UL 834

STANDARD FOR SAFETY

Heating, Water Supply, and Power Boilers – Electric

UL Standard for Safety for Heating, Water Supply, and Power Boilers – Electric, UL 834

Fifth Edition, Dated April 13, 2004

Summary of Topics

This revision of ANSI/UL 834 dated July 17, 2019 includes Limit control clarifications.

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.

The revisions are substantially in accordance with Proposal(s) on this subject dated May 17, 2019.

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1

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The most recent designation of ANSI/UL 834 as an American National Standard (ANSI) occurred on July 11, 2019. 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.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

RATING

MARKING

INSTRUCTIONS

APPENDIX A

INTRODUCTION

1 Scope

1.1 These requirements cover electric heating, water supply, and power boilers rated at 15,000 volts or less intended for commercial or industrial applications utilizing hot water or steam. They may also be used for commercial, industrial, or residential use space heating applications.

1.2 The boilers covered by these requirements are intended for installation in accordance with the National Electrical Code, NFPA 70, the International Mechanical Code, and the Uniform Mechanical Code.

1.3 Each boiler consists of sheathed resistance-type heating elements and a vessel or tank constructed, inspected, and stamped in accordance with the applicable sections of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Each boiler is provided with one or more safety valves or safety relief valves conforming to ASME requirements with all necessary temperature or pressure regulating controls, including an integral limit control, wiring, and auxiliary equipment assembled as a unit.

1.4 These requirements do not cover water supply boilers and hot water and steam generating equipment employing constructions which are outside the scope of, or not covered by, the ASME codes, nor commercial cooking or medical and dental equipment, nor other electric heating equipment or appliances which are covered in, or as part of, separate, individual requirements. Electrode-type boilers also are not covered by these requirements.

1.5 The equipment covered by this standard shall be one of the following types of water heating boilers:

a) High Pressure – A boiler furnishing:

1) Steam at pressures in excess of 15 psi (103 kPa); or

2) Hot water at temperatures in excess of 250°F (121°C) or at pressures in excess of 160 psi (1103 kPa).

b) Low-Pressure Hot-Water and Low-Pressure Steam – A boiler furnishing:

1) Hot water at pressures not exceeding 160 psi and at temperatures not more than 250°F; or

2) A boiler furnishing steam at pressures not more than 15 psi.

c) Miniature – A boiler that does not exceed the following limits:

1) 16 inches (406 mm) inside diameter of shell; and

2) 5 cubic feet (0.14 m^3) gross volume, exclusive of casing and insulation, and 100 psi (690 kPa) maximum allowable working pressure.

For the applicable ASME Code symbol, see Section 5.

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. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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.

2.5 A component of a boiler intended to be manually operated or adjusted or that will definitely require periodic servicing, for example replacement or cleaning, shall be accessible without the use of special tools.

3 Units of Measurement

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

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 Special Designations

5.1 A boiler assembly shall be constructed, equipped, inspected, tested, and marked in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code. The boiler marking shall consist of the ASME Code symbol and one of the following Designators.

″E″ – Designates a high pressure boiler [see 1.5(a)] constructed as follows:

1) The boiler pressure vessel has been assembled by a manufacturer other than the boiler manufacturer in accordance with the ASME Boiler and Pressure Vessel Code, Section I, Rules for Construction of Power Boilers or Section VIII, Division 1 as permitted by ASME Boiler and Pressure Vessel Code, Section I, Part PEB, Rules for Construction of Pressure Vessels;

2) The pressure vessel is stamped with the ASME Code Designator ″S″, ″M″, or ″U″; and

3) The boiler is assembled by methods that do not involve any welding or brazing of parts to the pressure vessel.

″H″ – Designates a low pressure steam or hot water boiler [see 1.5(b)] constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers.

″M″ – Designates a miniature boiler [see 1.5(c)] constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section I, Part PMB, Rules for Construction of Power Boilers.

″S″ – Designates a high pressure steam or high-temperature water boiler [see 1.5(a)] constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section I, Rules for Construction of Power Boilers.

″U″ – This Designator, along with the letters ″UB″, applies only to a pressure vessel when the vessel is constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels. The boiler has been completed in accordance with Section I, Part PEB, of the ASME Boiler and Pressure Vessel Code, Rule for Construction of Power Boilers.

6 Glossary

6.1 For the purpose of this standard the following definitions apply.

6.1.1 CONTROL ENCLOSURE PANEL – An enclosure for individual electrical components to prevent accidental contract with energized parts and to protect the components from physical damage.

6.2 PROTECTIVE (SAFETY) CONTROL – A control intended to prevent the risk of electric shock, fire, or injury to persons during abnormal operation of the appliance. An example would be a water temperature limit control. A protective control always provides Type 2 action. (See definitions 6.11 and 6.12.)

6.3 LIMIT CONTROL – A protective (safety) control that is responsive to changes in pressure, temperature, liquid level, or flow. This control may be used for regulating purposes or may be set beyond the intended operating range of the controlled equipment to limit its operation. This control may be electrical or mechanical in nature.

6.4 LOW VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts rms (42.4 volts peak) supplied by a battery or by a standard Class 2 transformer or other acceptable transforming device, or by a combination of transformer and fixed impedance having output characteristics in compliance with requirements established for a Class 2 transformer. A circuit obtained by connecting resistance in series with a line voltage supply circuit as a means of limiting the voltage and current is not considered to be a low voltage circuit.

6.5 OPERATING CONTROL – A control intended to start or regulate the appliance during normal operation. An example would be a water temperature-regulating control. An operating control could provide Type 1 and Type 2 actions. (See definitions 6.11 and 6.12). However, for the purposes of these requirements, is not intended to provide the regulating function of the boiler, see Section 31, Limit Controls.

6.6 PORTABLE – A boiler that is moved or can be easily moved from one place to another in normal use.

6.7 SAFETY RELIEF VALVE – An automatic pressure relieving device actuated by pressure upstream of the valve and characterized by opening pop action with further opening with increase in pressure over the popping pressure.

6.8 SAFETY VALVE – An automatic pressure relieving device actuated by pressure upstream of the valve and characterized by opening pop action.

6.9 TEMPERATURE-PRESSURE RELIEF VALVE – An automatic resetting pressure relieving device, actuated by pressure and by an integral thermal element that is in contact with, or is responsive to, the heated fluid. Functions similar to safety relief valve.

6.10 TRIM – Term used by industry for safety controls (mechanical, electrical, and visible) as stated in the ASME Code. This does not include decorative parts of the boiler. Examples of trim include the following:

a) Hot water heating boilers (Section IV):

1) Pressure gage;

2) Thermometer;

3) Water gage glass(es);

4) Pressure relief valves; and

5) Flow switches.

b) Low pressure steam boilers (Section IV):

1) Water gage glass(es);

2) Steam gages; and

3) Pressure relief valves.

c) High temperature hot water boilers (Section I):

1) Water gage glass(es);

2) Pressure gages;

3) Temperature gages; and

4) Pressure relief valves.

d) High pressure steam boilers (Section I):

1) Water gage glasses (including protective rods or shields on tubular water gage glasses);

2) Water gage glass connections;

3) Gage cocks;

4) Pressure gages; and

5) Pressure relief valves.

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

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

6.13 MEDIUM VOLTAGE – Voltage greater than 600 V, up to and including 15,000 V.

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CONSTRUCTION

7 Frame and Enclosure

7.1 General

7.1.1 The frame and enclosure of a boiler shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses likely to be encountered during intended service. The degree of resistance inherent in the boiler shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects that alone or in combination constitute an increase in the risk of fire, electric shock, or injury to persons.

7.1.2 An enclosure for individual electrical components, an outer enclosure, and combinations of the two are considered in determining compliance with 7.1.1.

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

7.1.4 Among the factors taken into consideration when an enclosure is being judged for acceptability 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 aging.

7.1.5 An outer cabinet is to be judged with respect to the size, shape, and thickness of metal. See 7.3.1.

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

Exception: This requirement does not apply to an opening for a mounting screw or nail, or for a manufacturing operation (such as paint drainage) if the opening has no dimension more than 17/64 inch (6.75 mm) or an area no more than 0.055 square inch (35.49 mm^2).

7.1.7 An opening for ventilation in the enclosure, other than in the bottom, shall be provided with one or more baffles that will reduce the likelihood of the emission of flame, molten metal, burning insulation, or the like from the boiler. A baffle as illustrated in Figure 7.1 located between an electrical part and an opening is considered to be acceptable.

Exception No. 1: In a compartment other than the one that houses a motor-overload relay or overcurrent-protective device, such as a fuse or circuit breaker, the baffles mentioned above may be omitted if:

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

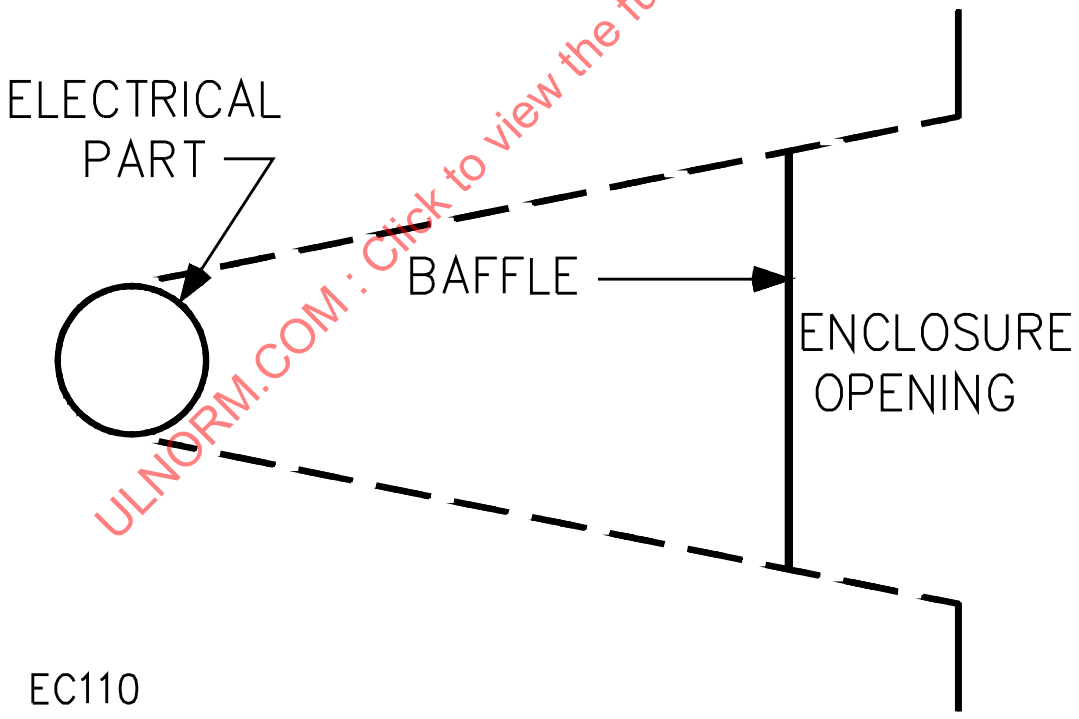
b) The enclosure is constructed so that it is found to be acceptable by short-circuit tests in accordance with Section 50.

Exception No. 2: Louvers in a vertical wall are acceptable without baffling if:

a) The width of each opening is not more than 3/8 inch (9.5 mm); and

b) There is no direct line-of-sight to a motor-overload relay or overcurrent-protective device.

Figure 7.1
Relationship of baffle and electrical part



7.2 Doors and covers

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

7.2.2 The door or cover of an enclosure shall be hinged if:

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

b) Uninsulated live parts are exposed during the routine replacement of the fuse or resetting of the manual reset device. Such a door or cover shall also be provided with an automatic latch (see 7.2.5) or the equivalent. If live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, a captive screw or equivalent means, which requires the use of a tool or key to open, shall be provided to secure the door or cover in place. See 7.2.3.

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

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

b) An extractor-type fuse with its own enclosure.

7.2.3 The captive screw may be omitted from the door or cover over the compartment housing the uninsulated live parts if it is provided in the cover that must be opened to gain access to the door or cover. An arrangement employing two mating hinged doors is acceptable if the automatic latch and captive screw are provided only on one door if:

a) That door is to be opened first and closed last; and

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

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

7.2.5 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door closed and requires some effort on the user's part to open it is considered to be an acceptable means for holding the door closed as required by 7.2.2.

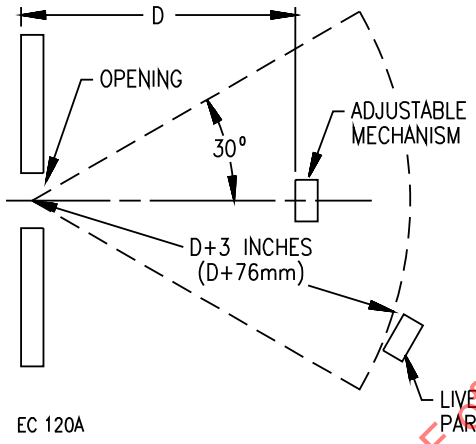
7.2.6 A cover interlocking mechanism is considered to comply with 7.2.2 if it:

a) Must be engaged in the closed position of the cover before parts are energized; and

b) Secures the cover in the closed position, when provided as the sole means for securing the door or cover closed.

7.2.7 If an opening is provided for access to a control that is intended to be reset, adjusted, or otherwise manipulated by the user or service personnel, it shall not be possible to contact live uninsulated or film-coated insulated parts when examined in conjunction with Figure 7.2.

Figure 7.2
Acceptability of live part through adjustment opening



A live part beyond an opening that may be used in making an adjustment that is considered to be a function of user servicing is not considered to be accessible if a 1/16-inch (1.59-mm) diameter straight rod cannot touch the part when the rod is inserted through the opening and moved to all positions possible without producing an angle of more than 30 degrees between the rod and a line drawn between the center of the opening and the center of the face of the adjusting mechanism. The length of the rod beyond the opening shall not exceed the distance between the opening and the face of the adjusting mechanism by more than 3.0 inches (76.2 mm).

7.3 Enclosure thickness

7.3.1 Sheet metal that serves as an electrical enclosure shall comply with Tables 7.1 and 7.2. An enclosure thinner than specified in Tables 7.1 and 7.2 shall comply with 7.1.1 with respect to the following:

a) Location of the enclosure;

b) Construction and location of components; and

c) The strength and rigidity of the frame and enclosure.

Table 7.1
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in 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	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(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		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	(15)		(15)	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	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)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(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 the torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Constructions that are 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) A 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, e.g., 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 limited to the dimensions specified.

[d] Sheet steel for an enclosure intended for outdoor use is required to be not less than 0.034 inch (0.86 mm) in thickness if metal coated and not less than 0.032 inch (0.81 mm) in thickness if uncoated.

Table 7.2
Minimum thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inches (mm)	(AWG)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)	(18)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(6)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)	

[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 the torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Constructions that are 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) A 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, e.g., 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 limited to the dimensions specified.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use is required to be not less than 0.029 inch in thickness.

7.3.2 With reference to 7.3.1(a), the surface of an enclosure which will be protected from damage shall not be less than 22 MSG or GSG (steel) or 18 AWG (aluminum, copper, or brass) unless a lesser thickness meets the requirements in Tables 7.1 and 7.2. See 7.1.5 and 12.1.

7.3.3 With reference to 7.3.1(b), the minimum thickness of an enclosure is able to be less than specified in Tables 7.1 and 7.2 for the size enclosure as indicated below. The thickness is not to be less than 0.026 inch (0.66 mm) uncoated steel or 0.029 inch (0.74 mm) coated steel or 0.036 inch (0.91 mm) aluminum, copper, or brass unless a lesser thickness meets the requirements in Tables 7.1 and 7.2. See 7.1.5 and 12.1.

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

b) When the electrical components are located at least 5 inches (128 mm) from the enclosure surface, the minimum thickness is to be the value indicated in the second line above the normal value.

7.3.4 With reference to 7.3.1(c), consideration is to be given to the degree of deflection or distortion which may affect the requirements of 7.1.1.

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

7.3.6 The specifications in 7.3.5 require use of a barrier of nonflammable material:

a) Under a motor unless:

1) The structural parts of the motor or of the boiler provide the equivalent of such a barrier;

2) The motor is provided with a thermal motor protector (a protective device that is sensitive to both temperature and current) that prevents the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load under which the motor runs without causing the protector to cycle, and from becoming more than 150°C (302°F) with the rotor of the motor locked; or

3) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the heater when the motor is energized under each of the following fault conditions:

i) Open main winding;

ii) Open starting winding;

iii) Starting switch short-circuited; and

iv) Capacitor of a permanent split capacitor motor short-circuited.

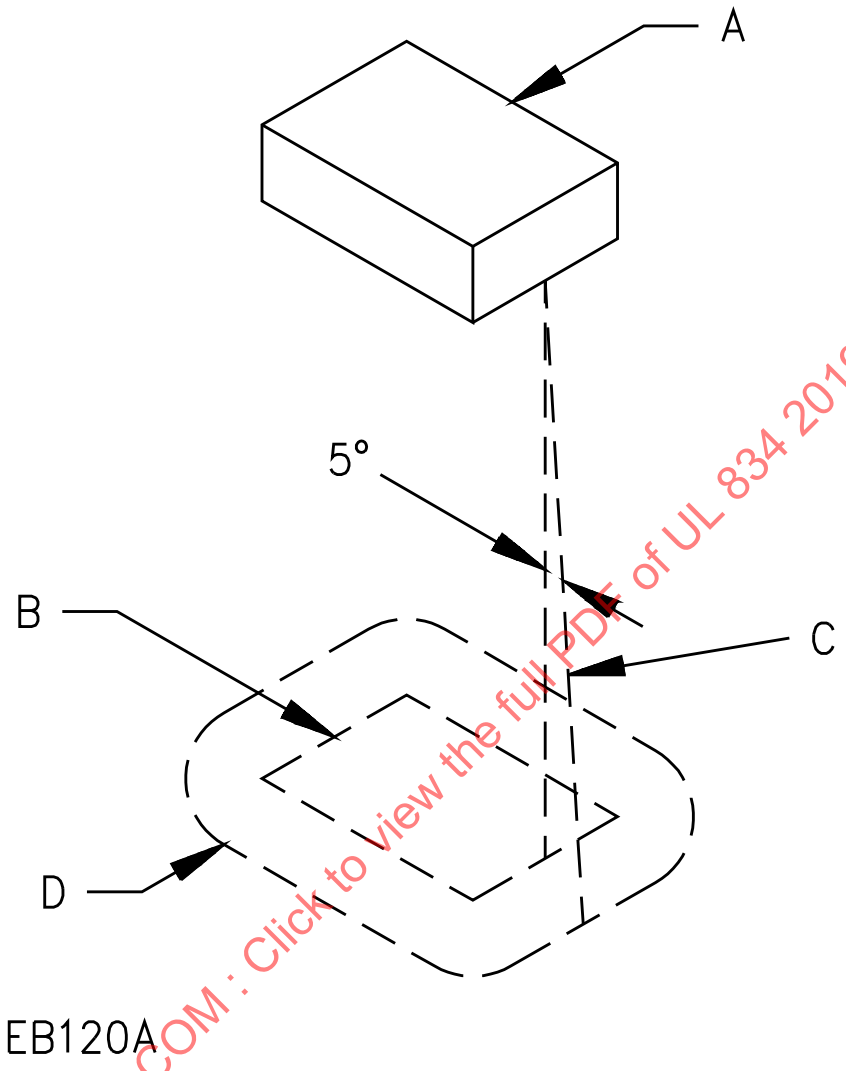
b) Under wiring, unless it is of the flame retardant type. Neoprene or thermoplastic insulated wires are considered to be of this type.

A switch, transformer, relay, solenoid, or a similar device shall be individually and completely enclosed except at terminals, unless it is determined that malfunction of the component does not result in a risk of fire, or unless there are no openings in the bottom of the enclosure. An opening in the bottom of the enclosure does not meet the intent of the requirement when it is located directly below field or factory made splices, or overload or overcurrent protective devices.

Exception: A bottom barrier is not required when the unit is marked in accordance with 57.21.

7.3.7 The barrier mentioned in 7.3.6 shall be horizontal, shall be located as indicated in Figure 7.3, and shall have an area not less than described in Figure 7.3. 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 7.3
Location and extent of barrier



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

B – Projection of outline of component on horizontal plane.

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

1) Tangent to the component;

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 that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

7.4 Live parts

7.4.1 An electrical part of a boiler shall be so located or enclosed that protection against unintentional contact with uninsulated live parts is provided.

7.4.2 With respect to 7.4.1, to reduce the likelihood of unintentional contact that involves a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either (a) or (b):

a) For an opening that has a minor dimension (see 7.4.6) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 7.4.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 7.3.

Exception: This requirement does not apply to a motor that already complies with 7.4.3.

Figure 7.4
Articulate probe with web stop

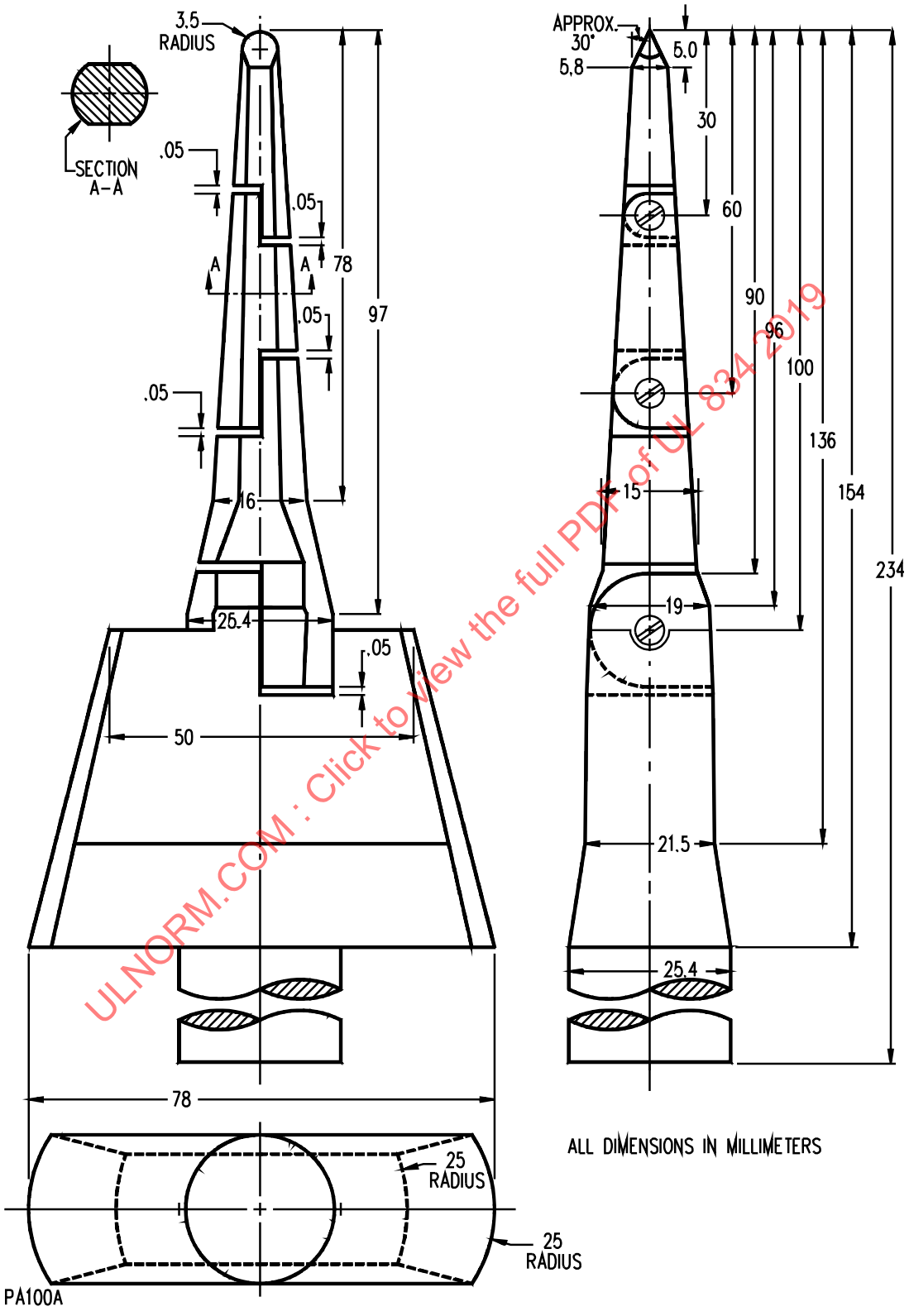


Table 7.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] or opening		Minimum distance from opening to part	
inches	(mm)[b]	inches	(mm)[b]
3/4	(19.1)[c]	4-1/2	(114.0)
1	(25.4)[c]	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
		30	(762.0)

[a] See 7.4.6.

[b] Between 3/4 inch (19.1 mm) and 2-1/8 inches (53.9 mm), interpolation is to be used to determine a value between values specified in the table.

[c] Any dimension less than 1 inch (25.4 mm) applies to a motor only.

[d] More than 2-1/8 inches (53.9 mm), but not more than 6 inches (152.0 mm).

7.4.3 With respect to a part or wire as mentioned in 7.4.2, in an integral enclosure of a motor as mentioned in the Exception to 7.4.2:

a) An opening that has a minor dimension (see 7.4.6) less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 7.6;

2) In a directly accessible motor (see 7.4.7), an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.7; and

3) In an indirectly accessible motor (see 7.4.7), an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.5.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 7.3.

Figure 7.5
Probe for uninsulated live parts

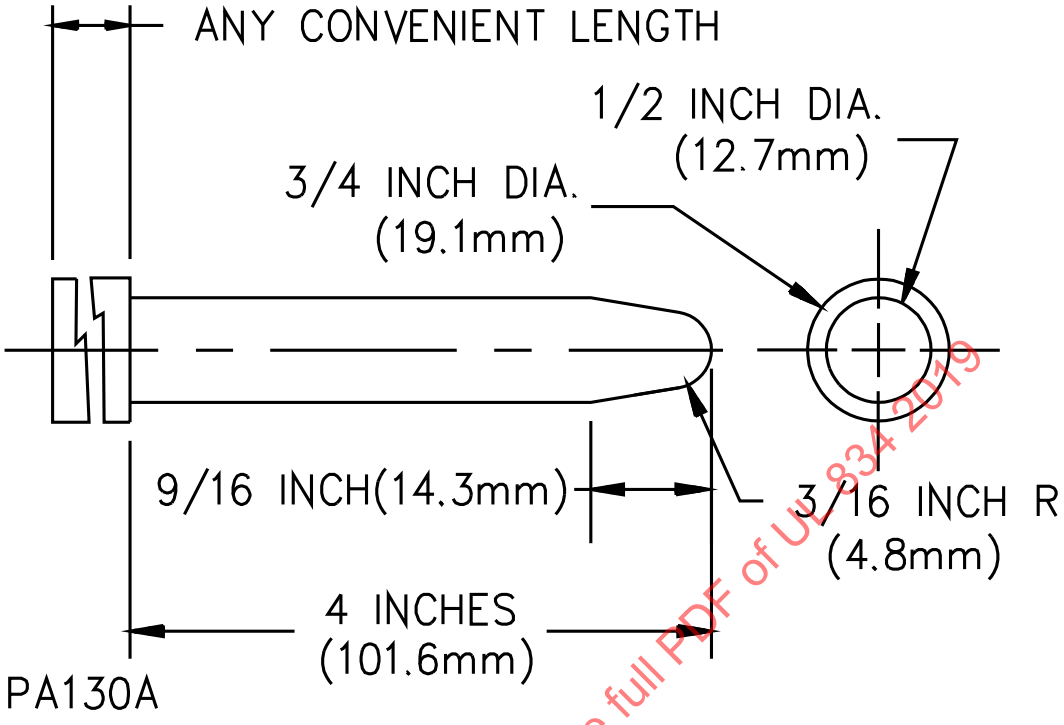


Figure 7.6
Probe for film coated wire

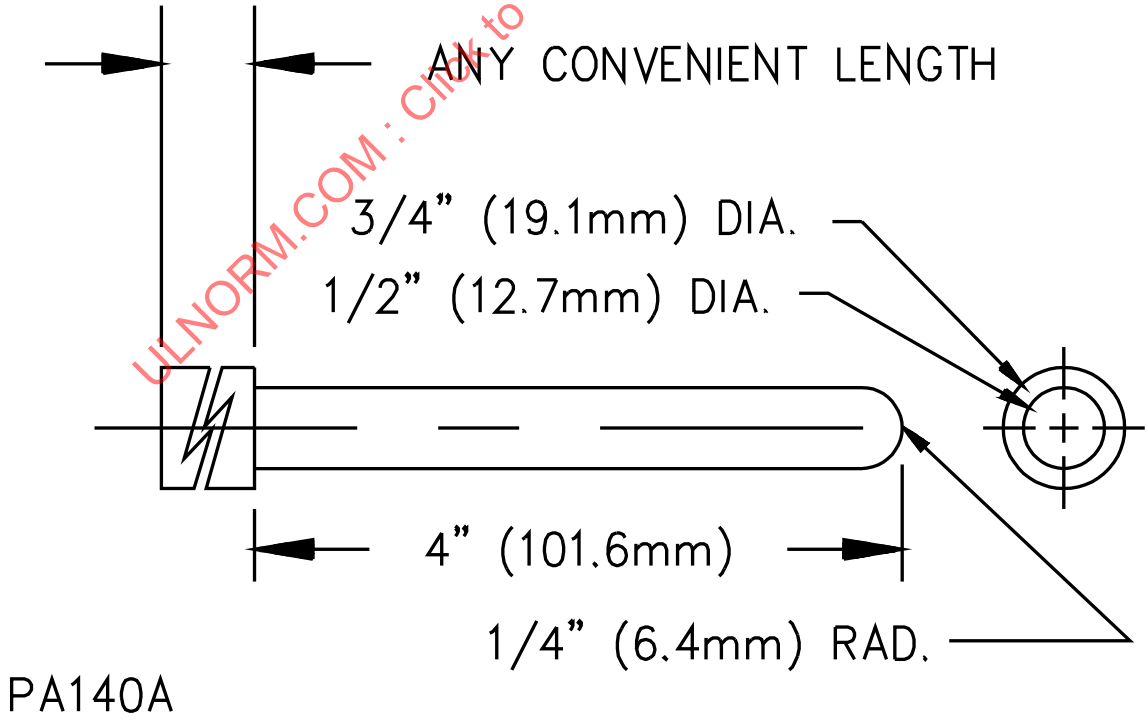
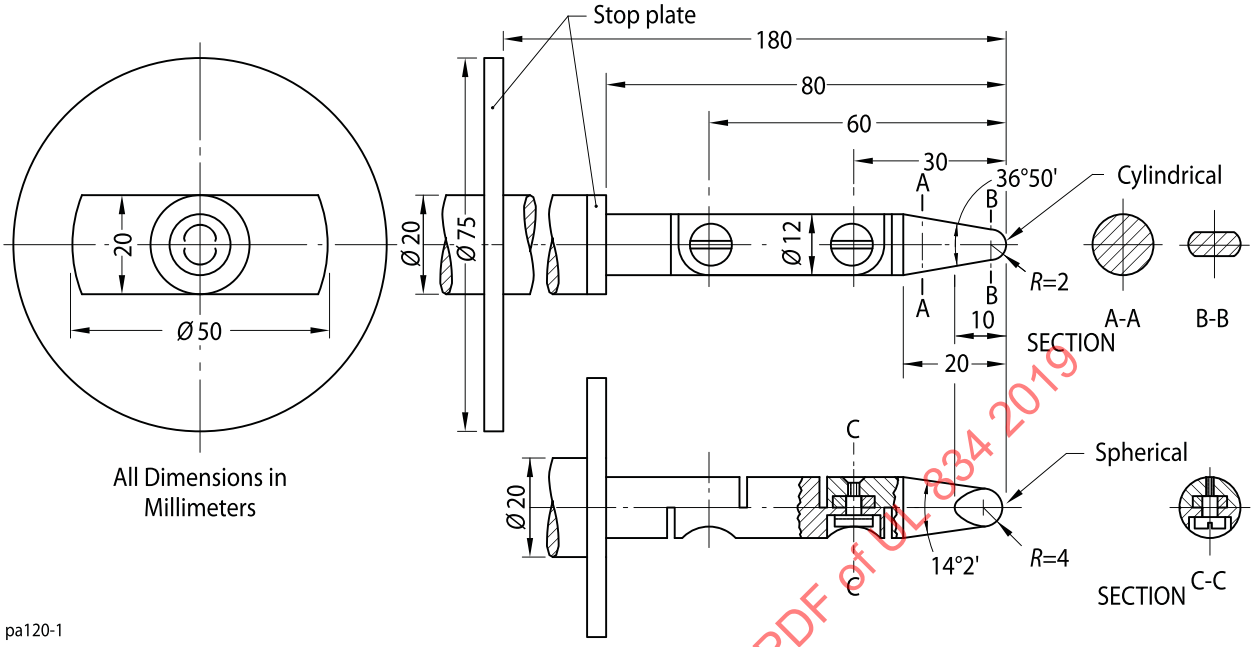


Figure 7.7
Articulate probe



7.4.4 The probes mentioned in 7.4.2 and 7.4.3 and illustrated in Figures 7.4 – 7.7 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. The probes illustrated in Figures 7.4 and 7.7 shall be applied in any possible configuration, and if necessary, the configuration shall be changed after insertion through the opening.

7.4.5 The probes mentioned in 7.4.4 and 7.4.6 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 are to be applied with the minimum force necessary to determine accessibility.

7.4.6 With reference to the requirements in 7.4.3 and 7.4.3, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

7.4.7 With reference to the requirements in 7.4.3, an indirectly accessible motor is a motor that is:

a) Accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool; or

b) Located at such a height, or is otherwise guarded or enclosed, so that it is unlikely to be contacted.

A directly accessible motor is a motor that can be contacted without opening or removing any part, or is located so as to be accessible to contact.

7.4.8 During the examination of a boiler in connection with the requirements in 7.4.2 or 7.4.3, a part of the outer enclosure that may be removed without the use of tools by the user of the boiler to permit the attachment of accessories, to allow access to means for making operating adjustments, or for other reasons, is to be disregarded; that is, it will not be assumed that the part in question affords protection against the risk of electric shock. A warning marking as specified in 48.8 is not considered to reduce against this risk of electric shock.

7.4.9 With reference to the requirements in 7.4.2 and 7.4.3, insulated brush caps are not required to be additionally enclosed.

8 Protection of Service Personnel

8.1 An uninsulated live part, and moving parts within the enclosure likely to cause injury to persons, which require examination, adjustment, servicing or maintenance while energized, shall be located, guarded, or enclosed to minimize unintentional contact by service personnel performing service functions that are performed with the equipment energized.

8.2 Mechanical service functions which have to be performed with the equipment energized include adjusting water control valves, adjusting the setting of temperature or pressure controls, resetting control trip mechanism, operating manual switches, oiling motors, and similar tasks. A factory set and sealed control is not considered to be adjustable.

8.3 The requirements in 8.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized. Such functions including opening of drain plugs, adjusting or replacing drive belts, and similar tasks.

8.4 Adjustable or resettable electrical controls 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 is accomplished in the normal direction of access if uninsulated live parts or moving parts 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.

Only uninsulated live parts involving a risk of electric shock are to be considered.

8.5 Accessibility and protection from the likelihood of electric shock and personal injury may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 8.1. If this construction is used, the following criteria apply:

a) The components shall be located with respect to the access opening in the outer cabinet so that the farthest component in the assembly is not more than 14 inches (356 mm) from the plane of this 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 likely to cause injury to persons shall be located no 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

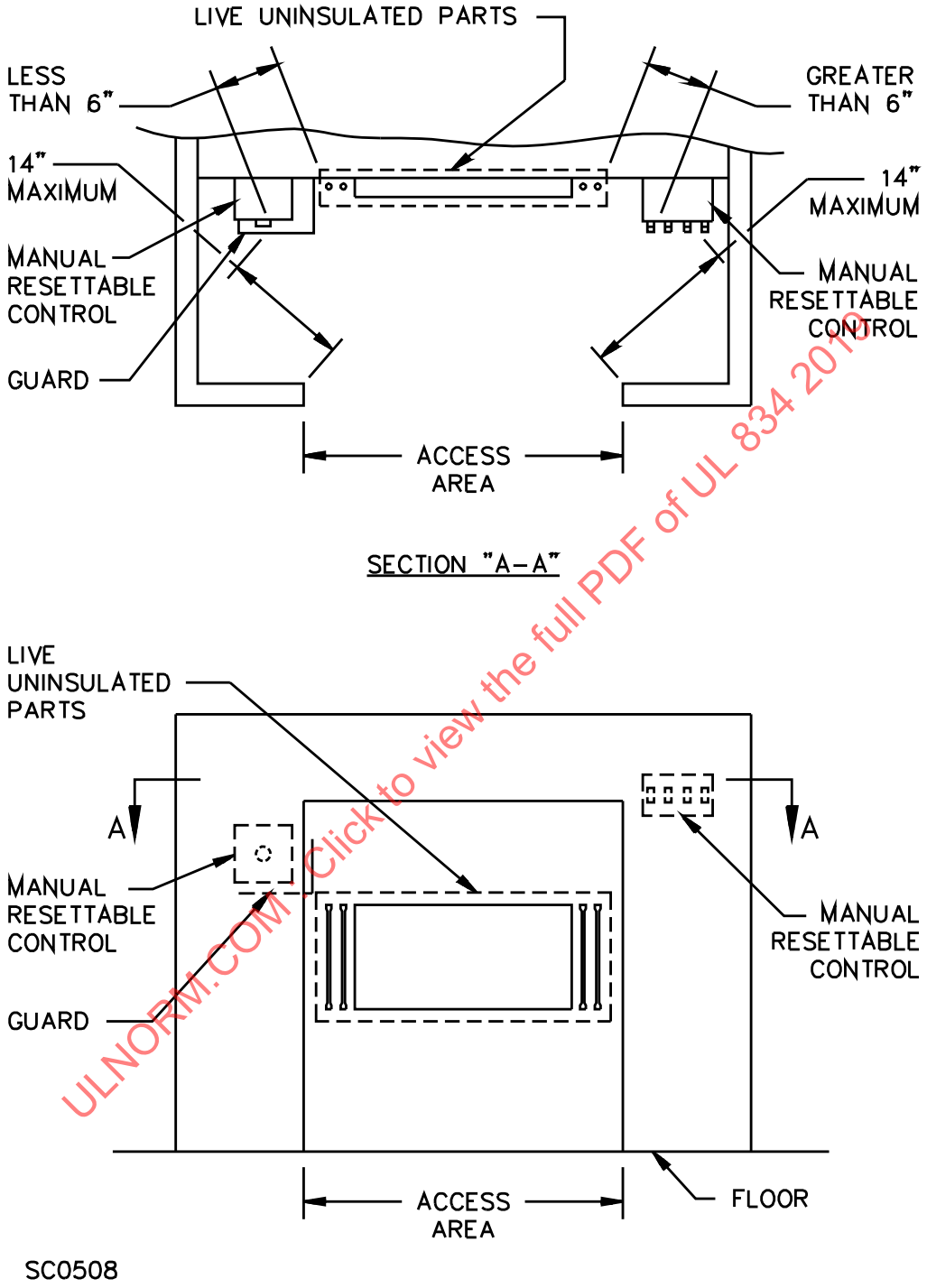
when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure;

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

d) Access to the components in the control assembly shall not be impeded in the direction of access by other components or by wiring in this assembly; and

e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure shall be located so that there is unimpeded access to these components through the access opening in the outer cabinet and so that they are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded. See 8.5.

Figure 8.1
Accessibility and protection



Inches	4	6	14
Millimeters	102	152	356

8.6 Component or control assemblies which are rotated or otherwise displaced for service shall have the electrical control components accessible for service as indicated by 8.1.

8.7 Other arrangements of location of components, guarding, or both shall have the electrical control components accessible for service as indicated by 8.1.

8.8 The electrical components referred to in 8.9 and 8.10 include fuses, adjustable or resettable overload relays, manual or magnetic motor controllers, magnetically operated relays, adjustable or resettable pressure or temperature controllers, manual switching devices, and clock timers. Such components in a low voltage circuit are to comply with the requirements of 8.1 in their relation to uninsulated live parts in a line-voltage circuit and to moving parts.

8.9 Nonadjustable magnetic motor controllers or magnetically operated relays which are inaccessible while energized because they are located behind sub-bases or the equivalent and are not visible when the access panel or panels are removed are not required to be accessible for service.

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

a) Coils of controllers, relays and solenoids, and transformer windings, if the coils and windings are provided with suitable insulating overwraps, at least 1/32 inch (0.8 mm) thick;

b) Enclosed motor windings;

c) Terminals and splices with acceptable insulation; and

d) Insulated wire.

8.11 There shall be a plainly marked ″off″ position on or adjacent to a switch of other than a momentary contact type if the switch controls parts that might cause injury to persons. However, if this switch does not de-energize all parts (components) having a risk of injury to persons, a marking located adjacent to the switch is to indicate such a condition exists with the switch in the ″off″ position.

8.12 Electrical components in a boiler shall be so located that access for servicing or replacement is not unduly restricted. There shall be no need to lift or remove unduly heavy parts, or reach to arms length to remove heavy parts. Large panels which need to be removed for replacement of heating elements, and the like, shall be provided with handles. If hinged doors are provided into two portions because of their physical size, one above the other, a means shall be incorporated to maintain the upper door out of the way when the lower door is opened.

9 Mechanical Assembly

9.1 A boiler or an externally mounted component shall be so assembled that it is not affected by vibration of normal operation. Brush caps shall be tightly threaded or otherwise designed to prevent loosening.

9.2 A switch, lampholder, attachment-plug receptacle, motor attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 9.3.

Exception No. 1: A component need not comply with this requirement when:

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

b) Means for mounting the switch reduce the risk that operation of the switch will loosen it;

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

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

Exception No. 2: A lampholder of a type in which the lamp is unable to be replaced (such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel) is not prohibited from turning when rotation does not to reduce the spacings below the minimum required values.

9.3 The means for preventing the turning mentioned in 9.2 shall consist of more than friction between surfaces. For example, a properly applied lock washer shall be considered as a means of preventing a device having a single hole mounting means from turning.

9.4 Uninsulated live parts shall be so mounted that they are prevented from turning or shifting if such motion results in a reduction of spacings below the minimum required spacing in 35.1.

9.5 Friction between surfaces shall not be the sole means to prevent shifting or turning of live parts, but a properly applied lock washer shall be considered to meet this requirement.

10 Corrosion Protection

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

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

10.2 The sheath employed to enclose a heating element shall be of a metal resistant to corrosion by the water in which the element is intended to be in contact.

11 Electrical Supply Connections of Permanently Connected Boilers

11.1 A boiler intended to be connected to a plumbing system by other than flexible nonmetallic hose shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, NFPA 70, would be appropriate for the boiler. See 15.1.

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

11.3 A terminal compartment intended for connection of a supply raceway shall be so attached to the boiler as to be prevented from turning with respect to the boiler.

11.4 A terminal or splice compartment shall be complete and shall enclose all field-wiring terminals and all splices to be made in the field unless the boiler enclosure is otherwise complete, for example, if all sides and a complete bottom are provided when the boiler is shipped from the factory. A ventilating opening shall not be located in the bottom of the terminal compartment. If provided, openings in the sides of terminal compartments shall be baffled.

11.5 A terminal or splice compartment shall be so located that when conduit connections are being made internal wiring and electrical components shall not be exposed to physical abuse or strain.

12 Field Wiring System Connections

12.1 Sheet metal to which a wiring system is to be connected in the field shall have an average thickness no less than 0.053 inch (1.35 mm) if uncoated steel, no less than 0.056 inch (1.42 mm) if galvanized steel, and no less than 0.072 inch (1.83 mm) if nonferrous. For sheet metal and in an application other than part of a wiring system, see Tables 7.1 and 7.2 for minimum acceptable thicknesses.

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

12.3 A knockout in a sheet metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

12.4 A knockout shall remain in place when a force of 10 pounds (44.5 N) is applied at right angles to the knockout by a 1/4 inch (6.4 mm) diameter mandrel with a flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

12.5 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 used during installation does not result in spacings between uninsulated live parts and the bushing less than the spacings required by this standard.

13 Provisions For Connections To Busway

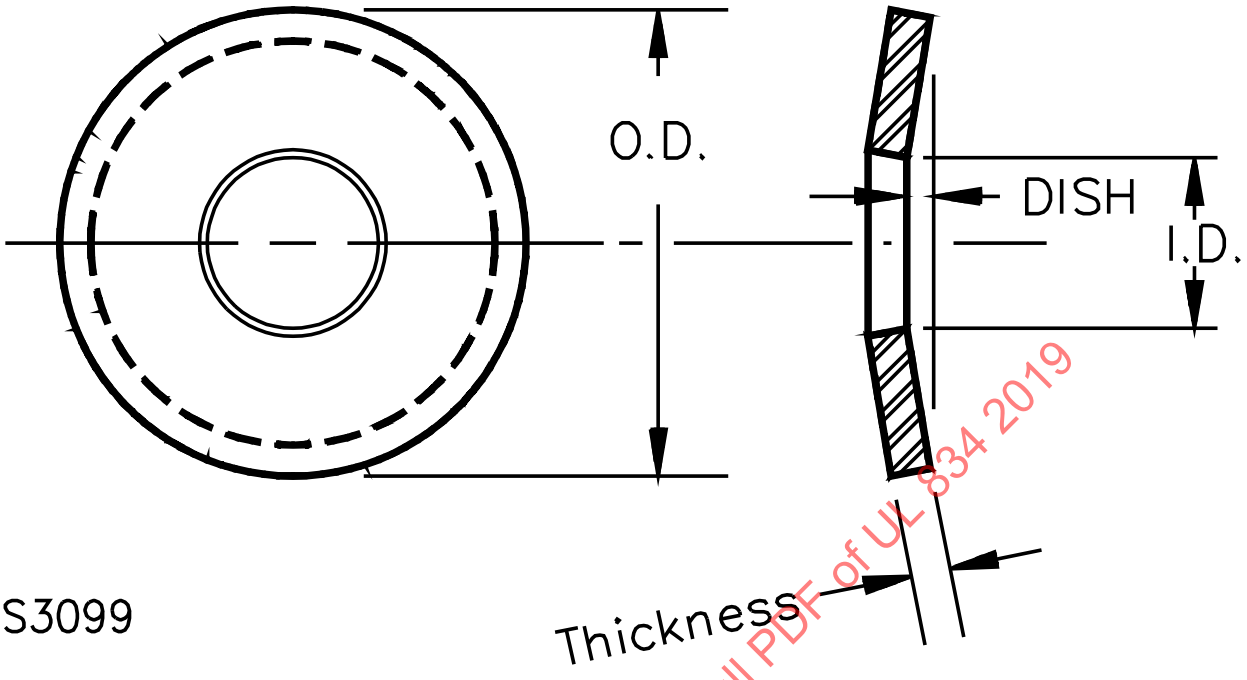
13.1 Means of connecting the busway terminal section to boiler bus bars shall be provided as part of the boiler, which shall include all mounting hardware such as bolts and nuts.

13.2 The boiler shall be provided with all necessary openings for busway entrance.

13.3 Bus bars provided within the boiler for connection to busways shall have adequate ampacity and sufficient contact area. For copper bus bars, ampacity shall be determined on the basis of 1000 amperes per square inch (645 mm^2) of cross-sectional area, and contact area shall be determined on the basis of 200 amperes per square inch (645 mm^2) of contact area. Aluminum bus bars shall be plated with tin, cadmium, nickel, or silver at all joints or terminal areas, and shall have an ampacity based on 750 amperes per square inch (645 mm^2) of cross-section area, and a current density at bolted plated joints not in excess of 200 amperes per square inch (645 mm^2).

13.4 When the busway termination consists of aluminum bus bars, the boiler copper bus bars shall be silver plated at the points of contact with the busway, and a spring washer shall be provided as part of the connecting hardware. A spring washer is a dished washer of stainless or hardened and tempered steel having an outer diameter not less than 150 percent of the bolt diameter, a thickness not less than 1/8 of the bolt diameter, and dished not less than 3-1/2 percent of the bolt diameter. A typical spring washer is shown in Figure 13.1.

Figure 13.1
Spring washer



13.5 The minimum spacings shown in Table 13.1 shall be maintained at bus bars where busway connections are to be made.

Table 13.1
Spacings for busways

Locations	250 volts or less				251 – 600 volts			
	Through air		Over surface		Through air		Over surface	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
Between live parts of opposite polarity	3/4	(19.1)	1-1/4	(31.8)	1	(25.4)	2	(50.8)
Between live parts and dead-metal parts	1/2	(12.7)	1/2	(12.7)	1	(25.4)	1	(25.4)

13.6 A minimum of 1/4 inch (6.4 mm) through air or over surface shall be maintained between live parts of opposite polarity and between live parts and dead metal parts with the busway installed as intended with the furnished mounting hardware. Reference is to be made to busway drawings when the busway terminal section is not available for examination.

13.7 A minimum of one access cover shall be provided to allow inspection of the busway installation.

13.8 Boilers rated greater than 600 V shall not be buss bar connected.

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14 Field Wiring Terminals and Leads

14.1 A permanently connected boiler shall be provided with wiring terminals or leads for the connection of supply conductors. Each terminal or lead shall be sized for connection of a branch-circuit conductor having an ampacity no less than the noncontinuous load plus 125 percent of the continuous load.

Exception: The terminals or leads may be sized at not less than 100 percent of the current rating of the boiler when all of the following conditions are met:

a) The boiler is rated 50 kilowatts or more;

b) The boiler is intended for space heating;

c) The boiler is provided with supplementary overcurrent protection for the heating elements; and

d) The marking required by 57.19 is provided.

14.2 For the purpose of these requirements, field-wiring terminals or leads are considered to be the terminals or leads to which power-supply, equipment grounding, or control connections will be made in the field when the boiler is installed. It is to be assumed that 60°C (140°F) wire will be used for connections to a boiler rated at 80 amperes or less, and that 75°C (167°F) wire will be used with a boiler rated at more than 80 amperes.

14.3 A field-wiring terminal shall be provided with a soldering lug or with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw – except that a wire-binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

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

14.5 A wire-binding screw at a field-wiring terminal shall not be smaller than No. 10, except that a No. 8 screw may be used at a terminal intended only for connection to a 14 AWG (2.1 mm^2) conductor. In control circuits, a No. 6 screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductor.

14.6 A field-wiring terminal plate tapped for a wire-binding screw shall be of metal no less than 0.050 inch (1.27 mm) in thickness. There shall be no fewer than two full threads in the metal of the plate.

Exception: A plate no less than 0.030 inch (0.76 mm) in thickness is considered to meet the intent of this requirement if the tapped threads have the required mechanical strength.

14.7 A field-wiring terminal plate formed from stock having the minimum required thickness as given in 14.6 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

14.8 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 14.1, but not smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

14.9 A wire-binding screw shall thread into metal.

14.10 A boiler intended for connection to a grounded power-supply conductor and employing a lampholder of the Edison screw-shell type, a single-pole switch, or a single-pole automatic control shall have one terminal or lead identified for connection of the grounded conductor. The identified terminal or lead shall be connected to the screw-shell of the lampholder.

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

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

14.13 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: The lead may be less than 6 inches (152 mm) if the field wiring supply connections are enclosed in a motor terminal box or wiring compartment.

14.14 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 14.2.

Table 14.2
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	3/4	3/4	3/4
8	(8.4)	3/4	3/4	3/4	1	1
6	(13.3)	3/4	3/4	1	1-1/4	1-1/4
4	(21.2)	1	1	1-1/4	1-1/4	1-1/4
3	(26.7)	1	1	1-1/4	1-1/4	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	1-1/2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
1/0	(54.0)	1-1/4	1-1/2	2	2	2
2/0	(67.0)	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	2-1/2
MCM						
250	127	2	2	2-1/2	2-1/2	3
300	152	2	2-1/2	2-1/2	3	3
350	177	2-1/2	2-1/2	2-1/2	3	3
400	203	2-1/2	2-1/2	3	3	3-1/2
500	253	2-1/2	2-1/2	3	3-1/2	3-1/2

Table 14.2 Continued on Next Page

Table 14.2 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 6 conductors in the conduit. If more than 6 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 the total cross-sectional area of the wires by 2.5, based on the cross-sectional area of Type THW wire.

15 Cord-Connected Boilers

15.1 A boiler which has no provision for connection to plumbing or condensate return, and is portable, shall employ for supply connections a length Type S, SO, ST, STO, HSO, or HSOO cord, or the cord shall be of a type having properties for the particular application.

15.2 If a boiler is provided with a directly attached flexible cord, an attachment plug shall be provided on the cord for attachment to the supply circuit. If a directly attached flexible cord is not provided, the boiler shall have terminals employing male blades, or the equivalent, that accommodates an appropriate plug. The cord including fittings shall not be less than 6 feet (1.8 m) long.

15.3 If the boiler does not have a permanently attached flexible cord, a cord set shall be provided. The length of the cord set, including fittings, shall not be less than 6 feet (1.8 m) long.

15.4 If a flexible cord or separate cord set is provided with a boiler, the ampacity of the cord and the rating of the fittings for the boiler rated at 15 amperes or less shall not be less than that of the boiler. For a boiler rated at more than 15 amperes, the ampacity of the cord shall not be less than the current rating of the boiler, and the current rating of the attachment plug shall not be less than 125 percent of the current rating of the boiler.

Exception: A 20-ampere plug may be provided for a boiler rated not more than 4000 watts at 240 volts.

15.5 Supplementary insulation, if employed on a flexible cord, shall:

a) Not extend more than 1/2 inch (12.7 mm) outside the boiler unless provided with additional mechanical protection;

b) Be prevented from fraying or unraveling; and

c) Not affect the means for providing strain relief.

15.6 A flexible supply cord shall be provided with strain relief if mechanical stress on the supply cord may be transmitted to terminals, splices, or interior wiring.

15.7 Means shall be provided to prevent the supply cord or lead from being pushed into the enclosure of a heater through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or lead to mechanical damage;

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

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with Section 53, Push-Back Relief Test.

15.8 When tested in accordance with 15.9, the strain-relief means provided on the flexible cord shall withstand for 1 minute, without displacement, a direct pull of 35, 50, or 100 pounds (154, 220, 446 N) as described in 15.9, applied to the cord, with the connections within the boiler disconnected.

15.9 A 35, 50, or 100 pound (15.9, 22.7, or 45.4 kg) weight is to be suspended on a cord incorporating 16 or 18 AWG (1.3 or 0.82 mm^2), 12 or 14 AWG (3.3 or 2.1 mm^2), or greater than 12 AWG conductors respectively and supported by the boiler so that the strain-relief means will be stressed from any angle that the construction of the boiler permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord to indicate that stress on the connections would have resulted.

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

15.11 A separate soft-rubber, neoprene, or poly-vinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor (but not elsewhere in a boiler except as indicated in 15.12) provided that:

a) The bushing is not less than 3/64 inch (1.2 mm) thick; and

b) The bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound employed.

15.12 A bushing of any materials mentioned in 15.11 may be employed at any point in a boiler if used in conjunction with a type of cord for which an insulating bushing is not required, and if the edges of the hole in which the bushing is mounted are smooth and free from burrs, fins, and the like.

16 Wiring Space

16.1 The space within the enclosure of a boiler shall provide ample room for the installation and distribution of wires and cables required for the proper wiring of the device.

16.2 The wire-bending space from a field-wiring terminal to a wall of the enclosure and to any barrier or other obstruction that is part of the boiler shall be as specified in Table 16.1, except that if a hole, knockout, or other provision for connection of a wiring system is provided in the wall opposite the terminal it will be considered to be obvious that a conductor will enter or exit the enclosure through that wall, and the wire-bending space shall be as specified in Table 16.2.

Table 16.1
Minimum width of gutter and wire-bending space[a,c]

Size of wire AWG or MCM (mm^2)		Wires per terminal[b]					
		1		2	3	4	5
14 – 10	(2.1 – 5.3)	Not Specified		–	–	–	–
8 – 6	(8.4 – 13.3)	1-1/2	(38.1)	–	–	–	–
4 – 3	(21.1 – 26.7)	2	(50.8)	–	–	–	–
2	(33.6)	2-1/2	(63.5)	–	–	–	–
1	(42.4)	3	(76.2)	–	–	–	–
1/0 – 2/0	(53.5 – 67.4)	3-1/2	(88.9)	5(127)	7(178)	–	–
3/0 – 4/0	(85.0 – 107)	4	(102)	6(152)	8(203)	–	–
250	(127)	4-1/2	(114)	6(152)	8(203)	10(254)	–
300 – 350	(152 – 177)	5	(127)	8(203)	10(254)	12(305)	–
400 – 500	(203 – 253)	6	(152)	8(203)	10(254)	12(305)	14(356)
600 – 700	(304 – 355)	8	(203)	10(254)	12(305)	14(356)	16(406)
750 – 900	(380 – 456)	8	(203)	12(305)	14(356)	16(406)	18(457)
1000 – 1250	(507 – 633)	10	(254)	–	–	–	–
1500 – 2000	(760 – 1010)	12	(305)	–	–	–	–

[a] The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned may be given further consideration.

[b] The main connection for a neutral is considered to be a terminal; that is, neutral branch terminals are not included when determining the number of wires per terminal.

[c] For ampacities of 110 amperes or less, and if the boiler is marked to indicate the use of 60 or 75°C wire, the wire bending space shall be based on the use of 60°C (140°F) insulation wire.

Table 16.2
Wire-bending space at terminals

Wire size AWG or MCM (mm^2)		Minimum bending space, inches (mm)							
		Wires per terminal							
		1		2		3		4 or more	
14 – 10 AWG	(2.1 – 5.3)	Not specified		–		–		–	
8	(8.4)	1-1/2	(38.1)	–		–		–	
6	(13.3)	2	(50.8)	–		–		–	
4	(21.2)	3	(76.2)	–		–		–	
3	(26.7)	3	(76.2)	–		–		–	
2	(33.6)	3-1/2	(88.9)	–		–		–	
1	(42.4)	4-1/2	(114)	–		–		–	
1/0	(53.5)	5-1/2	(140)	5-1/2	(140)	7	(178)	–	
2/0	(67.4)	6	(152)	6	(152)	7-1/2	(191)	–	
3/0	(85.0)	6-1/2	(165)	6-1/2	(165)	8	(203)	–	
4/0	(107)	7	(178)	7-1/2	(191)	8-1/2	(216)	–	
250	(127)	8-1/2	(216)	8-1/2	(216)	9	(229)	10	(254)
300	(152)	10	(254)	10	(254)	11	(279)	12	(305)
350	(177)	12	(305)	12	(305)	13	(330)	14	(356)
400	(203)	13	(330)	13	(330)	14	(356)	15	(381)
500	(253)	14	(356)	14	(356)	15	(381)	16	(406)
600	(304)	15	(381)	16	(406)	18	(457)	19	(483)

Table 16.2 Continued on Next Page

Table 16.2 Continued

Wire size AWG or MCM (mm^2)		Minimum bending space, inches (mm)							
		Wires per terminal							
		1		2		3		4 or more	
700	(355)	16	(406)	18	(457)	20	(508)	22	(559)
750	(380)	17	(432)	19	(483)	22	(559)	24	(610)
800	(405)	18	(457)	20	(508)	22	(559)	24	(610)
900	(456)	19	(483)	22	(559)	24	(610)	24	(610)
1000	(507)	20	(508)	–		–		–	
1250	(633)	22	(559)	–		–		–	
1500	(760)	24	(610)	–		–		–	
1750	(887)	24	(610)	–		–		–	
2000	(1010)	24	(610)	–		–		–	

16.3 If a conductor is restricted by barriers, branch-circuit units, or other means from being bent in a 90-degree or S-bend from the terminal to any usable location in the wall of the enclosure, the distance is to be measured from the end of the barrier or other obstruction.

16.4 The distance mentioned in 16.2 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the wall or barrier. The wire terminal is to be turned so that the axis of the wiring opening in the connector is as close to perpendicular to the wall of the enclosure as possible without defeating any reliable means provided to prevent its turning– such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or the like. A barrier, shoulder, or the like is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent. The main connection for a neutral is considered to be a terminal – that is, neutral branch terminals are not considered in this determination. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure. If the connectors for a circuit are fixed in position – for example, by the walls of a recess – so that they are turned toward each other, the distance is to be measured at the wire opening nearest to the wall in a direction perpendicular to the wall.

Exception: Side bending space may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal. The connector is not to be oriented so that the wire will be directed into a corner of the box to such extent that the transverse wall would necessitate additional bending.

16.5 A terminal compartment is considered to be a space into which wires are brought only for connection to terminals in that space.

17 Stability

17.1 The stability of a cord-connected boiler shall be such that it does not overturn when tilted 10 degrees from its intended freestanding position with all doors opened. The boiler is not to be bolted to other units or secured to the floor or other part of the building while its stability is being determined.

18 Current-Carrying Parts

18.1 Metal employed for a current-carrying part shall be acceptable for the application. Plated iron or steel may be used for current-carrying parts when the temperature of which during normal operation is more than 100°C (212°F), but plain (unplated) iron or steel shall not be used regardless of temperatures. A copper conductor, unless tinned, nickel-coated, silver-plated, or otherwise protected, shall not be subjected to a temperature rise of more than 125°C (225°F) at a pressure terminal connector, or to a temperature rise of more than 175°C (315°F) elsewhere. Stainless steel and other corrosion-resistant alloys may be used for current-carrying parts regardless of temperature.

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

a) Within a motor or associated governor;

b) On a control device; or

c) For a heating element assembly, including its terminations.

19 Internal Wiring

19.1 General

19.1.1 The internal wiring of a boiler shall consist of wires of a size rated for the application when considered with respect to:

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

b) Its exposure to oil or grease; and

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

19.1.2 For the purpose of these requirements, the internal wiring of a heater is considered to be all the interconnecting wiring beyond the wiring terminals or leads for field-wiring connections even though some of it is not completely enclosed or is in the form of flexible cord.

19.1.3 Except as specified in Table 42.1, there is no temperature limit applicable to a conductor provided with beads of noncarbonizable material. The number and arrangement of beads shall be such as to maintain spacings in accordance with Table 35.1. A conductor utilizing beads shall not be used outside an enclosure.

19.1.4 Insulated wire employed for internal wiring shall be standard building wire, fixture wire, flexible cord, or appliance wiring material acceptable for the application. See 19.1.5 – 19.2.9.

19.1.5 Building wire for internal wiring include rubber-insulated conductors such as Types RH, RHH, and RHW; thermoplastic-insulated conductors such as Types T, TW, THHN, THWN, a MTW; crosslinked polyethylene-insulated conductors such as Type XLP, and silicone rubber insulated conductors such as Type SRO.

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

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

19.1.8 Appliance wiring material used for internal wiring shall have thermoplastic insulation not less than:

a) 1/32 inch (0.8 mm) thick for 18 – 10 AWG (0.82 – 5.3 mm^2);

b) 3/64 inch (1.2 mm) thick for 8 AWG (8.3 mm^2); or

c) 1/16 inch (1.6 mm) thick for 6 – 2 AWG (13.3 – 33.6 mm^2).

19.2 Methods

19.2.1 The wiring and connections between external parts of a boiler shall be protected or enclosed, except that if flexibility of the wiring is essential, flexible cord (see 15.1) may be employed for external interconnections, or for internal connections that may be exposed during servicing.

19.2.2 Internal wiring that is exposed through an opening in the enclosure of a boiler is considered to be protected as required by 19.2.1 if, when judged as though it were film-coated wire, the wiring would comply with 7.4.1 and 7.4.2. Internal wiring within an enclosure that can be touched with the probe shall be protected or guarded so that it cannot be grasped or hooked in a manner that would subject the wire to stress.

19.2.3 If the wiring of a boiler is located so that it could be in proximity to combustible material or subjected to mechanical damage, it shall be in metal-clad cable, rigid metal conduit, electrical metallic tubing, metal raceway, or similarly protected.

19.2.4 Wiring shall be protected from sharp edges (including male screw threads), burrs, fins, moving parts, and other features that might abrade the insulation on conductors.

19.2.5 A hole through which insulated wires pass in a sheet metal wall within the overall enclosure of a boiler shall be provided with a smooth, rounded bushing, or shall have smooth, rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 19.2.1 shall be provided with bushings and strain relief in accordance with 19.2.7 and 19.2.8, unless the construction is such that the cord will be protected from stress or motion.

19.2.6 When there is risk of relative motion between the insulated wire and the metal surrounding the opening through which the wire passes because of expansion and contraction of the metal resulting from changes in temperature, the openings shall be fitted with an insulating bushing or the equivalent.

19.2.7 Strain relief shall be provided so that mechanical stress on a flexible cord is not transmitted to terminals or splices as determined by 15.9.

19.2.8 Means shall be provided to restrict that flexible cord from being pushed into the enclosure through the cord entry hole if such displacement is likely to subject the cord to mechanical damage or to expose the cord to a temperature higher than that for which it is rated, or if it is likely to reduce spacings, such as to a metal strain-relief clamp, below the minimum acceptable values.

19.2.9 A boiler comprised of several units intended to be interconnected in the field shall have provisions for accepting field-wired conductors between the units. The boiler shall be constructed so that conduit, metal raceway, armored cable or the like can be employed for connection of such wiring in accordance with the National Electrical Code, ANSI/NFPA 70.

20 Splices

20.1 All splices and connections shall be mechanically secured and shall provide electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection results in a risk of fire or electric shock.

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

20.3 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat-resistance and moisture-resistance characteristics, and the like. Thermoplastic tape shall not be wrapped over a sharp edge.

20.4 The means of connecting standard internal wiring to a wire-binding screw shall be such that loose strands of wire cannot contact other live parts that are not always of the same polarity as the wire, or that contact dead metal parts. This may be accomplished by the use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other equivalent means.

21 Separation of Circuits

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

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

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

a) Field-installed and factory-installed conductors of any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit, and except as noted in 21.5.

b) Uninsulated live parts of any other circuit of the boiler, and from any uninsulated live parts the short-circuiting of which would result in operation of the boiler that could cause a risk of fire, electric shock, or injury to persons, except that:

1) A construction in which field-installed conductors may make contact with wiring terminals is acceptable provided that Type T or equivalent conductors are or will be installed; and

2) A construction in which field-installed conductors that do or may have insulation less than the types of wire mentioned in (1) may make contact with low-voltage wiring terminals provided that the short-circuiting of such terminals would not result in operation of the boiler that could cause a risk of fire, electric shock, or injury to persons.

21.4 With respect to 21.3(a), a removable barrier or one having openings for the passage of conductors may be employed, provided adequate instructions for the use of the barrier are a permanent part of the appliance. If complete instructions in conjunction with a wiring diagram will provide for the intended separation of the high and low-voltage circuits, the barrier may, upon investigation, be omitted.

21.5 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts of the boiler 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 will be no intermingling of the conductors or parts of different circuits. If the number of openings in the enclosure does not exceed the minimum required for the intended wiring of the boiler, and if each opening is located opposite a set of terminals, it is to be assumed for the purpose of determining compliance with 19.2.5 that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings is provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated. To determine whether or not a boiler complies with the requirements in 19.2.5, it is to be wired as it would be in service, and in doing so, a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack in the wiring compartment.

22 Barriers

22.1 A barrier used to provide separation between the wiring of different circuits shall be of metal or other material, of adequate mechanical strength if exposed or otherwise likely to be subjected to mechanical damage, and securely held in place. Openings in a barrier for the passage of conductors shall not be larger in diameter than 1/4 inch (6.4 mm) and shall not exceed in number, on the basis of one opening per conductor, the number of wires that will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may contact it and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

22.2 A barrier of metal or of insulating material shall not be less than 0.028 inch (0.71 mm) thick, or shall be of greater thickness if its deformation may be readily accomplished to defeat its purpose.

23 Heating Elements

23.1 A heating element shall be securely supported. It shall be protected against mechanical damage and contact with outside objects.

23.2 In determining whether a heating element complies with the requirement in 23.1, consideration is to be given to sagging, opening, and other adverse conditions of the element resulting from:

a) Continuous heating; or

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

23.3 A wrap-around element shall be secured in place so that it cannot loosen. An investigation may be necessary to determine whether the construction complies with this requirement.

24 Electrical Insulation

24.1 Insulating washers, bushings, and the like, that are integral parts of a boiler, and bases or supports for the mounting of current-carrying parts shall be of a moisture-resistant material that will not be damaged by the temperatures to which they will be subjected under conditions of actual use. A molded part shall be constructed so that it will have the mechanical strength and rigidity necessary to withstand the stresses of actual service.

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

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

25 Thermal Insulation

25.1 Thermal insulation shall be of a material classed V-1 as described in UL 94, the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances. Glass fiber and mineral wool are considered to be classed V-1.

25.2 Thermal insulation that is not adequately rigid shall be mounted or supported to prevent it from sagging. Adhesive material employed for mounting thermal insulation shall retain its adhesive qualities for the temperatures to which the adhesive may be subjected in intended operation.

25.3 Determination of the acceptability of an adhesive is not required if the thermal insulation is mechanically supported by at least one rivet or the equivalent per square foot of material.

25.4 Electrically conductive thermal insulation shall not make contact with uninsulated live parts of a boiler.

25.5 Mineral wool thermal insulation containing conductive impurities in the form of slag shall not be used in contact with live parts.

26 Motors

26.1 A motor shall be capable of handling its maximum intended load without introducing a risk of fire, electric shock, or injury to persons.

26.2 A motor winding shall resist the absorption of moisture.

26.3 With reference to the requirement in 26.2, film contact magnet wire is not required to be additionally treated to prevent absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorbent materials shall be impregnated or otherwise treated to prevent moisture absorption.

27 Overcurrent Protection

27.1 Heating element circuits

27.1.0 A boiler that is rated 120 amperes or less shall have the branch circuit protected by an overcurrent protective device rated not more than 150 amperes.

27.1.1 A boiler that is rated at more than 120 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 120 amperes and shall be protected at not more than 150 amperes.

27.1.2 The overcurrent protective devices required by 27.1.1 shall be provided by the manufacturer as an integral part of the boiler or shall be provided by the manufacturer as a separate assembly, for independent mounting for use with the heater.

27.1.3 The overcurrent protection mentioned in 27.1.1, 27.1.2, 27.3.1 – 27.4.1, and 27.4.2 shall be of a type recognized by the National Electrical Code, ANSI/NFPA 70 for branch circuit protection. A cartridge fuse used for this purpose shall include Class CC (30 amperes maximum), G (60 amperes maximum), H, J, K, R, or T cartridge fuse. A plug fuse is 125 volts maximum.

27.2 Internal conductors

27.2.1 Each bus bar and insulated wire in a heating element circuit or a motor circuit in boilers rated at more than 40 amperes shall be protected by an overcurrent protective device provided as part of the boiler. If the boiler is intended for connection to more than one branch circuit, each section of the boiler intended for connection to a different branch circuit is to be considered individually in applying the foregoing requirement. The rating of the overcurrent-protective device shall be in accordance with Table 27.1.

Exception No. 1: If the internal wiring of the boiler is sized in accordance with Table 27.1, the overcurrent protective device is not required to be integral to the boiler, provided the branch circuit protection device also complies with the corresponding maximum rating in Table 27.1.

Exception No. 2: The requirement in 27.2.1 does not apply to a conductor:

a) No longer than 10 feet (3 m);

b) That is completely within the enclosure of the boiler;

c) That terminates in its load end in one or more overcurrent protective devices; and

d) That has an ampacity according to the 60°C tables in the National Electrical Code, ANSI/NFPA 70, nor less than 80 percent of the combined ratings of one or more overcurrent protective devices supplied by a conductor.

27.2.2 Deleted July 1, 2009

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

Table 27.1
Largest acceptable protective device

Kind of conductor	Conductor protected within the appliance				Current rating of largest acceptable overcurrent protective device
	Copper		Aluminum		
	AWG	(mm^2)	AWG	(mm^2)	
Wires	18 – 12	(0.82 – 3.3)	–		60
	–	–	10	(5.3)	80
	10	(5.3)	8	(8.4)	90
	8	(8.4)	6	(13.3)	125
	6	(13.3)	4	(21.2)	175
Solid Bus Bars		Copper		Low enough to limit the current density in the bus bar to 3000 amperes per square inch (4.458 amperes per square millimeter) of bus bar cross section	
		Electrical-conductor (EC) grade of aluminum (conductivity is 61 percent of IACS)		Low enough to limit the current density in the bus bar to 2000 amperes per square inch (3.100 amperes per square millimeter) of bus bar cross section	
		Aluminum having a conductivity of 55 percent of IACS		Low enough to limit the current density in the bus bar to 1776 amperes per square inch (2.753 amperes per square millimeter) of bus bar cross section	

27.3 Motors

27.3.1 A motor circuit shall be protected against short circuit and ground fault conditions by an overcurrent protective device conforming with the National Electrical Code, ANSI/NFPA 70. Such overcurrent protection shall be provided as part of the boiler or as a separate assembly if, in accordance with 27.1.2 the overcurrent protection is provided by the manufacturer for the heater circuits.

Exception: This requirement does not apply to a motor rated at 1/8 horsepower (93.3 watts output) or less connected to a circuit having overcurrent protection at 15 amperes or less.

27.3.2 The acceptability of the motor-circuit short circuit and ground fault overcurrent protective device to provide the protection required in 27.3.1 shall be determined by limited short circuit tests in accordance with Section 46 with an overcurrent protective device of the same type and having a current rating no less than that of the overcurrent protective device protecting the motor circuit and the boiler.

Exception No. 1: If each motor circuit is provided with independent overcurrent protection conforming with the National Electrical Code, ANSI/NFPA 70, for the motor-circuit involved, and if the motor overload protective device conforms with the requirements for such a device, the overload protective device is considered to comply with 27.3.1 and 27.3.2.

Exception No. 2: Short circuit tests are not required if the assembly complies with all of the following:

a) The motor circuit is protected by fuses.

b) The motor overload protective device conforms with the applicable requirements for such devices.

c) The thermally protected motor or separately enclosed overload protective device is within an outer cabinet, and the assembly is so constructed that it can be determined that flame and molten metal will be confined within the cabinet, and any combustible material, except electrical insulation or an air filter, is not located below the motor and has characteristics of material classed V-1 in accordance with UL 94, the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

d) The motor circuit conductors have an ampacity no less than one-third the ampacity of the supply circuit conductors that would be connected to the boiler as determined in accordance with 14.2 and 14.3, unless the conductors have been determined to be protected by the type and size of overcurrent device protecting the circuit.

e) A separate circuit is not connected to the overload device, such as an overload relay with contacts in a low-voltage control circuit.

27.3.3 With reference to (d) of Exception No. 2 to 27.3.2, conductors that comply with any of the following are acceptable without short circuit tests:

a) The conductors have an ampacity no less than that required by the National Electrical Code, ANSI/NFPA 70 for the load connected to the overcurrent device protecting the circuit.

b) The conductors are 18 AWG (0.82 mm^2) or larger and are no more than 4 feet (1.22 m) long, and are protected by a 60-ampere or smaller fuse.

c) The conductors are jumper leads, no longer than 3 inches (76.2 mm), between controls, or the conductors are located in a control panel.

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27.4 Receptacles and lamps

27.4.1 Overcurrent protection at no more than 15 amperes shall be provided by a fuse or circuit breaker for each general-use single receptacle, unless the equipment would be connected as intended to a branch circuit rated at 15 amperes or less.

27.4.2 Overcurrent protection at not more than 20 amperes shall be provided by a circuit breaker or fuses, as part of the boiler:

a) For each general-use duplex receptacle circuit; and

b) For each lampholder circuit, except as indicated in 27.4.3, independent of a heating element, unless the boiler would be connected as intended to a branch circuit rated at 20 amperes or less.

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

27.5 Control circuits

27.5.1 For the purpose of these requirements, a control circuit is one that carries electric signals directing the performance of a controller that, in turn, governs power delivered to a motor or other load. A control circuit does not carry main power current. If a control circuit is supplied through a transformer provided as part of the equipment, see Transformer Overcurrent Protection, Section 24 for additional requirements.

27.6 Direct-connected high-voltage control circuit

27.6.1 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 equipment. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the equipment. See 57.19.

27.7 Tapped high-voltage control circuits

27.7.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the boiler from the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 27.7.2 – 27.7.4. A control circuit that is tapped from the main power supply circuit at a point outside the control equipment enclosure shall be protected as specified in Column A of Table 430.72(b) of the National Electrical Code, ANSI/NFPA 70.

27.7.2 A tapped high-voltage control circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent protective device, or devices, shall not exceed the applicable value specified in Table 27.2.

Exception No. 1: 18, 16, and 14 AWG (0.82, 1.3, and 2.1 mm^2) conductors that do not exceed 4 feet (1.2 mm) in length between points of opposite polarity may be protected by fuses or "HACR Type" circuit breakers rated 60 amperes or less.

Exception No. 2: An overcurrent protective device of a higher rating may be used if the conductors withstand the Short Circuit Test specified in Section 50.

Exception No. 3: A lead 12 inches (305 mm) or less in length is not required to 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 or devices located on the primary side of the transformer provided:

a) This protection is in accordance with requirements specified in Transformer Overcurrent Protection, Section 24; and

b) The rating of the device does not exceed the applicable value specified in Table 27.2 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Table 27.2
Overcurrent protective device rating for control circuit conductors

		Maximum rating of overcurrent protective device, amperes			
Conductor size		Circuit does not leave enclosure		Circuit leaves 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	(5.3)	b	b	c	c

[a] Includes copper-clad aluminum.
[b] 400 percent of value specified for 60°C conductors in Table 310.17 of the National Electrical Code, ANSI/NFPA 70.
[c] 300 percent of value specified for 60°C conductors in Table 310.16 of the National Electrical Code, ANSI/NFPA 70.

27.7.3 Overcurrent protection for a tapped control circuit conductor, as required by 27.7.2, shall be provided as part of the equipment.

Exception: The overcurrent device or devices is not required to be provided as part of the equipment if, based on the marked rating or ratings of the equipment, the rating of the branch circuit overcurrent protective device or devices does not exceed the values specified in Table 27.2.

27.7.4 A control circuit overcurrent protective device or devices shall:

a) Be provided for all ungrounded conductors; and

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

27.7.5 The control circuit overcurrent protective device shall be:

a) A circuit breaker acceptable for branch circuit protection;

b) A fuse acceptable for branch circuit protection, such as a Class CC, G, H, J, K, L, R, or T cartridge fuse or Type S plug fuse; or

c) A supplementary type fuse having a short-circuit rating acceptable for the circuit in which it is used.

The equipment shall be marked in accordance with 57.17.

28 Transformer Overcurrent Protection

28.1 High-voltage transformer

28.1.1 A transformer (including an autotransformer), other than one as described in 28.2.1, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal overload protection in accordance with the requirements in 28.1.2;

b) Be protected by an overcurrent device in accordance with the requirements in 28.1.4; or

c) Comply with the Burnout Test – High-Voltage Transformer, Section 51.

28.1.2 If a high-voltage transformer is provided with a thermal overload protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings, under overload conditions, to those permitted for the class of insulation employed in the windings. See Overload Test – High-Voltage Transformer, Section 52.

Exception: If the thermal overload protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test – High-Voltage Transformer, Section 51.

28.1.3 A thermal cutoff shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manual or automatic resetting thermal protector shall have an endurance rating of not less than 6000 cycles and shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, pertaining to the calibration of temperature limiting controls. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

28.1.4 If a high-voltage transformer is protected by an overcurrent device, such protection shall comply with the requirements specified in 28.1.5 – 28.1.8.

28.1.5 Except as noted in 28.1.6 and 28.1.7, a high-voltage transformer shall be protected by an overcurrent device or devices located in the primary circuit and rated or set as indicated in Table 28.1 for the primary.

Table 28.1
Rating of transformer overcurrent protective devices

Rated primary or secondary current, amperes	Maximum rating of overcurrent device. Percent of transformer current rating when in:	
	Primary	Secondary
Less than 2	300[a]	167
2 or more, less than 9	167	167
9 or more	125	125
[a] If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction is to be such that the minimum spacing will be maintained under all operating conditions.		

28.1.6 Overcurrent protection in the primary circuit of a transformer, as described in 28.1.5, is not required to be provided as part of the equipment if, based on the marked rating or ratings of the equipment, the rating of the branch circuit overcurrent protective device or devices does not exceed the values specified in 28.1.5.

28.1.7 If the circuit supplying a transformer other than an autotransformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device provided as part of the equipment, and rated or set as indicated in Table 28.1 for the secondary.

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

a) Be provided for all ungrounded conductors; and

b) Have a voltage rating not less than the circuit in which it is used. The device shall be:

1) A circuit breaker acceptable for branch circuit protection;

2) A fuse acceptable for branch circuit protection, such as Class CC, G, H, J, K, L, R, or T cartridge fuse or Type S plug fuse; or

3) A fuse of the supplementary type (a type other than indicated in (b)), provided the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Short Circuit Test, Section 50.

The product shall be marked in accordance with the requirements in 57.17.

28.2 Low-voltage transformers

28.2.1 A transformer that directly supplies a low-voltage National Electrical Code, ANSI/NFPA 70, Class 1 or Class 2 circuit (see 6.5) shall, in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently limited transformer) or be equipped with an overcurrent device (not inherently limited transformer) and need not comply with the requirements in 28.1.1.

29 Lampholders

29.1 A lampholder shall be installed so that uninsulated live parts other than the screw shell are not exposed to contact by persons removing or replacing lamps in user service.

Exception: This requirement does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the boiler by means of tools. See 8.12.

30 Switches

30.1 A switch or other control device provided as part of a boiler shall be of a type intended for the application and shall have a current and voltage rating not less than that of the circuit (load) that it controls.

30.2 The current rating of a switch that controls a solenoid, magnet, transformer, or other inductive load is to be at least twice the rated full-load current of the component that is controlled unless the switch has been investigated and found to be acceptable for the application.

30.3 A switch employed on a boiler shall be located or protected so that it is not subjected to mechanical damage during use.

30.4 A manually operated switching device (or a pilot device) that serves to interrupt the main heater or control power-supply circuit to the boiler shall be marked to indicate the ″on″ position, ″off″ position, or both.

30.5 A switching device that interrupts the main boiler, control power-supply circuit, or both shall, when open, disconnect all ungrounded conductors of that circuit.

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

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

31 Limit Controls

31.1 A boiler shall be equipped with two factory installed limit controls. One control is to be of the automatically reset type for regulating the intended boiler operation (i.e. Operating Control). The second control is to be of the manually reset type for back-up protection (i.e. Protective or high limit control) and when activated result in the boiler shutting down.

31.1.1 An electro-mechanical limit control shall comply with the Standard for Limit Controls, UL 353 or for temperature limit controls or thermal cut outs, 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 or for pressure controls, the requirements for protective controls in the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

31.1.2 An electronic limit control with switched outputs that only relies on hardware circuitry to limit the temperature or pressure within the limits specified in 31.2 shall be investigated to the requirements of:

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

b) 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.

31.1.3 An electronic limit control that relies on software to limit the temperature within the limits specified in 31.2 shall be investigated to the requirements for software Class 2 in accordance with the Standard for Software in Programmable Components, UL 1998 and Standard for Limit Controls, UL 353.

31.1.4 Temperature limit controls shall have no more than a 2.8°C (5°F) initial variation from rated operating temperature and shall have no more than a 5.5°C (10°F) or 5 percent variation, whichever greater, from initial operating temperature after testing in accordance with the Operation and Endurance Tests of the Standard for Limit Controls, UL 353.

31.1.5 Pressure limit controls shall have no more than a 5 percent variation from rated operating pressure and from initial operating pressure after testing in accordance with the Operation and Endurance Tests of the Standard for Limit Controls, UL 353.

31.1.6 As an alternate to 31.1.1 – 31.1.5, temperature and pressure limiting controls shall be investigated to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and

a) For temperature controls, the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9 utilizing the declarations specified in Table 31.1; or

b) For pressure controls, the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2-6: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6 utilizing the declarations specified in Table 31.1.

Table 31.1
Limit control parameters

UL 60730-1, Table 1 item number[a]	Information	Control requirement
6	Purpose of control	Manually Reset Thermal Cut-Out or Pressure Sensing Control, as applicable
7	Type of load controlled	AC heater load
26	Number of Manual cycles (M)	6000: 1000 with load 5000 without load
29	Type of disconnection or interruption	Micro-Disconnection (B)
39	Type 1 or Type 2 action	Type 2.B
40	Additional features	Manual reset, D, J or H Action
41	Manufacturing deviation, maximum	±2.8°C (±5°F) for thermal cut-out 5 percent for pressure sensing control
42	Drift	Not vary from the as-received by more than 5 percent, or for thermal cut-out, by more than 5.5°C (10°F), whichever is the greater
48	Operating value	121°C (250°F) setpoint for thermal cutout As declared for pressure sensing control
49	Pollution degree	Pollution degree 2[b]
52	The minimum parameters of any heat dissipater (heat sink) not provided with an electronic control but essential to its correct operation	Must be specified
53	Output waveform if other than sinusoidal	Must be specified
58A	Required protection/immunity from mains borne perturbations, magnetic and electromagnetic disturbances	Required[c]
60	Surge immunity	IEC 61000-4-5 installation Class 3. Overvoltage category III
69	Software Class	C[d]
74	External load and emission control measures to be used for test purposes	Must be specified
91	Fault reaction time	Must be specified
92	Class or classes of control function(s)	C

[a] This table should be used as a correlation for the parameters specified for the Standard for Limit Controls, UL 353, evaluations.

[b] Pollution Degree 2 applies except when the manufacturer declares Pollution Degree 3 due to exposure of condensation or water to the control during normal operation.

[c] For the purpose of the tests specified in the Electromagnetic compatibility (EMC) requirements – immunity, Annex H, Section 26 of the Standard for Automatic Electrical Controls - Part 1: General Requirements, UL 60730-1, the products covered by this Standard should be considered as: a) Installation Class 3 for indoor use, or 4 for outdoor use (See the Explanatory notes for surge immunity test, Annex R, of UL 60730-1); b) Overvoltage Category III applies for permanently-connected equipment; c) Test Level 3.

[d] Does not apply to electromechanical controls or controls with protection implemented in hardware only – see Item 92.

31.2 In determining compliance with 31.1:

a) A low pressure and a high pressure steam boiler shall be provided with pressure operated limit controls that operate to shutdown the boiler before the pressure exceeds the maximum operating pressure, as applicable, see pressure limits of 1.5.

b) A water boiler shall be provided with temperature operated limit controls that operate to shutdown the boiler before the water temperature exceeds the maximum rated operating temperature. For a low pressure hot water boiler, see 1.5, the maximum operating temperature shall not exceed 250°F (121°C).

31.3 The two limit control circuits, see 31.1, shall be separate from each other so that malfunction of any component in one circuit will not adversely affect the operation of the other circuit.

31.3.1 The sensing elements for the limiting controls shall not be located such that disabling of one or any combination of heating element prevents both limit controls from operating to protect the boiler as intended.

31.4 Limit-control circuits shall be 2-wire, one side grounded, having a nominal voltage of 120 volts or less.

Exception: It is the intent of the requirements in 31.4 that a short circuit or combination of short circuits to ground will not render the temperature-limiting control inoperative. A safety control arrangement, other than described in 31.4, may be considered acceptable if it accomplishes the intent of the requirements.

31.5 The limit control shall be wired so that its circuit interrupting means is located in the ungrounded conductor of the limit circuit.

31.6 For a portable boiler, the limit control shall be of the nonmercury type.

31.7 The limit control shall be operative whenever the boiler is connected to the branch circuit power supply.

31.8 Any component including contactors and controls that comprise a safety circuit and function to interrupt the heating element supply circuit shall be investigated as follows:

a) For electro-mechanical components, 100,000 cycles of operation (6000 for a manually reset control), in accordance with 31.1.1 and 31.1.4 – 31.1.5, as applicable; and

b) For electronic components, in accordance with 31.1.2 – 31.1.6, as applicable. The component shall be arranged so that it affects the direct opening of that element, whether the switching mechanism is integral with the sensing element or remote from it.

31.9 An intermediate stage for heater-circuit control, such as a temperature sensor and associated sequence controller, shall be investigated for use as part of a safety circuit and shall comply with 31.8.

Exception: This requirement does not apply to intermediate stage controls if their malfunction does not interfere with the intent of 31.8.

31.10 The manually reset limit control shall operate at a temperature or pressure that is above the predetermined temperature or pressure limit allowed by the automatic limit control.

31.11 A component, such as a relay or the like, shall not be wired in conjunction with a safety device so that malfunction of the component results in the safety circuit being bypassed or defeated.

31.12 Under any condition of operation, the limit control shall function so that the temperature, pressure, or both, whichever is applicable, does not exceed the established design working parameters of the boiler.

32 Low-Water Cutoff

32.1 A boiler shall be equipped with a liquid-level responding limit control, in accordance with 31.1.1 – 31.1.3 as applicable and 31.3 – 31.4, to interrupt all ungrounded heating element circuit conductors before the water in the boiler falls below the top of the heating elements.

Exception No. 1: A low-water cutoff need not comply with the requirements for Limit Controls, Section 31, if the boiler contains immersion elements and complies with the Low-Water Abnormal Test (low-water cut-out shunted out of the circuit), Section 49.

Exception No. 2: A hot water heating boiler is not required to be equipped with a low-water cutoff if all of the following criteria are met:

a) An ASME Code H vessel is utilized;

b) The maximum heat input is 400,000 Btu's per hour [117.2 kw (422 MJ)] or less;

c) The boiler contains immersion elements; and

d) The boiler complies with the Low-Water Abnormal Test, Section 49.

33 Terminals and Sensing Elements of Operating and Limit Controls

33.1 If the bulb, capillary tubing, or other sensing element of an operating or limit control is depended upon to control operation of the boiler so that a risk of injury to persons does not occur, such a part shall be located or shielded so that it is protected from mechanical damage during field installation or subsequent use of the boiler.

33.2 In connection with 33.1, particular attention is to be given to those constructions of boilers that require partial disassembly, or are constructed to permit rearrangement of internal parts, at the time of installation.

34 Pressure-Relieving Devices

34.1 A boiler shall be provided with one or more safety valves or safety relief valves conforming to the requirements of the ASME Boiler and Pressure Vessel Code Section under which it was built. The stamped opening pressure of the safety valve or safety relief valve shall not be more than the maximum pressure stamped on the boiler and, except as noted in 34.3, shall be factory installed on the boiler assembly.

34.2 Each safety valve and safety relief valve shall be marked with the ASME Certification Mark and have either the ″V″ designator for high pressure boilers or the ″HV″ Designator for low pressure boilers.

34.3 A valve that is shipped unattached to a boiler for mounting in the field shall comply with the following:

a) The valve shall be shipped in the same overall shipping container with the boiler;

b) Instructions for mounting the valve shall be included; and

c) The boiler shall have provision, such as a threaded boss, to permit the valve to be mounted as intended.

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34.4 A boiler that has a rated power input of more than 1100 kW (3.96 GJ) shall be provided with two or more safety valves or safety relief valves. When not more than two valves of different sizes are mounted singly, the relieving capacity of the smaller valve shall not be less than 50 percent of that of the larger valve.

Exception: This requirement does not apply to a boiler constructed in accordance with Section IV of the ASME Code.

34.5 There shall be no shut-off valve between the pressure-relief means and the parts that it is intended to protect.

34.6 The minimum valve relieving capacity shall be 3.5 pounds steam/hour per kilowatt of rated power input or 3500 Btu/hour per kilowatt of rated power input.

34.7 A pressure-relief or safety device shall be connected as close as possible to the pressure vessel or parts of the system that it is intended to protect, and shall be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative.

35 Spacings

35.1 The spacings in a boiler shall not be less than those specified in Table 35.1.

Table 35.1
Minimum acceptable spacings

Voltage rating, V	Minimum spacings							
	Between a live part and the enclosure				Between uninsulated live parts of opposite polarity; and between a rigidly mounted uninsulated live part and a dead metal part that is exposed to contact by persons or that may be grounded[a]			
	Through air		Over surface		Through air		Over surface	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 250 volts	1/2	(12.7)	1/2	(12.7)	1/8	(3.2)	1/4	(6.4)
251 – 600 volts	1/2	(12.7)	1/2	(12.7)	1/4	(6.4)	3/8	(9.5)
2500 volts maximum[b]	2	(50.8)	3	(76.2)	1	(25.4)	2	(50.8)
7200 volts maximum[b]	3	(76.2)	4	(102)	2	(50.8)	3.5	(88.9)
15000 volts maximum[b]	6	(152)	8	(203)	4	(102)	7	(178)

[a] If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction is to be such that the minimum spacing will be maintained under all operating conditions.

[b] Because of the effect of configuration, spacings in excess of those indicated may be required to meet performance requirements of this standard.

35.2 The spacings specified in Table 35.1 do not apply to the inherent spacings of a component part of a boiler. Such spacings are judged under the requirements for the component in question.

35.3 The spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

35.4 At closed-in points only, such as the screw-and-washer construction of an uninsulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable on a boiler rated 250 volts or less. Within a thermostat, except at contacts, the spacing between uninsulated live parts on opposite sides of the contacts shall not be less than 1/32 inch (0.8 mm) through air and 3/64 inch (1.2 mm) over the surface of insulating material, and the construction is to be such that the spacings are permanently maintained.

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

35.6 An insulating lining or barrier of fiber or similar material employed where spacings would otherwise be unacceptable shall not be less than 1/32 inch (0.8 mm) in thickness, and shall be so located or of such material that it will not be affected by arcing; except that fiber not less than 1/64 inch (0.4 mm) in thickness may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone. See Table 35.1.

35.7 Unless protected from mechanical abuse during assembly and intended functioning of the boiler, a barrier of mica shall be 0.010 inch (0.26 mm) or more in thickness.

36 Grounding

36.1 A boiler intended for permanent connection to the branch circuit supply shall be provided with a terminal solely for the connection of an equipment-grounding conductor, sized in accordance with Table 36.1, and such terminal shall be so located and secured that its removal during any servicing of the boiler will be unlikely. Sheet-metal screws shall not be provided for connection of equipment grounding conductors to enclosures. See also Section 14, Field Wiring Terminals and Leads and 36.9.

Table 36.1
Size of bonding conductor or strap

Size of bonding conductor[a]		Rating or setting of automatic overcurrent device in circuit ahead of equipment not exceeding
Copper wire	Aluminum or copper clad aluminum wire	
14 AWG	12 AWG	15 Amperes
12	10	20
10	8	60
8	6	100
6	4	200
3	1	400
1	2/0	600
1/0	3/0	800
2/0	4/0	1000
3/0	250 MCM	1200
4/0	350	1600
250 MCM	400	2000
350	500	2500
400	600	3000
500	800	4000
700	1000	5000
800	1200	6000

[a] Or equivalent cross-sectional area.

36.2 For a cord connected boiler, the power supply cord or cord set shall have a conductor suitable for equipment grounding purposes. See 15.1 and 36.5.

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

36.4 With reference to 36.3, the resistance may be determined by any convenient method. If unacceptable results are recorded, either a direct or alternating current equal to the current rating of the maximum branch-circuit overcurrent-protective device that may be employed with the boiler is to be passed from the equipment grounding terminal to the dead metal part, and the resulting drop in potential is measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

36.5 A grounding conductor of a flexible cord shall be:

a) Finished to show a green color with or without a yellow stripe;

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

c) Connected to the enclosure of the boiler. This connection shall be made by a screw not intended to be removed during routine servicing not involving the power supply cord, or by other reliable means. Solder alone is not acceptable for this connection.

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

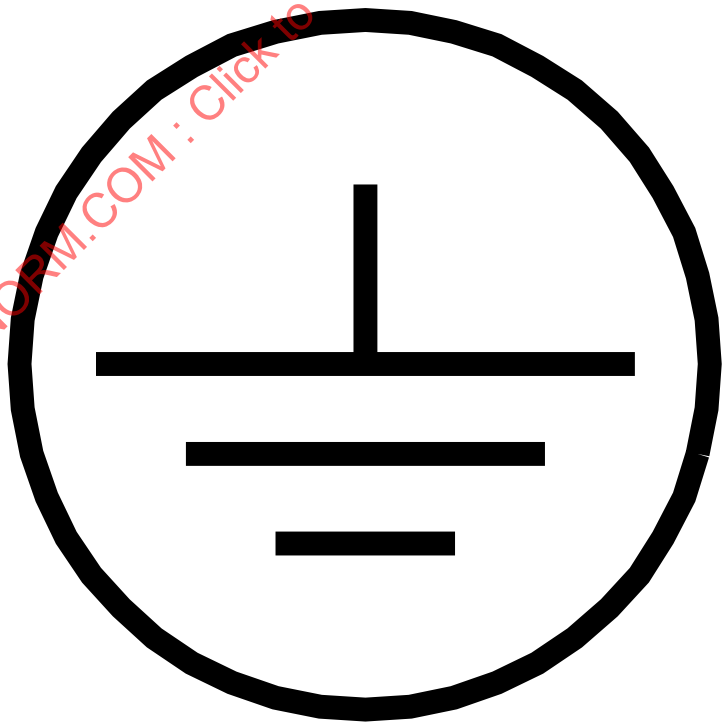
36.8 The requirements in 36.7 relating to color coding for identification does not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

36.9 A wire-binding screw intended for the connection of an equipment grounding conductor shall be identified by:

a) Use of a green-colored head that is slotted or hexagonal, or both; or

b) The grounding symbol illustrated in Figure 36.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 36.1
Grounding symbol



36.10 A pressure wire connector intended for the connection of such a conductor shall be identified by:

a) Being marked G,″ ″GR,″ ″GROUND,″ ″GROUNDING,″ or the like;

b) A marking on a wiring diagram provided on the appliance; or

c) The grounding symbol illustrated in Figure 36.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

36.11 The wire-binding screw or pressure wire connector shall be located inside the terminal compartment and in a manner that will make it unlikely to be removed during routine servicing of the boiler.

36.12 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 36.11, the size of the conductor or strap shall be in accordance with Table 36.1.

36.13 An equipment grounding conductor not smaller than 18 AWG (0.82 mm^2) copper and not smaller than the circuit conductors if an integral part of a flexible cord assembly may be used to ground cord-connected equipment where the equipment is protected by overcurrent devices not exceeding 20 ampere rating.

36.14 The equipment grounding conductor need not be larger than the circuit conductors supplying the equipment.

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

36.16 An internal connector for bonding non-current-carrying parts for ground continuity purposes (excluding a field-installed grounding conductor or the grounding conductor of a supply cord) may employ a quick-connect terminal of the specified dimensions, provided the connector is not likely to be displaced and provided the appliance is limited to use on a circuit having a branch circuit protective device in accordance with Table 36.2.

Table 36.2
Internal terminal connections for bonding

Terminal dimensions inches (mm)	Rating of protective device amperes
0.020 by 0.187 by 0.250 (0.51 by 4.75 by 6.4)	20 or less
0.032 by 0.187 by 0.250 (0.81 by 4.75 by 6.4)	20 or less
0.032 by 0.205 by 0.250 (0.81 by 5.2 by 6.4)	20 or less
0.032 by 0.250 by 0.312 (0.81 by 6.4 by 7.9)	60 or less

PERFORMANCE

37 General

37.1 A boiler shall be subjected to all applicable normal and abnormal tests as indicated in Sections 38 – 49.

38 Test Installation for Alcove or Closet

38.1 The boiler is to be installed in an enclosure, as described below, in the as-received condition, with clearances in integral inches, as selected by the manufacturer, to walls and ceilings of the test enclosure. The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the assembly to the ceiling specified by the manufacturer. See Figures 38.1 and 38.2.

Figure 38.1
Alcove installation

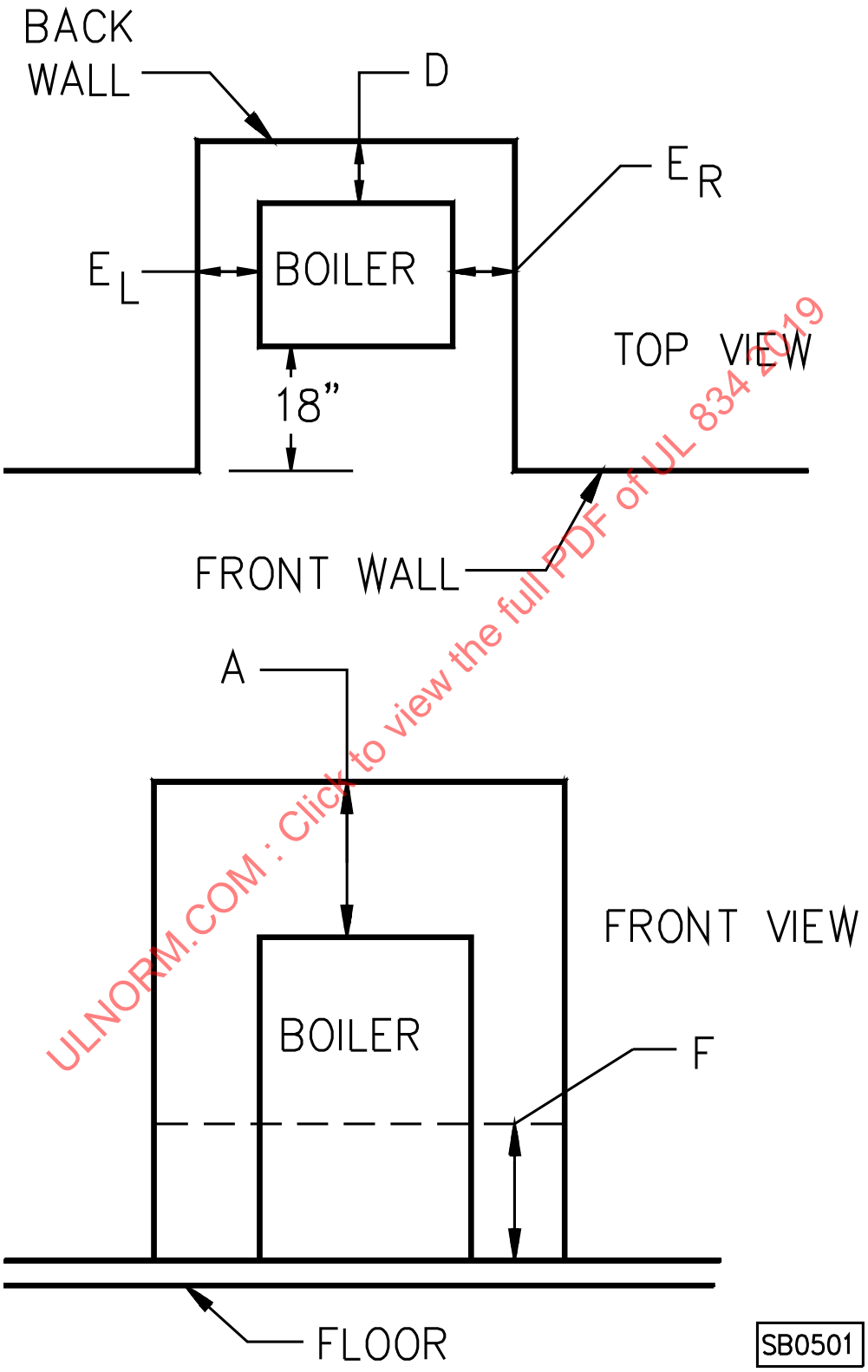
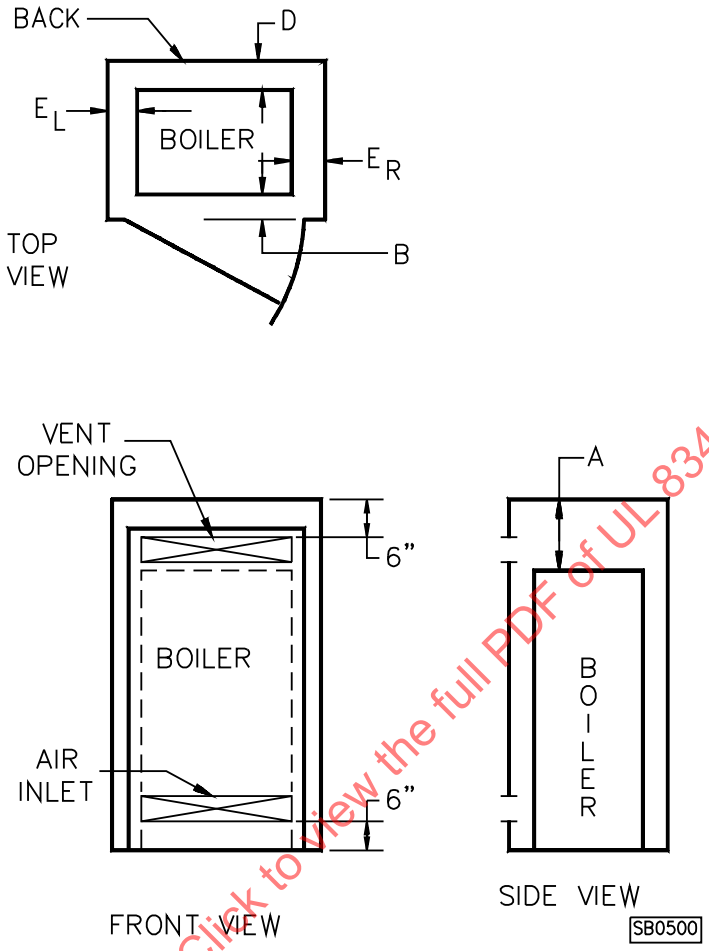


Figure 38.2
Closet installation



Description of dimension, symbols, and abbreviations:

A – Clearance above top of boiler.

B – From front of boiler. Prefix ″C″ to numeral indicates acceptability for closet or alcove installations; prefix ″A,″ acceptability for alcove installation but not for closet.

D – From back of boiler.

EL – From left side of boiler.

ER – From right side of boiler.

F – Indicates type of flooring: ″NC″ for noncombustible; ″C″ for combustible. Numeral indicates minimum clearance below suspended units to combustible floor.

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

38.2 The walls and ceiling of the enclosure are to be made of 1 inch (25.4 mm) nominal thickness wooden boards or 3/4 inch (19.1 mm) thick plywood. The walls are to be vertical and at right angles to each other. The interior surface of the walls and ceiling are to be finished in flat black paint. All joints of the enclosure are to be sealed. The floor is to be of material selected by the manufacturer for testing purposes and as indicated in the installation instructions. Combustible floors are to be made of 3/4 inch (19.1 mm) thick plywood or equivalent, finished in flat black paint.

38.3 For alcove installation, the enclosure is to be opposite the front of the boiler. The side walls are to extend 18 inches (457 mm) beyond the front of the boiler, and a wall is to be placed opposite the open side of the enclosure at a distance of 48, 36, or 24 inches (1.2, 0.9, or 0.6 meters) from the front of the boiler, as specified by the manufacturer for testing purposes.

38.4 For closet installation, a door is to be provided as part of the enclosure. The door is to be located from the front of the boiler no more than the minimum distance as specified by the installation instructions. If ventilating openings are provided, these are to be located as shown in Figure 38.2 and the height of the openings are to be one-half the width.

39 Leakage Current Test

39.1 The leakage current of a cord-connected boiler rated for a nominal 250 volt or less supply, employing a standard attachment plug rated 20 amperes or less, when tested in accordance with 39.3 – 39.8 shall not be more than 0.75 milliampere for stationary or fixed boilers and 0.5 milliampere for portable boilers.

39.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces.

39.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible and from one surface to another where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered suitable for protection against the risk of electric shock as defined in 7.4.1 – 7.4.8. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages which do not present a risk of fire or electric shock.

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

39.5 The measurement circuit for leakage current shall be as shown in Figure 39.1. The measurement instrument is defined in (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

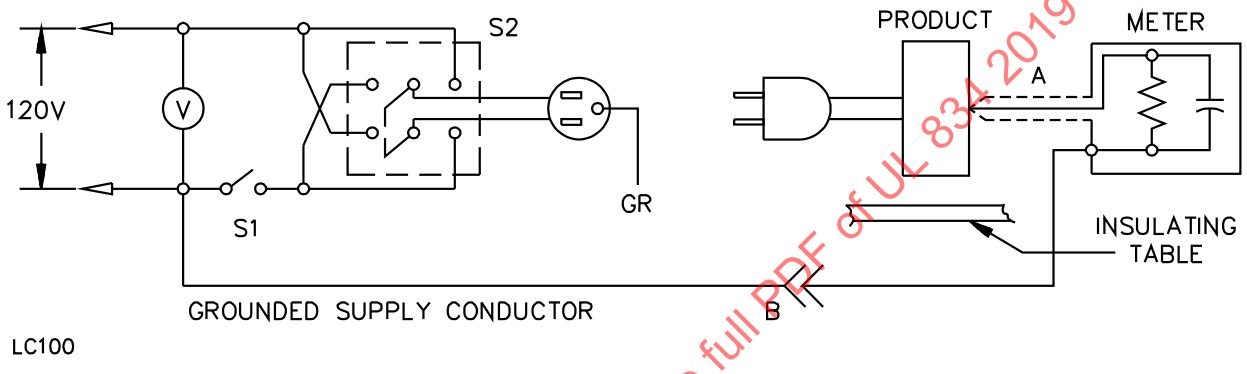
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

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

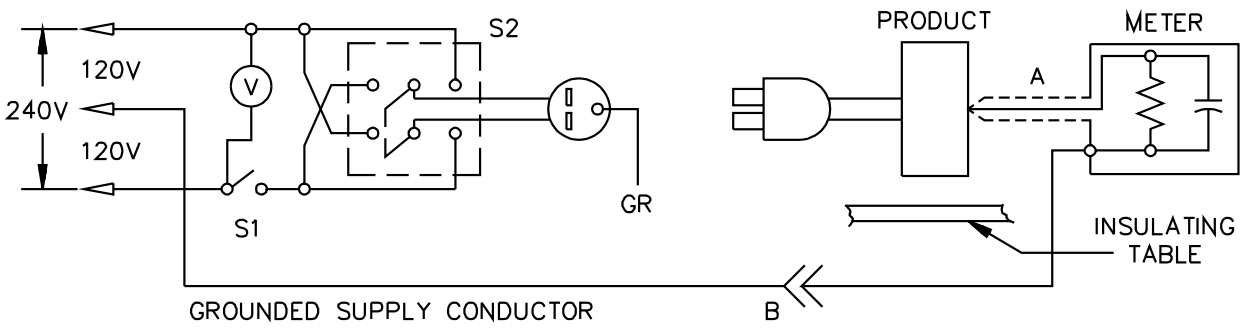
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.75 milliamperes, the measurement is to have an error of not more than 5 percent.

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

Figure 39.1
Leakage-current measurement circuits

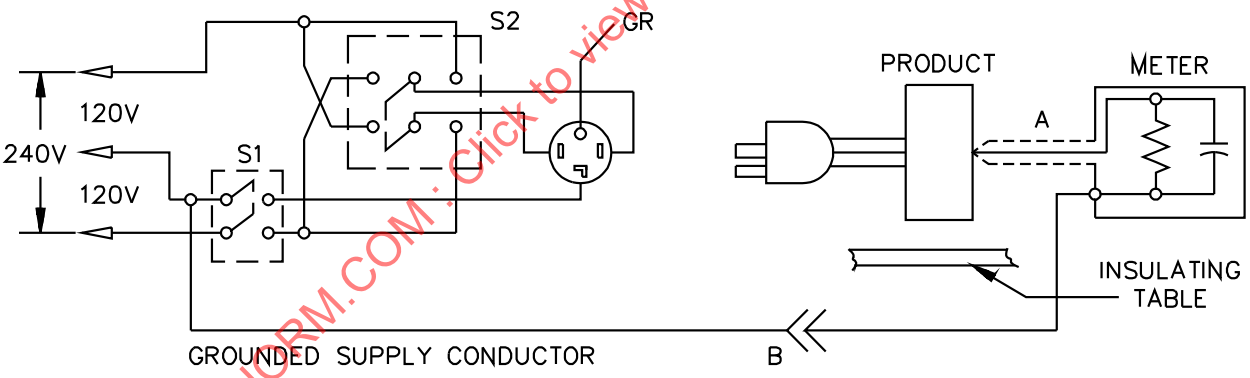


Appliance (boiler) intended for connection to a 120 volt power supply.



LC200

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



LC300

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

A – Probe with shielded lead.

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

39.6 A sample boiler is to be prepared, conditioned, and tested as follows:

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

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

c) The sample is to be conditioned in an ambient temperature of 21 – 27°C (70 – 80°F) and approximately 50 percent relative humidity for not less than 8 hours;

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

e) The supply voltage is to be adjusted to rated voltage; and

f) A boiler that requires connection to a potable water supply is to be filled with water.

39.7 The test boiler is to be installed so that all parallel ground paths – such as through the fill and drain lines – will be eliminated.

39.8 The leakage current test sequence, with reference to the measuring circuit, Figure 39.1 is to be as follows:

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

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

c) The boiler manual switching devices are then to be returned to their operating positions and the unit allowed to run until thermal equilibrium is obtained. Leakage current is to be monitored continuously. For this test, thermal equilibrium is defined as the condition in which leakage current is found to be constant or decreasing in value. Both positions of switch S2 are to be used in determining this measurement. Thermal equilibrium may involve cycling caused by an automatic control in the heating and vending mode. This cycling is to be observed with switch S2 in both positions; and

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

39.9 Usually, a boiler will be carried through the complete leakage current test program as covered in 39.8 without interruption for other tests. However, the leakage current tests may be interrupted to conduct other nondestructive tests.

40 Power Input Test

40.1 The power input to a boiler shall not be more than 105 percent of its marked rating.

40.2 To determine whether a boiler complies with the requirement in 40.1, the power input is to be measured with the boiler at normal operating temperature and while connected to a rated supply circuit.

41 Limit Control Cutout Test

41.1 The maximum setting of the limit control allowed by a fixed stop shall not permit a pressure of more than 15 psi (103 kPa) in a low pressure steam boiler, and a water temperature of more than 250°F (121°C) in a low pressure hot water heating boiler under any condition of operation. The limit control of a high pressure boiler at its maximum setting shall function when the steam pressure is not more than the designed working pressure of the steam 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.

41.2 A limit control incorporating a mercury tube switch to sense pressure, temperature, or both is to be plumb prior to conducting this test. See 52.1.

41.3 The boiler is to be filled to a normal level with water. The limit control is to be adjusted to the maximum setting. A resetting pressure relief valve set to relieve at a pressure equivalent to the working pressure of the boiler [30 psi (207 kPa) minimum for low pressure hot water boilers] is to be connected to the boiler. A steam boiler is to be provided with a safety valve set to operate at a pressure equivalent to the working pressure of the boiler.

41.4 The outlet water temperature is to be measured by a thermocouple which has been reliably secured to the outlet pipe as close as possible to the boiler vessel, and which is insulated from ambient air. A laboratory-type steam pressure gage ranged to facilitate the determination of pressure is to be installed on a steam boiler.

41.5 A regulating valve is to be placed as close as permissible to the outlet of the boiler.

41.6 The boiler elements are to be energized at rated voltage and the water or steam valves adjusted to slowly raise the temperature or pressure until the limit control functions. Neither the maximum water temperature in the boiler nor the pressure shall exceed the values stated in 41.1.

42 Temperature Test

42.1 A boiler, when tested under conditions of maximum normal load, shall not attain a temperature at any point to:

a) Constitute a risk of fire;

b) Damage any material employed in the boiler; or

c) Exhibit temperature rises at specific points greater than those specified in Table 42.1.

42.2 All values in Table 42.1 are based on an assumed ambient temperature of 25°C (77°F). The tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). For the tests, the ambient measuring thermocouple is to be placed centrally 24 inches (610 mm) in front of the boiler and 24 inches (610 mm) above the test-enclosure floor.

Table 42.1
Maximum temperature rises

Material or component	Degrees	
	C	(F)
A. MOTORS		
1. Class A insulation systems on coil windings of an a-c motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor[a, b]		
a. In an open motor:		
Thermocouple or resistance method	75	(135)
b. In a totally enclosed motor:		
Thermocouple or resistance method	80	(144)
2. Class A insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor[a,b]		
a. In an open motor:		
Thermocouple method	65	(117)
Resistance method	75	(135)
b. In a totally enclosed motor:		
Thermocouple method	70	(126)
Resistance method	80	(144)
3. Class B insulation systems on coil windings of an a-c motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor[a,b]		
a. In an open motor and on vibrator coils:		
Thermocouple or resistance method	95	(171)
b. In a totally enclosed motor:		
Thermocouple or resistance method	100	(180)
4. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor[a,b]		
a. In an open motor:		
Thermocouple method	85	(153)
Resistance method	95	(171)
b. In a totally enclosed motor:		
Thermocouple method	90	(162)

Table 42.1 Continued on Next Page

Table 42.1 Continued

Material or component	Degrees	
	C	(F)
Resistance method	100	(180)
B. COMPONENTS		
1. Capacitors:		
a. Electrolytic	65	(117)
b. Other types	See Notes c and d	
2. Fuses, Class CC, G, J, L, and T	85	(153)
3. Fuses other than specified in item 2	65	(117)
4. Relay, solenoid, transformers and coils with:		
a. Class 105 insulated systems:		
Thermocouple method	65	(117)
Resistance method	85	(153)
b. Class 130 insulation systems:		
Thermocouple method	85	(153)
Resistance method	105	(189)
5. Sealing Compound		
C. CONDUCTORS		
1. Copper Conductors – General		
a. Copper conductor, bare, without tinning, nickel coating, or silver plating	175	(315)
b. Copper conductor, with tinning, nickel coating, or silver plating	No limit	
c. Termination of copper conductor in a pressure terminal connector, unless both are tinned, nickel coated, or silver plated	125	(225)
2. Insulated wire or cord	25°C(77°F) less than its established temperature rating[f,g]	
3. Stainless steel and other corrosion-resistant alloys	No limit	
D. ELECTRICAL INSULATION – GENERAL		
1. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[h]	125	(225)
E. SURFACES		
1. Any point on a surface adjacent to a boiler, including the surface on which the boiler is mounted or supported, and specified points on test surfaces and enclosures at designated clearances from the boiler; metal surfaces of a boiler at point of contact with the test surfaces and surfaces of a boiler which are recessed within the test enclosure. See Figures 38.1 and 38.2 and 57.3	65	(117)
2. Any point within a terminal box or wiring compartment of a boiler in which power supply conductors are to be connected, including such conductors themselves, unless the boiler is marked in accordance with 57.10	35	(63)
F. GENERAL		
1. Knobs, handles, buttons, levers, and the like that may need to be manipulated by the user during normal operation[i]		
Metal	35	(63)
Nonmetallic	60	(108)

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple may be more than the maximum acceptable temperature specified in this table provided the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple may be more than the specified value by:

1. 5°C (9°F) for Class A insulation on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less, open type;

Table 42.1 Continued on Next Page