCE

46 General

46.1 A boiler, hydronic heating appliance, and/or water heater assembly shall meet the applicable requirements when tested as described herein. An assembly of a type not described specifically herein is to be tested in accordance with the intent of these requirements. If any indications are observed during the tests prescribed herein that an assembly will not continue to meet the requirements in normal usage, such supplementary tests shall be conducted as deemed necessary to assure the appliance meets the requirements of this Standard.

46.2 A hydronic heating appliance and water heater is to be investigated for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than specified in Table 46.1, as specified under Form II. At the manufacturer's request, the appliance may be investigated for installation on combustible floors, at the clearances specified in Form IIa.

46.3 A boiler assembly is to be tested normally as suitable for installation on noncombustible floors and with clearances to combustible walls and ceilings not less than indicated in Table 46.1. Such a boiler assembly is categorized under Form II or Form III, depending on its physical size and/or operating flue gas temperature as noted in Table 46.1. At the option of the manufacturer, a boiler assembly operating at not more than 1000°F (537°C) flue gas temperature may be tested as suitable for installation on combustible floors and when so tested is categorized under Form IIa or Form IIIa, depending on its physical size.

Table 46.1
Standard clearances

Type of Appliance	Minimum clearance, inches (mm)					
	A	B	C	D	E	F
Form II	6 (152)	24 (610)	18 (457)	6 (152)	6 (152)	NC
Form IIa	6 (152)	24 (610)	18 (457)	6 (152)	6 (152)	C
Form III	18 (457)	48 (1219)	18 (457)	18 (457)	18 (457)	NC
Form IIIa	18 (457)	48 (1219)	18 (457)	18 (457)	18 (457)	C

Where:

A = top, B = front, C = Chimney, D = back, E = sides, F = flooring

C – Combustible.

NC – Noncombustible.

Forms II and IIa – Water-wall type hot-water boilers operating at not in excess of 250°F (121°C) and water-wall steam boilers operating at not over 15 psi (103.4 kPa) pressure, not larger than 100 cubic feet (2.8 m^3) in size (excluding burner).

Forms III and IIIa – Steam boilers operating at not more than 1000°F (537°C) flue gas temperature not classified under Forms II and IIa.

46.4 At the further option of the manufacturer, an appliance may be tested with clearances less than those indicated in Table 46.1.

46.5 If an appliance is to be tested in a partial enclosure at clearances less than those designated as standard in Table 46.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are to be at least 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 46.1, the connector arrangement is to be as specified in 47.2.2 and Figure 47.2. Except for those modifications of the enclosure and as otherwise provided herein, tests are to be conducted in the manner described for standard clearances.

46.6 The minimum standard clearances designated in Table 46.1 are based on the boiler assembly being installed in a room that is large compared to the size of the assembly. All clearances designated in Table 46.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

46.7 The maximum temperature rise above ambient of flue gases during the Continuous Operation Temperature Test shall not exceed 930°F (517°C).

46.8 With respect to 46.7, determination that the flue gases in the vent pipe are at a negative pressure are to be made in the center within the vent pipe, 6 inches (152 mm) downstream from the connection of the vent pipe to the flue gas outlet of the appliance. The vent pipe is to be connected in accordance with 47.2.3. The pressure of the flue gases shall be negative at all permitted inputs of the appliance.

47 Test Installation for Standard Clearances

47.1 Enclosure

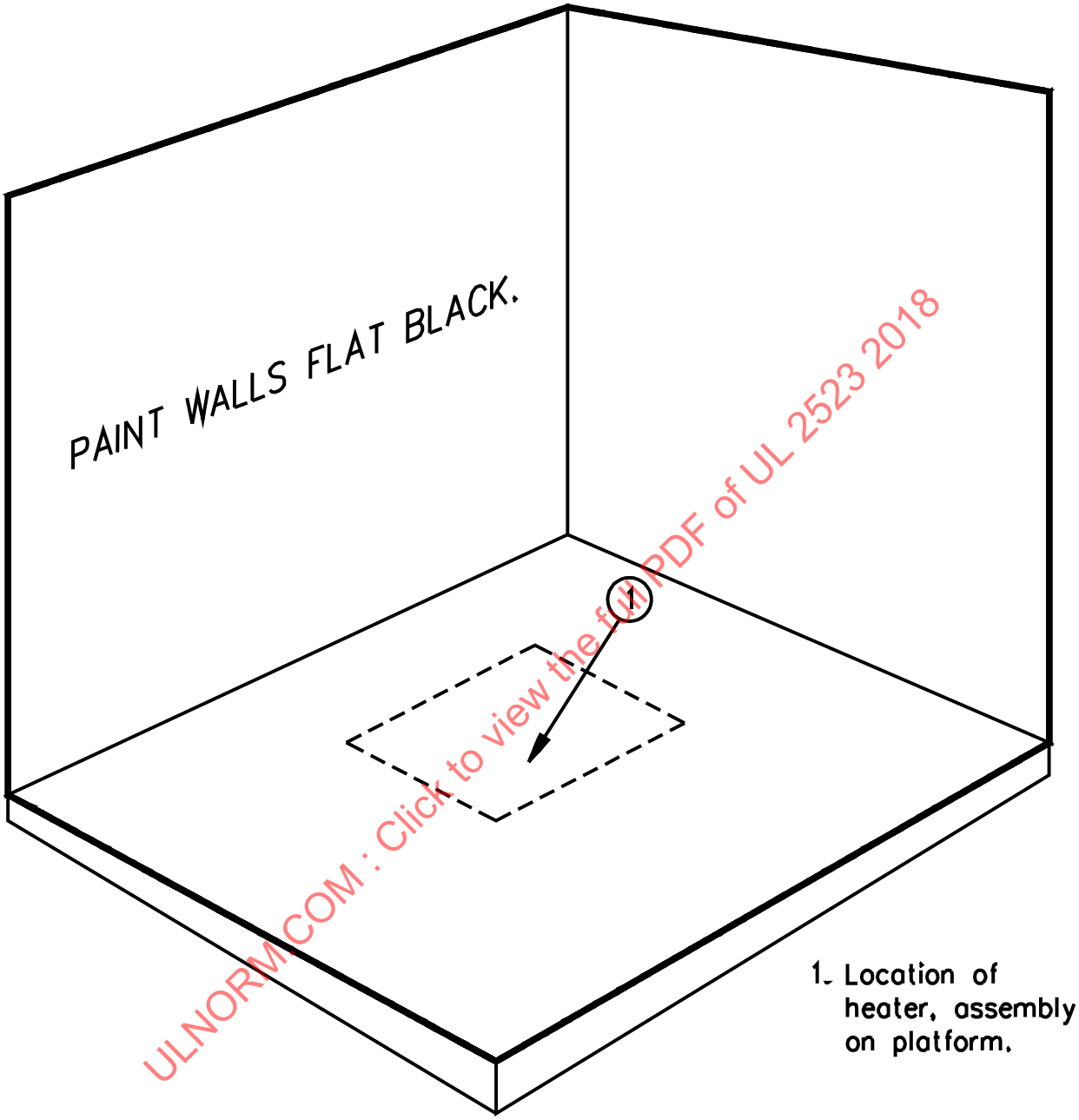
47.1.1 An appliance is to be placed in a partial enclosure in the as-received condition, as described in 47.1.2 – 47.1.5. Except as permitted by 46.3, the distance from the back, side, and top of the assembly and from the chimney connector to the walls and ceiling of the enclosure is to be as indicated in Table 46.1. If one side of the assembly may create a higher wall temperature than the other, that side of the assembly is to be directly opposite one wall.

47.1.2 As an alternative to 47.1.1, when tested at clearances designated as standard in Table 46.1, the partial test enclosure may be eliminated and thermocouples attached to the outer casing panels as specified by Section 57, Electrical Tests. The temperature at points on external surfaces of the appliance, except within 9 inches (229 mm) of the flue collar or any inspection or relief opening, shall not exceed the values specified in Table 55.1.

47.1.3 The appliance assembly is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the appliance the minimum allowable distance above the floor.

47.1.4 The partial enclosure is to be formed by two walls of 1 inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19.1 mm) thick, set at right angles and finished in flat black. See Figure 47.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to be such as to obtain the minimum clearance above the appliance specified in Table 46.1 and in accordance with 46.3. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the appliance. Except as permitted by 46.3, the walls are to be the minimum distance specified in Table 46.1 from the side and back of the appliance assembly, except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 47.1.10.

Figure 47.1
Enclosure for standard clearances



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

47.1.6 If a appliance is intended to be insulated in service, it may be tested with the covering furnished by the manufacturer as standard equipment. If the covering is not furnished as part of the appliance , the assembly may be tested with plastic magnesia or equivalent insulation 1-1/2 inches (38.1 mm) thick.

47.1.7 If a covering is not furnished by the manufacturer or if the covering is furnished by the manufacturer but not factory assembled on the appliance, the manufacturer is to specify such covering as is specified in 47.1.6 or the manner in which the separately packaged factory furnished covering is to be installed. This information is to be furnished in conjunction with the clearance information to appear on the assembly.

47.1.8 The limit control, if furnished separately for mounting in the field, is to be located as specified in the installation instructions furnished with the appliance.

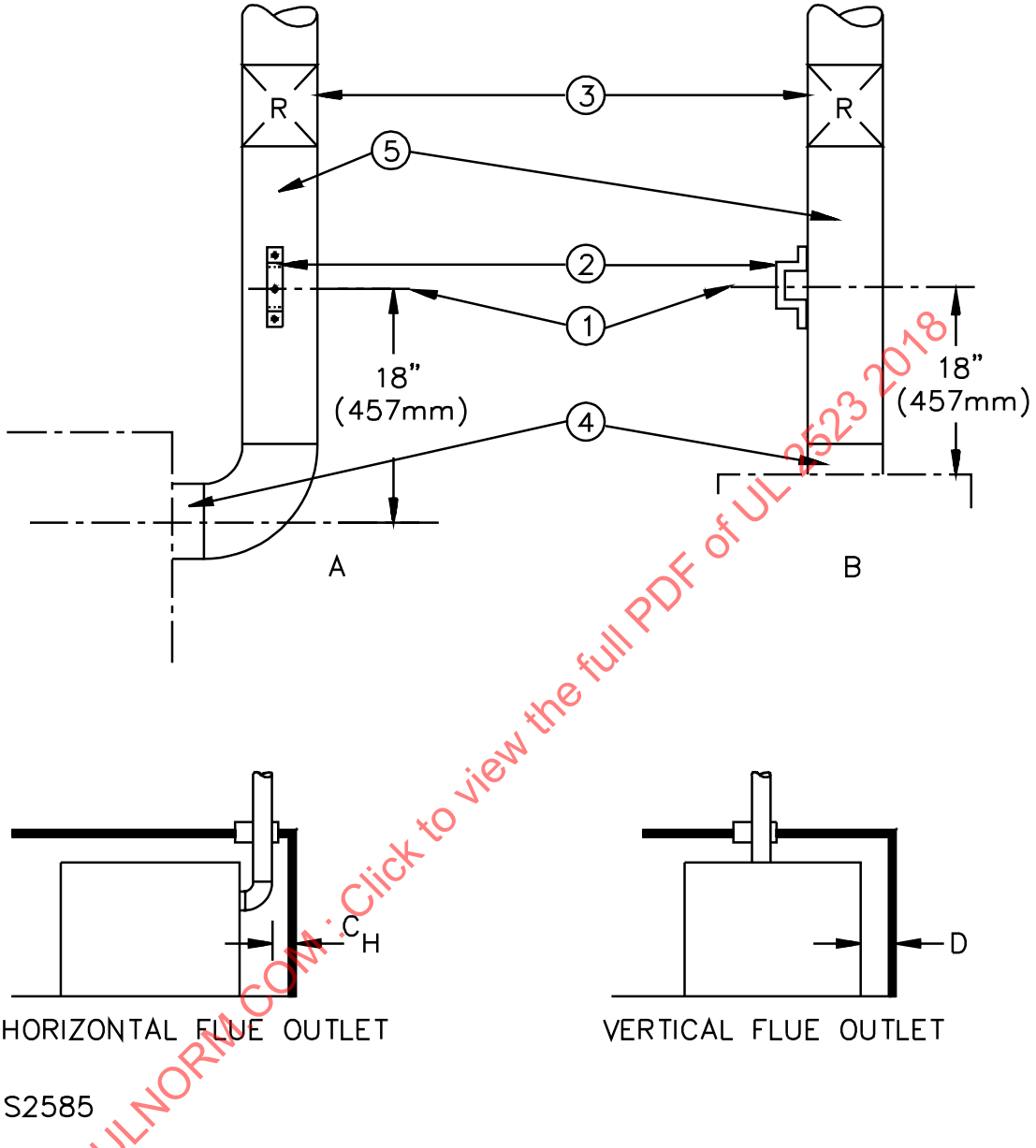
47.1.9 The water temperature in the appliance is to be measured by a thermocouple located so that the water temperature 1 inch (25.4 mm) below the outlet connection may be determined. For a steam boiler, the thermocouple shall be located 1 inch below the surface of the water.

47.1.10 Steam pressure is to be measured by a commercial steam gauge of appropriate range.

47.2 Chimney connector

47.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the appliance. Galvanized stovepipe not heavier than 0.023 inch (0.58 mm) (No. 24 GSG) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure, directly connected to and extended vertically above a vertical flue outlet, and connected to a horizontal flue outlet by using a 90-degree sheet metal elbow at the bottom of the vertical section. See Figure 47.2.

Figure 47.2
Chimney connector – Standard Clearance test



1. Centerline of thermocouple.

2. Support bracket.

3. Draft Regulator.

4. Flue collar.

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

47.2.2 For an appliance tested in a partial enclosure (see Figure 47.1) at clearances less than those designated as standard in Table 46.1, the clearances from the chimney connector are to be not less than 9 inches (229 mm). When the chimney connector clearances are less than those designated as standard in Table 46.1, the chimney connector arrangement is to be as specified in 47.2.3 and Figure 47.3.

47.2.3 An appliance with vertical flue outlets is to be tested with two chimney connector arrangements, Styles I and III, and an appliance with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III as indicated in Figure 47.4, unless the manufacturer elects to specify the minimum clearance from the appliance as that obtained when tested with the chimney connector arranged in accordance with Style I or II only.

Figure 47.3
Sealing of annulus around chimney connector

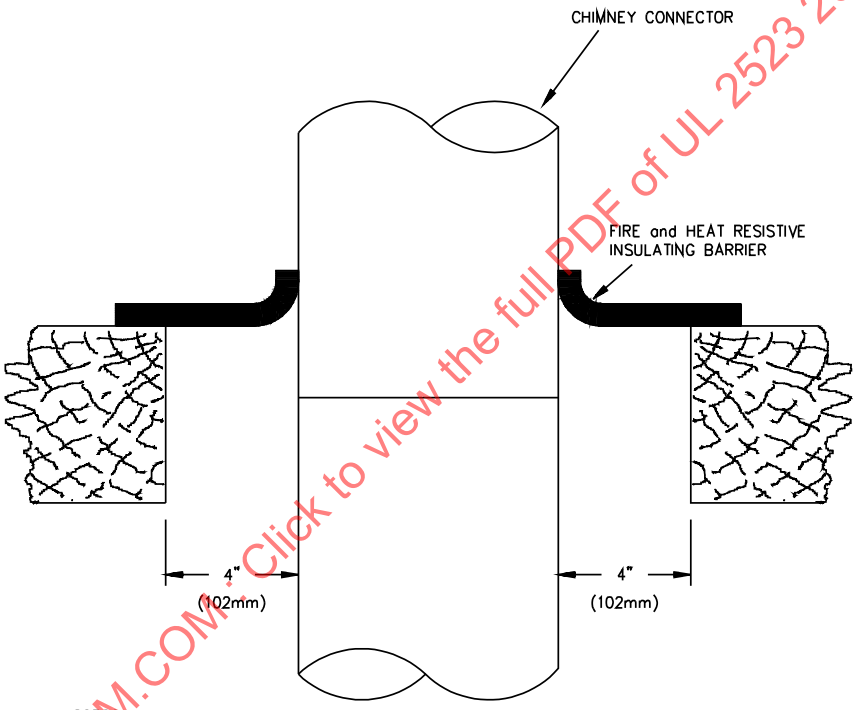
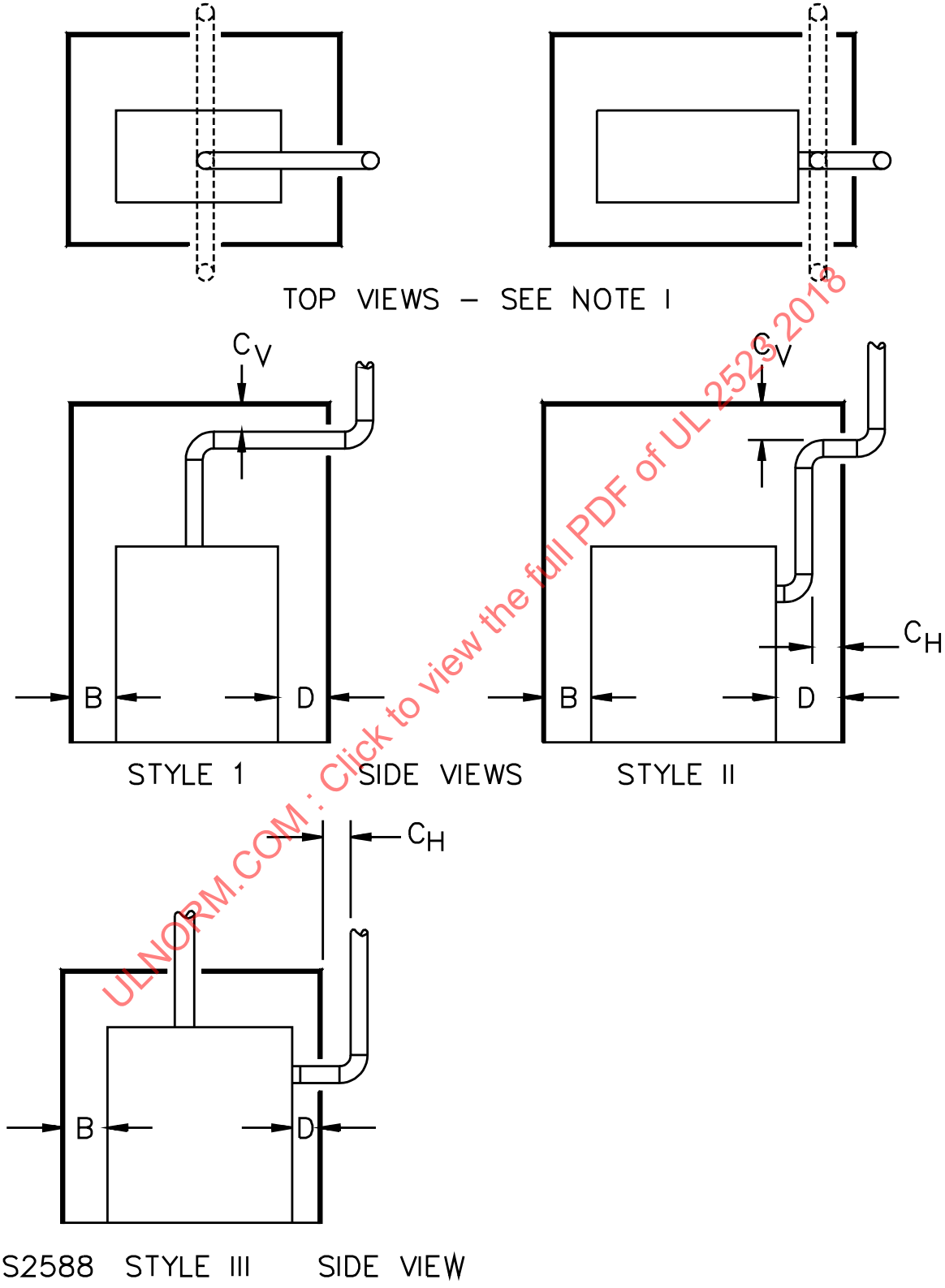


Figure 47.4
Chimney alternate arrangement



47.2.4 Where the chimney connector pierces the enclosure, an opening 8 inches (203 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 47.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50.8 mm) from the outer edge of the annulus.

47.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2 of Figure 47.2.

47.2.6 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 47.2.

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

47.2.8 The adjustment of a built-in draft regulator specified in 47.2.7 is intended to supply the minimum dillution air allowed by the design. The draft regulator specified in 47.2.6 shall be adjusted to provide the manufacturer's specified draft.

48 Initial Test Conditions

48.1 The appliance assembly is to be set up for test in the appropriate enclosure and manner described in Test Installation for Standard Clearances, Section 47.

48.2 Unless otherwise specified in the describing the tests, boiler assemblies are to be tested at the test voltages indicated in Table 50.1.

48.3 The appliance assembly is to be fired at its maximum initial fuel load, with each type of fuel for which the unit is rated.

48.4 The input, air-fuel ratio, and other operating conditions are to be in accordance with the manufacturer's instructions.

48.5 All heating surfaces in contact with combustion products and the vent pipe of the device to be fired for the test are to be thoroughly cleaned before the testing is begun.

48.6 The limit control is to be bypassed to permit continued operation when required by a test. During test, the temperature or pressure within the appliance is to be not greater than its rated temperature or pressure, but not less than the appropriate value given below:

a) 200°F (93.3°C) in a low pressure hot-water boiler;

b) 12 psi (82.74 kPa) in a low pressure steam boiler;

c) 95 percent of maximum rated temperature in a high pressure water boiler; or

d) 95 percent of rated working pressure in a high pressure steam boiler.

48.7 The water level in the boiler is to be maintained at normal level. The boiler is to be fired for the temperature test until equilibrium temperatures are attained.

49 Instrumentation

49.1 Draft

49.1.1 Draft is to be measured by a draft gauge which may be read directly to 0.005 inch (or 0.13 mm) water column and which has an accuracy of ±0.0025 inch (0.064 mm). A gauge is to be checked for zero reading at the beginning and the end of each test.

49.2 Power measurement

40.2.1 The total electrical input to a fuel burning assembly is to be measured in amperes.

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

49.3 Speed measurement

49.3.1 Mechanical or electronic means are to be used to measure the speed of a motor or of a mechanism driven by it. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (94 W).

49.4 Temperature measurement

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

49.4.2 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 55.1.

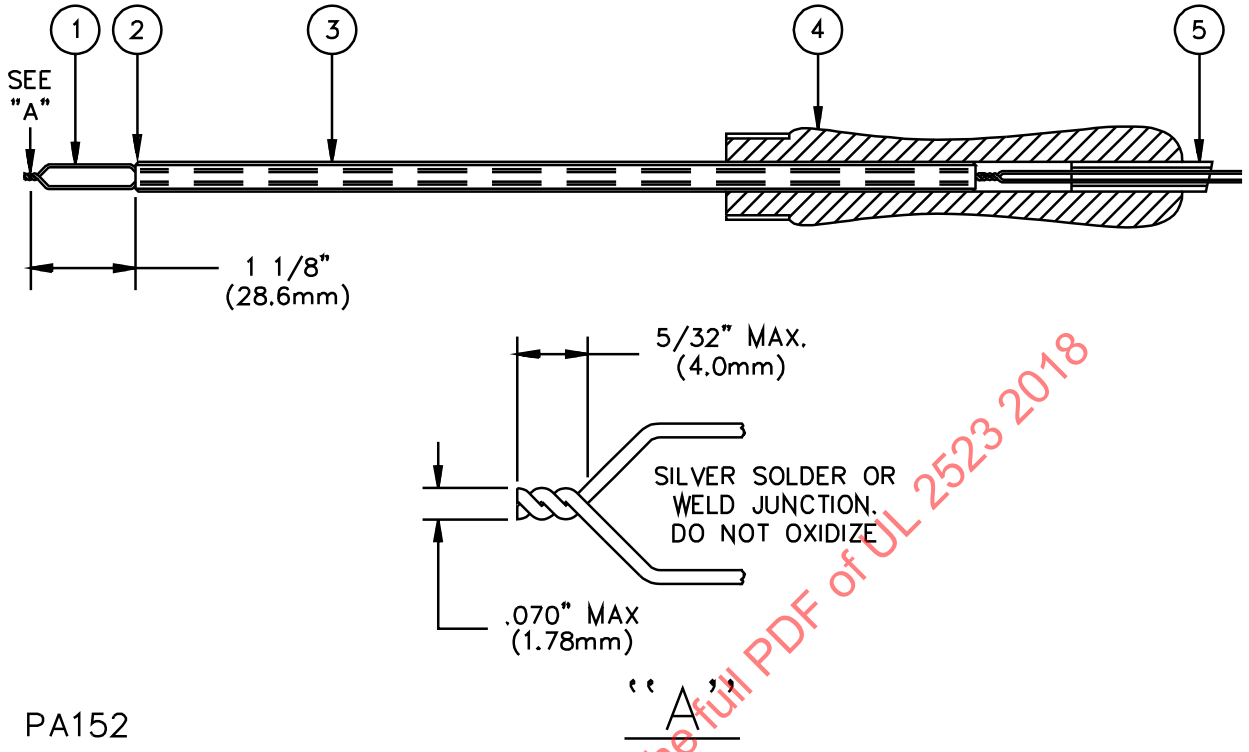
49.4.3 Each thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material whose temperature is being measured. In most cases, adequate thermal contact results from securely taping or cementing the thermocouple in place; but where a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

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

49.4.5 Thermocouples are to be attached to surfaces other than as described in 49.4.3 and 49.4.4 by being cemented or taped to the surface in a manner to assure good thermal contact with the surface.

49.4.6 The flue-gas temperature is to be measured by a thermocouple such as illustrated by Figure 49.1 inserted into the chimney connector as shown on Figure 49.2. There is to be no draft control between the appliance and the point where the flue-gas temperature is measured. If a draft control is incorporated in the appliance, it is to be dependably sealed in the position allowing maximum draft during all tests.

Figure 49.1
Standard thermocouple for flue-gas temperature



1. 20 AWG (0.51 mm^2) iron-constantan, asbestos, or woven-glass-covered thermocouple wires extending from hot junction to potentiometer or reference junction.

2. 1 – Leeds & Northrup Standard 714B, or equal, 1/4 inch (6.4 mm) outside diameter of two-hole porcelain insulator cut to length and ends beveled on two sides.

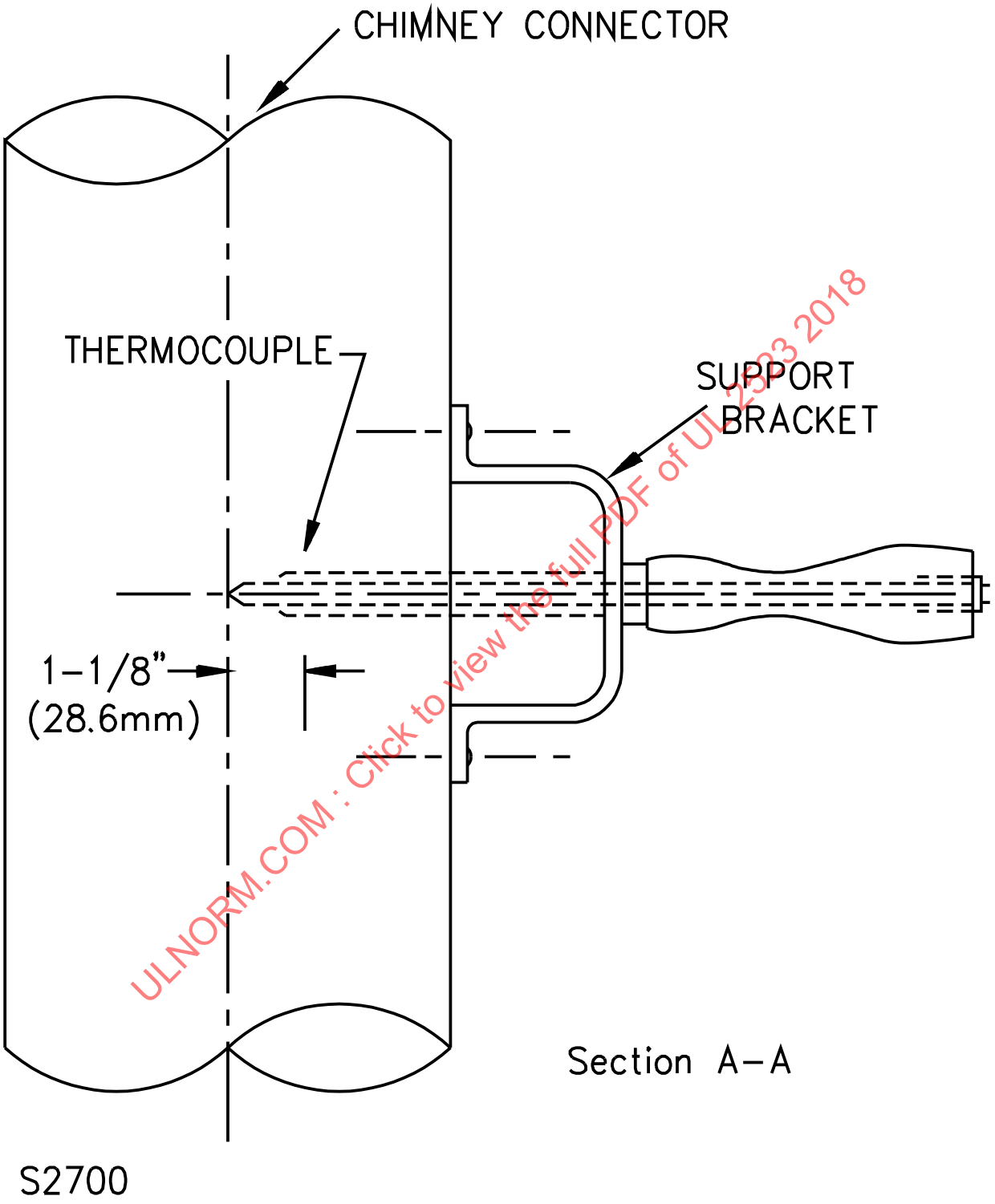
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

5. 1 – Piece of rubber tubing, approximately 5/16 by 3/32 by 2 inches long (7.9 by 2.4 by 50.8 mm long).

6. In lieu of individual components described in (1), (2), and (3) above, any combination of preassembled parts of tubing, insulators and thermocouples may be used.

Figure 49.2
Flue-gas thermocouple and support bracket



49.4.7 Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation such as more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

50 Test Voltage

50.1 Unless otherwise specified, appliances are to be tested at the potentials indicated in Table 50.1.

Table 50.1
Test voltages

Rated voltage	Normal test voltage	Overvoltage	Undervoltage[a]
110 – 120	120	132	102
200 – 208	208	229	177
220 – 240	240	264	204
254 – 277	277	305	235
440 – 480	480	528	408
550 – 600	600	660	510
Other	Rated	110 percent rated	85 percent rated

[a] Values in this column are applicable to alternating-current potentials. Undervoltage tests for a direct-current burner or component are to be conducted at 80 percent rated voltage.

51 Solid Fuels and Test Firing Procedures

51.1 General

51.1.1 An appliance is to be fired with the following test fuels for the tests in this Standard, as applicable and in accordance with the instructions provide with the unit and by the manufacturer:

a) Firebrands or hardwood logs

b) Charcoal

c) Wood pellets

d) Shelled corn; or

e) Other types of solid fuels designated by the manufacturer.

Refer to Sections 51.2 – 51.4 for details regarding the specific test fuels. If an appliance is intended for use with more than one type of fuel, it shall be tested with representative fuels to cover each fuel specified to ensure compliance with the requirements of this Standard.

51.1.2 If an appliance is intended for use with other types of solid fuels, such as sawdust, corncobs, or any other biomass fuel, the tests specified in Sections 52 – 56 may also be performed burning the specified fuels in accordance with the manufacturer's instructions at the discretion of the testing agency.

51.1.3 For automatically fueled appliances, there shall be no burnback into the fuel hopper when the appliance is operated under any of the firing conditions specified in these requirements.

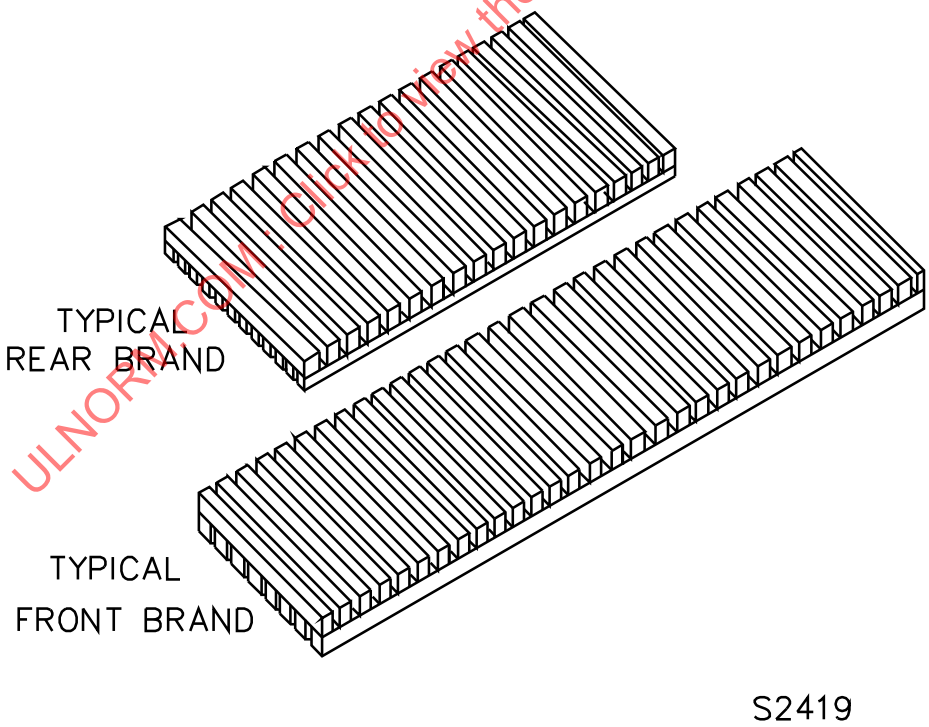
51.1.4 There shall be no spillage of flames outside the appliance when the appliance is operated under any of the firing conditions specified in these requirements.

51.2 Firebrands and hardwood logs

At the manufacturer's recommendation, manually fed appliances intended to be used with wood are to be tested using firebrands or hardwood logs in accordance with this section.

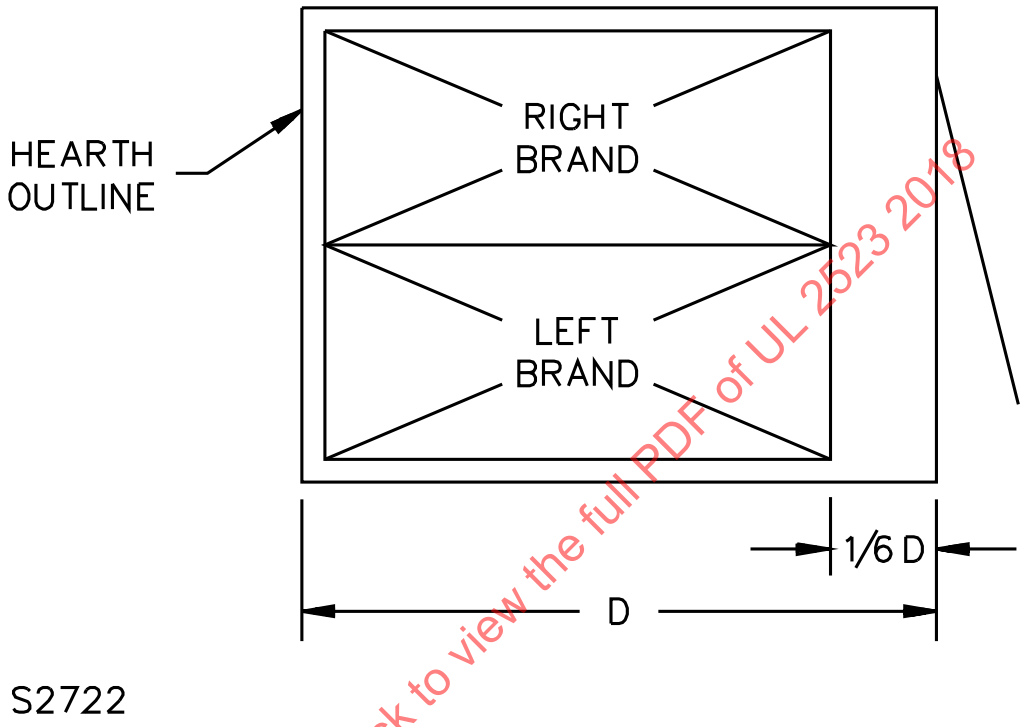
51.2.1 A firebrand is to be prepared in strips as illustrated in Figure 51.1 from dry (moisture content of 19 percent or less) strips of Douglas fir, birch, maple, or oak. . Each strip is to be 3/4 by 3/4 inch (19.1 by 19.1 mm) in cross section and weigh 0.020 ±0.002 pound per cubic inch (554.0 ±55.4 kg/mm^3). The strips are to be placed 1 inch (25.4 mm) apart, on centers providing a 1/4 inch (6.35 mm) space between strips. The brands are to be conditioned in an oven at 105 – 150°F (40.5 – 66°C) for at least 16 hours prior to being burned, and the conditioned brands are to be used within 3 hours of removal from the oven.

Figure 51.1
Brands



51.2.2 Each brand is to have an area in the plan view equal to at least one-third of the total grate or hearth area. Its dimensions are to permit the front edge of the brand to be positioned horizontally in the hearth, as illustrated in Figure 51.2, and to be recessed from the feed door of the room-heater combustion chamber a distance of approximately one-sixth of the maximum grate or hearth depth.

Figure 51.2
Typical relation of brands to grate or hearth



51.2.3 Firebrands are to be fed to the fire at a rate of one brand every 7-1/2 minutes. If an ash pan is provided, it is to be emptied at 15 minute intervals. If coals build up in the fire chamber, they are to be raked level before adding the next brand. The rate of fueling is not to cause the height of fuel buildup to exceed either the top of the fire-chamber opening or the level designated by the manufacturer.

51.2.4 To produce flash-firing conditions, eight brands stacked four deep are to be added to the fire after equilibrium temperatures have been obtained by firing as described in 51.2.3.

51.2.5 Hardwood logs shall be birch, maple, or oak measuring approximately 6 inches (150 mm) in diameter and 18 inches (450 mm) in length with a moisture content no to exceed 22 percent on a wet basis.

51.2.6 Initially, the unit shall be loaded with hardwood logs to the physical limitation of further loading of the combustion chamber. In order to maintain the maximum equilibrium temperatures produced by firing hardwood logs, the fuel shall be reloaded when the level of fuel has dropped to approximately 2/3 of full capacity, as described above.

51.2.7 To produce flashing-firing conditions, pieces of spruce, pine, and/or fur lumber having a cross-sectional area of approximately 1.5 inches (38 mm) by 1.5 inches (38 mm) and in lengths not to exceed 19.5 inches (500 mm) are to be added to the fire (to the physical limitation of further loading of the fire chamber) after equilibrium temperatures have been obtained by firing hardwood logs as described in 51.2.6.

51.3 Charcoal

51.3.1 The testing of a unit with charcoal also covers the appliance for use with coal. For test firings with charcoal, the appliance is to be loaded to a depth of approximately 6 inches (152 mm) with charcoal briquettes[a] formed in the shape of a 2.0- by 1.9-inch (50- by 48-mm) square pillow having rounded edges and a maximum thickness of 1.2 inches (30 mm). As such, briquettes are to have a count weight of 17 per pound (37 kg), a heat content (dry basis) of 11,500 Btu per pound (26,750 J/kg), and a moisture content of 5 percent.

[a]A type suitable for this test is manufactured by the Kingsford Company, P. O. Box 493, Pleasanton, California 94566.

51.3.2 Charcoal briquettes are to be added at 7-1/2 minute intervals to the fire in amounts that will maintain a 6-inch (152-mm) bed of fuel. The fuel is to be poked and stirred in an effort to maintain a maximum intensity of burning. If an ash pan is provided, it is to be emptied every 7-1/2 minutes.

51.3.3 Throughout the firing tests, spillage of combustion products or flame from the appliance meets the intent of the requirement only during fueling, in the form of sporadic wisps of smoke and flickers of flame not projecting more than 6 inches (152 mm) from the plane of the fuel-loading opening.

51.4 Wood pellets

51.4.1 The wood pellet fuel to be used in the following tests shall meet the heat content, bulk density, moisture content, ash content and pellet size specifications outlined in Standard Specification for Room Heaters, Pellet Fuel-Burning Type, ASTM E1509.

51.4.2 When the manufacturer specifies and supplies specific wood pellet fuel, the fuel supplied by the manufacturer shall be used for the following tests. The heat content, bulk density, moisture content, ash content, pellet size and fines shall be determined as specified in ASTM E1509 and recorded.

51.4.3 Unless otherwise noted in the individual tests of this Standards, the fuel hopper is to be filled with the specified wood pellet fuel and following the manufacturer's instructions, the appliance is to be ignited. The pellet feed rate, combustion air controls, thermostatic controls, and the like are to be adjusted to produce the maximum temperatures.

51.5 Automatically Fueled Appliances

51.5.1 The normal burn rate shall not exceed the maximum burn rate under firing conditions unregulated by the appliance temperature controllers.

51.5.2 The test shall begin with the fuel hopper empty. The weight of a sufficient quantity, of the specified pellet fuel, to operate at the maximum burn rate for a minimum of 30 minutes shall be measured in pounds (kg).

51.5.3 Any manual fuel delivery control is to be adjusted to the maximum and allowed to regulate the fuel feed rate.

51.5.4 If the appliance fails to operate for at least 30 minutes before the temperature regulating control begins regulating the rate of fuel feeding the burner, the appliance controls are to be bypassed.

51.5.5 To achieve the condition of maximum normal rate specified in 51.5.3 – 51.5.4, any control or component, including the main burner, that would cause the fuel delivery system to reduce or interrupt the rate of feed is to be rendered inoperable.

Exception: A control that is integral to the fuel delivery system and unaffected by water temperature shall not be bypassed.

51.5.6 The quantity of fuel measured in 51.5.2 shall be loaded into the hopper and the appliance fuel delivery system operated at normal maximum rate, the time, not less than 30 minutes, required to exhaust the fuel is to be measured.

51.5.7 The rate in pounds/hour (kg/hr) is to be calculated.

52 Water Temperature Control Test – Hydronic Heating Appliance and Water Heater

52.1 When tested as described in 52.2 and with the temperature-regulating control set at the maximum temperature position allowed by a fixed stop, shall not exceed an outlet-water temperature of 194°F (90°C).

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

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

53 Limit Control Test – Water Heater

53.1 A water heater shall be operated as described in 53.2 until the limit control functions. The temperature of the water shall not exceed 210°F (99°C) but shall be higher than that maintained by the temperature-regulating control as determined in the Water Temperature Control Test, Section 52.

53.2 With the heater installed as described in the Water-Temperature Control Test, Section 52, the temperature-regulating control is to be made inoperative. The heater is to be placed in operation with the inlet-water valve opened and the outlet-water valve closed, until the limit control functions. The water temperature is to be measured in accordance with 47.1.10.

54 Limit Control and Low Water Control Test – Boiler

54.1 The limit control for a low-pressure boiler when adjusted to its maximum setting allowed by a fixed stop shall function when the temperature of the water in a hot-water heating boiler is not more than 250°F (121°C) and when the pressure in a steam heating boiler is not more than 15 psi (103 kPa), when the boiler assembly is tested as described herein. The limit control for a high-pressure boiler shall function when the pressure in a steam boiler is not more than the designed working pressure of the boiler, or when the water temperature in a hot-water boiler is not more than the temperature of saturated steam at the designed working pressure of the boiler, when the boiler assembly is tested as described herein.

54.2 The boiler is to be filled to the intended level with water. A steam or a hot-water boiler is to be provided with a pressure-relief valve.

54.3 The limit control, if adjustable, is to be adjusted to the highest temperature or pressure setting, as applicable.

54.4 The water temperature obtained in a hot-water boiler is to be measured as described in 47.1.9. The inlet and outlet water valves are to be adjusted so that hot water passes the thermocouple bead during the test.

54.5 A slow-closing valve is to be placed in the steam outlet line of a steam boiler.

54.6 The boiler is to be placed in operation and the water or steam valves adjusted to raise the temperature or pressure until the limit control functions. Neither the maximum water temperature in the boiler nor the pressure is to exceed the values indicated in 32.5.2 and 32.6.1.

54.7 Following the test in 54.6, the boiler is allowed to be filled to the intended level with water. The boiler is to be fired at any input, a feed water device, if provided is to be disconnected, and the boiler drain valve opened. Firing is to continue until the low water control operates to de-energize the combustion air supply.

54.8 Observations shall be made to ensure, upon interruption of the combustion air blower circuit, the water level does not continue to drop below the lowest permissible water level established by the manufacturer.

55 Temperature Test

55.1 When an appliance is tested in accordance with Sections 55 – 56, no part shall attain a temperature sufficient to:

a) Impair the effectiveness of required corrosion protection;

b) Impair operation of safety controls;

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

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

55.2 The temperature rises at specific points shall not exceed those specified in Table 55.1 except as permitted in the footnotes to the table.

Table 55.1
Maximum temperatures and maximum temperature rises

Device or Material	Column 1 Maximum Temperature Rise		Column 2 Maximum Temperature	
	°C	(°F)	°C	(°F)
A. MOTORS[a,b]				
1. Class A insulation on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors)				
a. In open motors –				
Thermocouple or resistance method	75	(135)		
b. In totally enclosed motors				
Thermocouple or resistance method	80	(144)		
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current motors and universal motors)				
a. In open motors –				
Thermocouple method	65	(117)		
Resistance method	75	(135)		
b. In totally enclosed motors –				
Thermocouple method	70	(126)		
Resistance method	80	(144)		
3. Class B insulation on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors).				
a. In open motors –				
Thermocouple or resistance method	95	(171)		
b. In totally enclosed motors –				
Thermocouple or resistance method	100	(180)		
4. Class B insulation on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current motors, universal motors.				
a. In open motors –				
Thermocouple method	85	(153)		

Table 55.1 Continued on Next Page

Table 55.1 Continued

Device or Material	Column 1 Maximum Temperature Rise		Column 2 Maximum Temperature	
	°C	(°F)	°C	(°F)
Resistance method	95	(171)		
b. In totally enclosed motors –				
Thermocouple method	90	(162)		
Resistance method	100	(180)		
B. COMPONENTS				
1. Field-wiring terminals[c]	50	(90)		
2. Points on or within terminal box which may be in contact with field wiring[c]	35	(63)		
3. Capacitors				
Electrolytic type[d]	40	(72)		
Other types[e]	65	(117)		
4. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated windings –				
Thermocouple method	65	(117)		
b. Class 130 insulated windings –				
Thermocouple method	85	(153)		
5. Sealing compounds			40°C (72°F) less than its melting point	
6. Transformer enclosures[b] –				
a. Class 2 transformer	60	(108)		
b. Power and ignition transformers	65	(117)		
C. INSULATED CONDUCTORS[f, g]				
1. Appliance wiring material				
75°C rating	50	(90)		
80°C rating	55	(99)		
90°C rating	65	(117)		
105°C rating	80	(144)		
200°C rating	175	(315)		
250°C rating	225	(405)		
2. Flexible cord – Types SO, ST, SJO, SJT	35	(63)		
3. GTO cable	35	(63)		
4. Wire, Code				
Types RF, FF, RUW	35	(63)		
Types RH, RFH, FFH, RHW, THW, THWN	50	(90)		
Types T, TF, TFF, TW	35	(63)		
Type TA	65	(117)		
5. Other types of insulated wires	See note f			
D. ELECTRICAL INSULATION – GENERAL[g]				
1. Class C electrical insulation material	Not specified			
2. Class H (180) electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	(117)		
4. Phenolic composition used as electrical insulation or as parts of where deterioration will result in a risk of fire or electric shock	125	(225)		
5. Thermoplastic material			25°C (45°F) less than its temperature rating	

Table 55.1 Continued on Next Page

Table 55.1 Continued

Device or Material	Column 1 Maximum Temperature Rise		Column 2 Maximum Temperature	
	°C	(°F)	°C	(°F)
6. Varnished cloth insulation	60	(108)		
E. METALS				
1. Aluminum Alloys				
a. 1100(2S)	183	(330)		
b. 3003(3S)	239	(430)		
c. 2014, 2017, 2024, 5052[h]	294	(530)		
2. Aluminum-coated steel, heat-resistant type[i]	572	(1030)		
3. Carbon steel-coated with type A19 ceramic	572	(1030)		
4. Galvanized Steel[j]	267	(480)		
5. Low-carbon steel, cast iron[k,l,m]	461	(830)		
5. Low-carbon steel, cast iron[k,l,m]	461	(830)		
6. Stainless Steel	686	(1235)		
Types 302, 303, 304, 321, 347	667	(1200)		
Type 309S	867	(1560)		
Type 310, 310B	894	(1610)		
Type 430	728	(1310)		
Type 446	961	(1730)		
F. GENERAL				
1. Air Filter	50	(90)		
2. Flue gases[n]	517	(930)		
3. Operating knobs, handles, and levers				
a. Metallic			50	(122)
b. Glass			78	(172)
c. Plastic[o]			85	(185)
d. Wood			150	(302)
4. Surfaces of appliance at points of zero clearance to test structure	65	(117)		
5. Surface of floor beneath and within 3 feet (0.91 m) of appliance to be classified for installation on combustible floors	65	(117)		
6. Surfaces of test enclosure (ceiling, walls, and the like)	65	(117)		

[a] The motor diameter is to be measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, and the like, used solely for motor cooling, mounting, assembly, or connection.

[b] Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. 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 a thermocouple may be (not including universal motors):

1. 5°C (9°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
2. 10°C (18°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type.
3. 15°C (27°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type.
4. 20°C (36°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type.

Table 55.1 Continued on Next Page

Table 55.1 Continued

Device or Material	Column 1 Maximum Temperature Rise		Column 2 Maximum Temperature	
	°C	(°F)	°C	(°F)
[c] The temperature rise observed on the terminals and at points within a terminal box may exceed the values specified, provided the box is marked in accordance with 72.6 and 72.7. The wiring may not attain a temperature rise higher than 65°C (117°F).				
[d] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be more than 65°C (117°F).				
[e] A capacitor that operates at a temperature higher than a 65°C (117°F) rise may be judged on the basis of its marked temperature rating.				
[f] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code; the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question where Column 1 temperature rises are specified.				
[g] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and found to have heat resistant properties.				
[h] These and other alloys containing more than 1 percent magnesium shall not be used when the reflectivity of the material is employed to reduce the risk of fire.				
[i] When the reflectivity of aluminum-coated steel is utilized to reduce the risk of fire, the maximum allowable temperature rise is 461°C (830°F).				
[j] The specified maximum temperature uses apply if the galvanizing is required as a protective coating, or the reflectivity of the surface is utilized to reduce the risk of fire.				
[k] When solid fuel is fired, the specified maximum temperature rises shall not apply to parts of No. 8 gage (3.86 mm) or heavier steel and 3/16 inch (4.8 mm) thick or heavier cast iron employed for the hearth and to other parts of No. 12 gage (2.36 mm) or heavier steel, and 1/8 inch (3.2 mm) thick or heavier cast iron when: 1. The part is not the only enclosure; and 2. Malfunction of the part will not expose adjacent combustible construction to the fire in the fire chamber.				
[l] When solid fuel is fired, the specified maximum temperature rise shall not apply to parts of 1/4 inch (6.4 mm) or heavier steel and 5/16 inch (7.9 mm) thick or heavier cast iron.				
[m] For combination oil-fired and solid-fuel-fired appliances in which a chamber is provided exclusively for burning fuel oil, the temperature rise on steel portions of the chamber shall not exceed 517°C (930°F) when oil only is being fired.				
[n] For Manually Fed Appliances: The flue-gas temperature rise may exceed 517°C (930°F) for a cumulative period not exceeding 12.5 percent of the test duration but shall not exceed 738°C (1330°F) during the Continuous Operation Tests. During Flash Fire and other tests, the temperature rise may exceed 738°C (1330°F) for a cumulative period not exceeding 10 minutes but shall not exceed 905°C (1630°F).				
[0] Category includes plastic with a metal plating not more than 0.005 inch (0.13 mm) thick; and metal with a plastic or vinyl covering not less than 0.005 inch (0.13 mm) thick.				

56 Continuous Operation Test

56.1 General

56.1.1 The following requirements shall apply when an appliance is operated in accordance with 56.1.2 – 56.1.3:

a) The test results shall demonstrate compliance with the requirements in 55.1;

b) The temperature rises shall not exceed the values specified in Column 1 of Table 55.1; and

c) The temperature of the outlet water shall be adjusted and maintained in accordance with 56.1.2 and 56.1.3.

56.1.2 Limit and operating controls are to be bypassed to permit continued operation during this test. However, a thermostatic damper control and damper mechanism that complies with the requirements of Section 31, Flue Dampers, Draft Regulators, and Air Shutters, is to be adjusted to the maximum setting allowed by its fixed stop and is to be permitted to function as intended to control the rate of burning. A damper or shutter that is manually operated or that does not comply with the requirements in Section 31 is to be fixed in the fully open position.

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

56.2 Continuous operation

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

56.2.2 For manually loaded appliances, solid-fuel firing is to consist of consecutive firings of the applicable fuel as follows:

a) Charcoal loaded into the chamber in accordance with 51.3.2;

b) Firebrands or hardwood logs loaded into the chamber in accordance with normal firing procedures specified in Section 51.2; and firebrands or lumber loaded into the chamber in accordance with flash-fire procedures, 51.2.4 or 51.2.7, respectively.

56.2.3 For automatically fueled appliances, firing is to be at maximum rate, in accordance with Section 51.5.

56.3 Motor and controller failure

56.3.1 With the appliance operating as described in 56.2, each motor and blower such as the fuel feed, combustion, air circulating and such are to be shut down and the appliance operated until maximum temperatures are achieved. The motors and blowers are to be rendered inoperable individually and in any combination to determine compliance to this requirement.

56.3.2 Once maximum temperatures are achieved, the door or cover of an appliance, if so equipped, is to be cycled open and then closed to check for flame spillage or other abnormal conditions, at the discretion of the testing agency.

56.3.3 For motors and blowers, such as the fuel feed, combustion, air circulating, equipped with a speed and/or timing control device, failure tests shall be applied to each motor and/or blower controller individually and in any combination, per 56.3.4.

56.3.4 With the appliance operating as described in 56.2, each motor and blower controller, per 56.3.3, is to be bypassed allowing the motor or blower to operate at full uncontrolled speed until maximum temperatures are achieved.

56.3.5 Controller failure tests do not apply to controllers if the only possible controller failure mode would cause the motor controlled by the controller to shut down.

56.3.6 During the tests the temperature rise limits in Column 1 of Table 55.1 apply.

56.4 Loss of electrical power

56.4.1 Solid-fuel firing is to include operation during loss of electrical power. The appliance is to be readied for test and operated as follows:

a) The flow of water through the heater is to be regulated to maintain an outlet water temperature of 175 ±5°F (80 ±2°C) with an approximate 18 °F (10 °C) temperature differential between the outlet and the inlet. As applicable, the boiler water pressure shall be maintained at 14.5 ±0.75 psi (100 ±5 kPa).

b) The appliance is to be fired in accordance with the applicable firing procedures specified in Section 51 and the inlet and outlet water valves are to be fully closed upon loss of electrical power.

During the test the temperature rise limits in Column 1 of Table 55.1 apply.

56.4.2 Once maximum temperatures are achieved, the door or cover of an appliance, if so equipped, is to be cycled open and then closed to check for flame spillage or other abnormal conditions, at the discretion of the testing agency.

57 Electrical Tests

57.1 Dielectric test

57.1.1 An appliance shall be capable of withstanding without breakdown for a period of 1 minute, the application of a 60 hertz potential between high-voltage live parts and dead metal parts, and between live parts of high- and low-voltage circuits. The test potential is to be:

a) 1000 volts plus twice the rated voltage; or

b) 1000 volts for a motor rated at no more than 1/2 horsepower (373 W output) and no more than 250 volts.

57.1.2 If higher than rated voltage is attained in a motor circuit through the use of capacitors, the rated voltage of the appliance is to be used in determining the dielectric voltage-withstand test potential. However, if the developed steady-state capacitor voltage exceeds 500 volts, the test potential for the involved parts is to be 1000 volts plus twice the attained voltage.

57.1.3 A low-voltage circuit shall be capable of withstanding without breakdown for a period of 1 minute, the application of a 60 hertz alternating potential of 500 volts applied between low-voltage live parts of opposite polarity and between low-voltage live parts and dead metal parts.

57.1.4 The dielectric voltage-withstand test between low-voltage live parts of opposite polarity need not be conducted on the complete assembly if the components have been separately subjected to this test condition and if the wiring material is as indicated in Table 11.1.

57.1.5 A transformer rated 500 volt amperes or more, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 57.1.1 – 57.1.3. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute.

Exception: A transformer rated 500 volt amperes or more need not be used if the high potential testing equipment used for the test maintains the specified high potential voltage at the equipment for the duration of the test.

57.2 Short-circuit test

57.2.1 Inherent overheating-protective devices, bonding conductors or connections when required, and conductors of multiple motor circuits shall withstand short-circuit and ground-fault conditions when protected by:

a) A device that is recognized for branch-circuit protection and located in the product; or

b) A branch-circuit protective device of the type and maximum rating specified on the product nameplate.

There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line and low-voltage circuits.

57.2.2 For the purpose of these tests:

a) Circuit breakers and fuses are not considered to be interchangeable;

b) Fuses of the same rating are considered to be interchangeable;

c) HACR Type circuit breakers of the same rating are considered to be interchangeable; and

d) Other types of circuit breakers are not considered to be interchangeable with each other or with HACR Type circuit breakers.

57.2.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the appliance as indicated in Table 57.1. The appliance full-load current is determined by adding the motor full-load current of each motor, as determined in accordance with the National Electrical Code, NFPA 70, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current is to be used as the basis for selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit.

Table 57.1
Short-circuit test currents

115 V	Single phase		277 V	Circuit capacity amperes
	208 V	230 – 240 V		
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 –16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
208 V	**Three phase**		**550 – 600 V**	**Circuit capacity amperes**
	220 – 240 V	**440 – 480 V**		
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	1500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

57.2.4 Except as indicated in 57.2.6 – 57.2.9, an overcurrent protective or a thermal protective device in an appliance having more than one motor wired for connection to one supply line shall withstand short-circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

57.2.5 The nearest standard size fuse, rated no higher than the current indicated in 57.2.4 but no less than 15 amperes, is to be used for the test. The maximum fuse size marked on the appliance, as specified in 69.2, is not to exceed this value.

57.2.6 With reference to 57.2.4, the protective device may be tested with a fuse having a lower rating than indicated if the appliance:

a) Will start and operate without blowing the fuse; and

b) Is marked to indicate such a maximum limit of fuse protection.

57.2.7 The test specified in 57.2.1 is not required to be conducted if:

a) A thermally protected motor or a separately enclosed motor-overload protective device is within an outer cabinet of the appliance;

b) The motor or device is intended to be protected by a fuse or HACR Type circuit breaker as specified on the unit nameplate or provided as part of the unit and is acceptable for branch-circuit protection;

c) The assembly is constructed so that flame and molten metal are confined within the cabinet;

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 11.2.16; and

e) Short-circuiting between live parts of different circuits does not result.

57.2.8 Short circuit tests need not be conducted on an assembly provided with more than one motor, each not exceeding 1 horsepower (746 W output) in rating and intended to be used on a branch circuit protected at no more than 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, if the following conditions are met:

a) The marked maximum branch circuit protective device size does not exceed 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts; and

b) The full-load current rating of each motor does not exceed 6 amperes.

57.2.9 Short circuit tests are not required to be conducted on an assembly provided with more than one motor if the motors have full-load current or horsepower rating(s) in excess of those ratings specified in 57.2.8 if:

a) The marked maximum branch circuit protective device size of the assembly does not exceed the maximum size for protecting the motor of the smallest rating; and

b) It is determined that a fuse of marked size will not open under the most severe conditions of service that might be encountered.

57.2.10 A nonrenewable cartridge fuse is to be connected in series with the device. A new fuse and device, connection, or conductor are to be used for each test.

57.2.11 Bonding conductors and bonding connections shall not open when the appliance is subjected to the conditions of this test.

57.2.12 Motor-circuit conductors shall not become damaged when the appliance is subjected to the conditions of this test.

57.2.13 For the test referenced in Exception No. 2 of 16.3.3, three samples of each conductor under consideration are to be subjected to each test condition specified and a new protective device is to be used for each test. The conductor and connection to be tested are to be connected in series with the overcurrent-protective device. Consideration is to be given to both short-circuit and ground-fault conditions. The capacity of the circuit is to be based on the ratings of the unit in accordance with Table 57.1 and is to be measured without the lead to be tested in the circuit. The voltage source for the test circuit is to be as specified in Table 57.1 and the power factor is to be 0.9 – 1.0 unless a lower power factor is determined to be acceptable. None of the conductors or lead terminations shall be damaged as a result of the test.

57.2.14 There shall be no ignition of cheesecloth surrounding the enclosure of a protective device when three samples are tested.

58 Non-Metallic Dip Tube Test – Water Heaters

58.1 Deformation of weight loss

58.1.1 A nonmetallic dip tube when tested in accordance with the requirements of 58.1.2 – 58.1.4 shall:

a) Have a linear deformation not in excess of 1/2 inch (12.7 mm);

b) Have a total lateral deformation not in excess of 1-1/2 inches (38.1 mm); and

c) Undergo no weight loss.

58.1.2 Twelve 51 inch (1.30 m) long samples of each kind and section of dip tubes 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.

58.1.3 Linear deformation is to be determined by suspending the samples as they are in service for 40 hours in water maintained at 93°C (200°F). These samples are then to be cooled to room temperature, any surface water is to be removed, and the length and weight are to be determined and compared with the original results. Any weight loss is evidence of noncompliance.

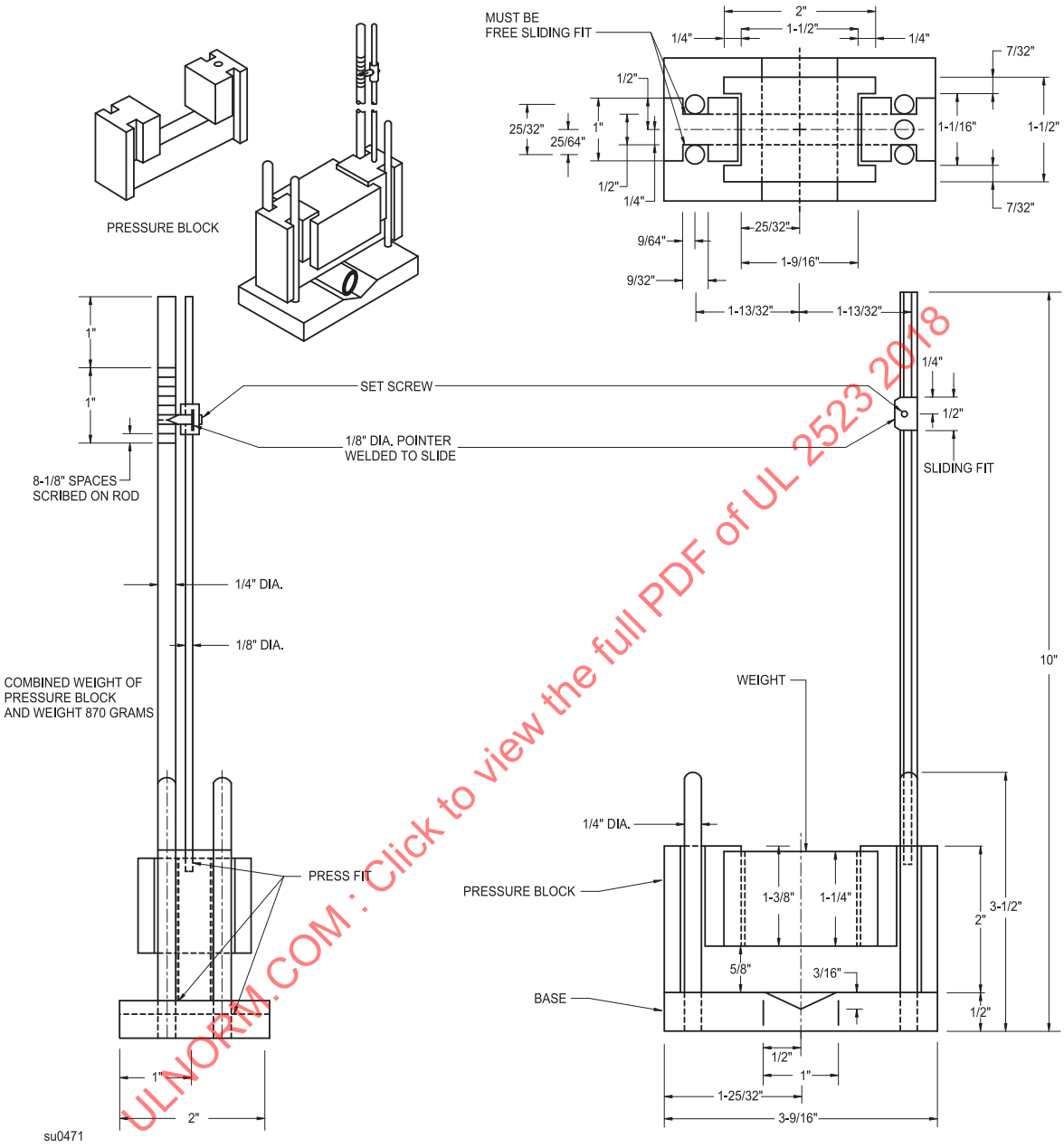
58.1.4 Lateral deformation is to be determined by installing one end of each sample in a fixture (as it is by a tank inlet fixture) and measuring the distance between the position of the center line of the free end and the extended center line of the fixture. Following immersion for 48 hours in water maintained at 93°C (200°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 capable of being used when 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.

58.2 Resistance to crushing

58.2.1 A nonmetallic dip tube shall not deform more than 1/4 inch (6.4 mm) for a test period of 24 hours when subjected to transverse loading under a weight of 870 grams (31 ounces) while being maintained at a temperature of 107 plus 3 minus 0°C (225 plus 5 minus 0°F) as described in 58.2.2 – 58.2.5.

58.2.2 Ten 2 inch (50.8 mm) long samples of each kind and section of dip tubes are to be subjected to this test. The apparatus for the test is to be as illustrated in Figure 58.1.

Figure 58.1
Heat deformation tester



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

58.2.3 The scale on the test apparatus shown in Figure 58.1 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 required to 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 plus 3 minus 0°C (225 plus 5 minus 0°F). The temperature is then to be held constant for the duration of the test.

58.2.4 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.

58.2.5 The dip tube complies with the requirements when the average deformation of the samples does not exceed 1/4 inch (6.4 mm) and the rate of deformation is uniform. Immediate deformation of any test sample upon application of the test load is to be identified as noncompliance of the lot submitted for test.

58.3 Collapse

58.3.1 A nonmetallic dip tube shall not collapse, as evidenced by a reduction in internal diameter in excess of 1/8 inch (3.2 mm) after immersion in water at a temperature of 107 plus 3 minus 0°C (225 plus 5 minus 0°F) under the conditions of test described in 58.3.2 – 58.3.6. A tank rated for the test pressure is to be used.

58.3.2 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 58.3.3 – 58.3.6.

58.3.3 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 outlet 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.

58.3.4 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 is 40 psi (276 kPa).

58.3.5 The storage vessel is to be filled and the test water heater placed in operation, with the thermostat bypassed. When the temperature indicated by the thermometer or thermocouple in the top of the storage vessel is 107 plus 3 minus 0°C (225 plus 5 minus 0°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.