

January 10, 2007

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SUBJECT 2523

OUTLINE OF INVESTIGATION

FOR

SOLID FUEL-FIRED WATER HEATERS AND BOILERS

Issue No. 1

JANUARY 10, 2007

Summary of Topics

This is the first issue of the Outline of Investigation for Solid Fuel-Fired Water Heaters and Boilers.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net.ul.com/ulforeword.html>

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INTRODUCTION

1 Scope

1.1 These requirements apply to factory built manually and/or automatically fueled solid fuel-fired water heaters and boilers, as defined in Section 5, intended to be fixed non-moveable appliances.

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

1.3 The furnaces 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 Outline of Investigation 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 Outline of Investigation; or
- b) Is superseded by a requirement in this Outline of Investigation.

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.

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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 outline are rms.

4 Undated References

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

5 Glossary

5.1 For the purpose of this outline of investigation, 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 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.

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

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

5.23 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.

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

5.25 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:

- a) An internal maximum working pressure of less than 160 psi (1103 kPa) and storage water volume not in excess of 120 gallons (454 L) or;
- b) A constant atmospheric internal working pressure and a storage water capacity not in excess of 1000 gallons (3785 L).

CONSTRUCTION – ALL APPLIANCES

6 Corrosion Protection

6.1 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.

6.2 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.

ELECTRICAL – ALL APPLIANCES

7 General

7.1 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.

7.2 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.

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 so as 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

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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 are to 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.

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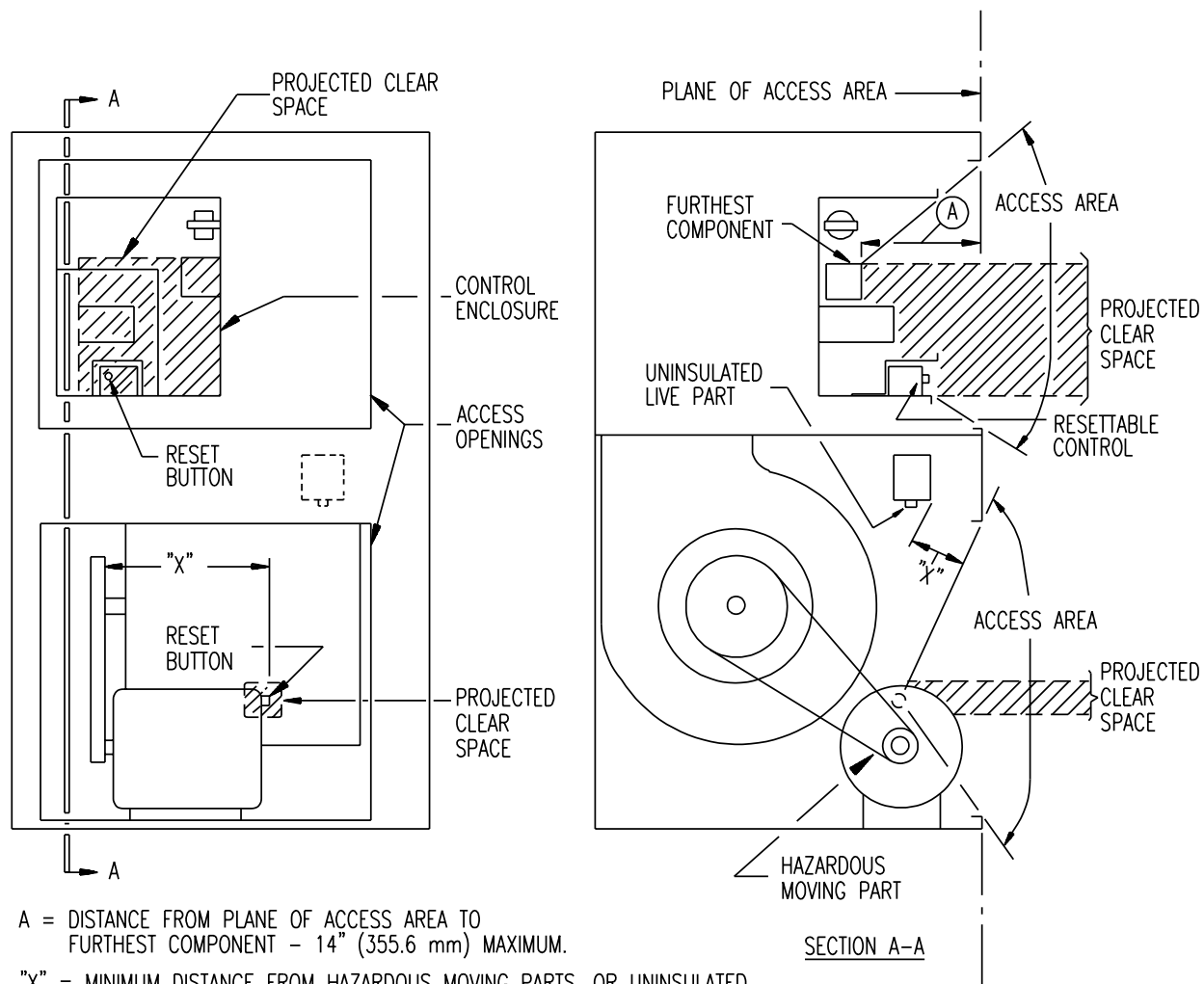
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Figure 8.1
Accessibility and protection



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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. If the removal of doors, panels or shields will expose such moving parts;

- a) The opening or removal of the door, panel or shield shall require the use of tools; or
- b) An interlocking device shall shut off the mechanism; or
- c) A warning marking shall be displayed as described in 70.2.17.

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).

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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 is not to be considered when judging compliance with 8.1 and 8.9 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

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 judging the acceptability of an enclosure are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Combustibility;
- e) Resistance to corrosion; and
- f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

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

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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 inches (cm)	Maximum length ^c inches (cm)	Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	Uncoated (MSG)	Metal coated (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)
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 least 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		inches (mm)	
inches	(cm)	inches	(cm)	inches	(mm)
3.0	(7.6)	Not limited	7.0	Not limited	0.023 (0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)
4.0	(10.2)	Not limited	10.0	Not limited	0.029 (0.74)
5.0	(12.7)	6.0	(15.2)	13.5	(34.3)
6.0	(15.2)	Not limited	14.0	Not limited	0.036 (0.91)
6.5	(16.5)	8.0	(20.3)	18.0	(45.7)
8.0	(20.3)	Not limited	19.0	Not limited	0.045 (1.14)
9.5	(24.1)	11.5	(29.2)	25.0	(63.5)
12.0	(30.5)	Not limited	28.0	Not limited	0.058 (1.47)
14.0	(35.6)	16.0	(40.6)	37.0	(94.0)
18.0	(45.7)	Not limited	42.0	Not limited	0.075 (1.91)
20.0	(50.8)	25.0	(63.4)	55.0	(139.7)
25.0	(63.4)	Not limited	60.0	Not limited	0.095 (2.41)
29.0	(73.7)	36.0	(91.4)	78.0	(198.1)
37.0	(94.0)	Not limited	87.0	Not limited	0.122 (3.10)
42.0	(106.7)	53.0	(134.6)	114.0	(289.6)
52.0	(132.1)	Not limited	123.0	Not limited	0.153 (3.89)
60.0	(152.4)	74.0	(188.0)	160.0	(406.4)

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

- 1) single sheet with single formed flanges (formed edges),
- 2) a single sheet which is corrugated or ribbed, and
- 3) an enclosure surface loosely attached to a frame, 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 least 1/2 inch (12.7 mm) wide.

9.1.5 Electrical parts within the outer cabinet need not 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 to the outer cabinet unless the thickness of sheet metal is in compliance with Table 9.1;

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- 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 are to be considered when determining if it complies with the requirement of 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 is 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.

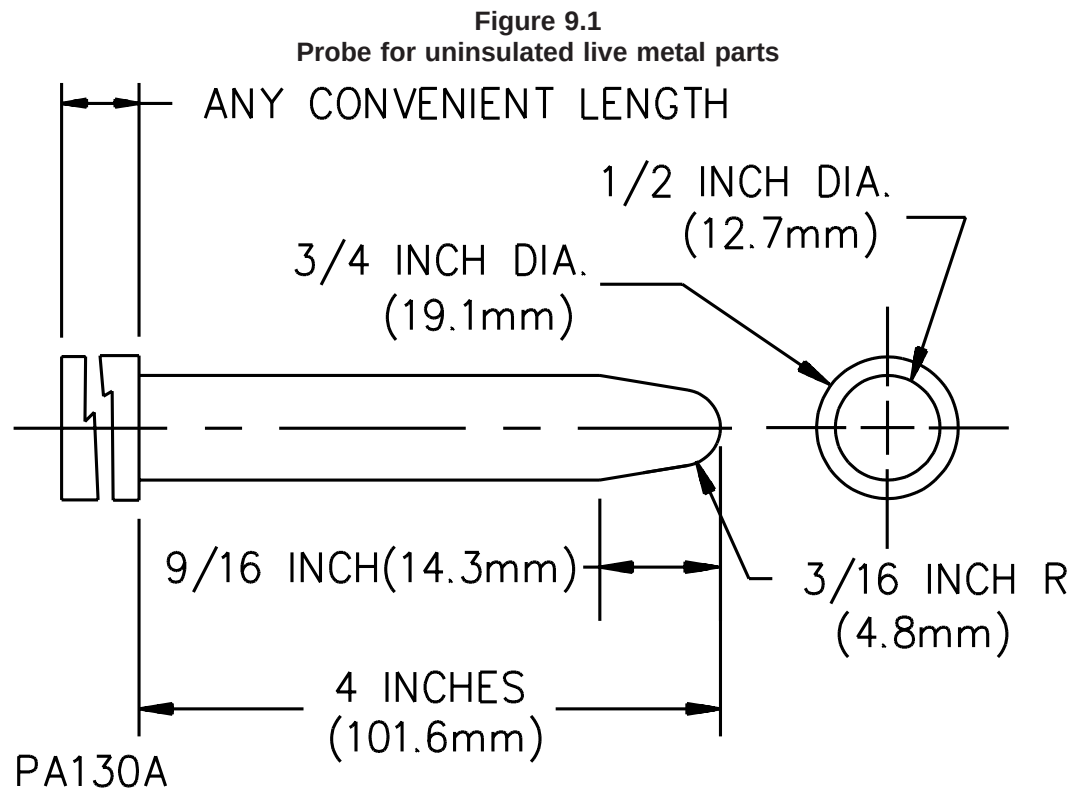
9.1.14 A junction box partially formed by another part such as a fan scroll or a motor casing is to fit such that:

- 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 judging an opening in an electrical enclosure are given in the following items and the related figures:

- a) An opening that will 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 will permit entrance of a 3/4 inch diameter rod is acceptable under the conditions described in Figure 9.3.



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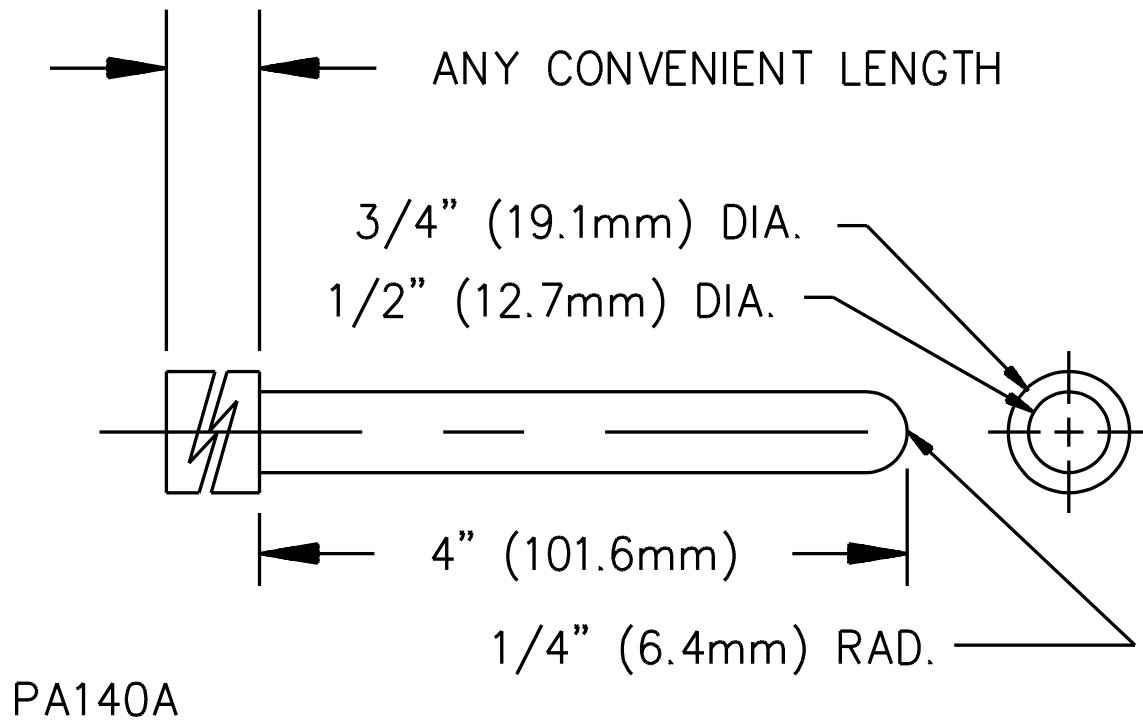
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Figure 9.2
Probe for film-coated wire

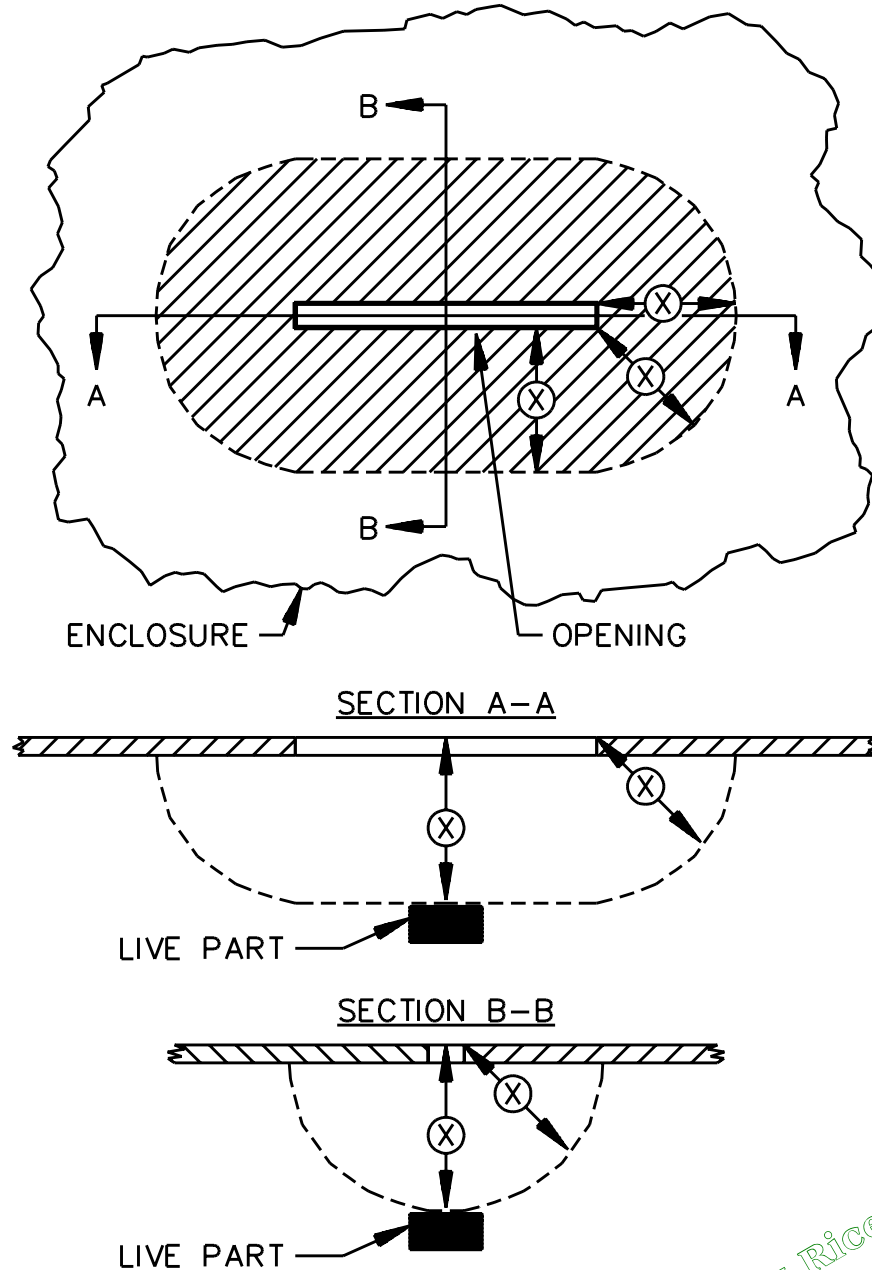


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Figure 9.3
Opening in enclosure



EC100B

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

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

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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 – General

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 judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

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

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

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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 boiler 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.

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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.

9.4.5 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.

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 mm²).

Table 10.1
Size of junction boxes

Size of conductor AWG (mm ²)	Free space within box for each conductor, 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

Wire size AWG (mm ²)	Number of wires				
	2	3	4	5	6
^a This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of type THW wire.					

10.1.6 Wiring exterior to an appliance assembly between the burner assembly and a limit control, a primary safety 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 boiler assembly if adequate instructions for installing such wiring are furnished with each boiler assembly. 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 boiler assembly 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 will 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 boiler assembly 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.

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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 might result 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 will be prevented from turning or shifting in position if such motion may result 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 mm²) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

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 mm²).

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 mm²) 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 mm²) or smaller wire, and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm²); 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 mm²).

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 boiler assembly. If the boiler assembly 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 boiler assembly.

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.

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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	FFH-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)

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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, if used, shall be not 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 are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

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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 will provide 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 will not permit entrance of a rod having a diameter of 1/2 inch (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 inch 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 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 so located 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 mm²) 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 may permit operation of the appliance that may result 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 is to 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.

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