UL 296A

STANDARD FOR SAFETY

Waste Oil-Burning Air-Heating Appliances

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UL Standard for Safety for Waste Oil-Burning Air-Heating Appliances, UL 296A

Third Edition, Dated August 2, 2018

Summary of Topics

This revision of ANSI/UL 296A is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 17, 2018.

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AUGUST 2, 2018
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UL 296A

Standard for Waste Oil-Burning Air-Heating Appliances

Previous numbered and unnumbered editions of standards covering heating appliances have been published since 1987.

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Second Edition – October, 1995

Third Edition

August 2, 2018

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through October 8, 2018.

The most recent designation of ANSI/UL 296A as a Reaffirmed American National Standard (ANS) occurred on October 8, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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PART I – ALL WASTE OIL-BURNING AIR-HEATING APPLIANCES

INTRODUCTION

1 Scope

1.1 These requirements cover air-heating appliances of the central furnace and unit heater types and boiler assemblies intended for burning waste oil fuels and having fuel inputs rated no more than 20 gallons/hour (75.7 liters/hour) or approximately 3,000,000 Btu/hour (3,160,000 kj/hour).

1.2 These requirements cover automatically-lighted, mechanical-atomizing type burners that typically are used with these appliances. The burner is to be factory-installed on or provided with each appliance.

1.3 The burners covered by these requirements are equipped with an automatic primary safety control to prevent the abnormal discharge of oil at the burner in the event of ignition failure or flame failure.

1.4 Requirements for the installation and use of waste oil-burning appliances are included in the Installation of Oil Burning Equipment, ANSI/NFPA 31. Waste oil-burning appliances are for use only in commercial and industrial applications.

1.5 In addition to being investigated for use with waste oils, the heating appliances covered by these requirements are investigated for use with a numerical grade of fuel oil, graded according to the Specification for Fuel Oils, ANSI/ASTM D396.

1.6 The terms ″combustible″ and ″noncombustible″, as used in these requirements, are defined in the Glossary of Terms Relating to Chimneys, Vents, and Heat-Producing Appliances, ANSI/NFPA 97M.

2 General

2.1 The term ″appliance″ refers to any equipment covered by this standard. The term ″furnace″ refers to a central furnace. The term ″heater″ refers to a unit heater.

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

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

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3 Glossary

3.1 For the purpose of this standard, the following definitions apply.

3.2 ACCESSIBLE, READILY – Capable of being reached easily and quickly for operation, adjustment, and inspection.

3.3 AIR, PRIMARY – The air introduced into a burner and that mixes with the fuel before it reaches the ignition zone.

3.4 AIR, SECONDARY – The air externally supplied to the flame at or beyond the point of ignition.

3.5 AIR SHUTTER – An adjustable device for varying the size of the air inlet or inlets regulating primary or secondary air.

3.6 APPLIANCE, DIRECT VENT SYSTEM – A self-contained appliance that is inherently constructed so that:

a) All air supplied for combustion;

b) The combustion system of the appliance; and

c) All products of combustion

are completely isolated from the atmosphere of the space in which the appliance is installed.

3.7 APPLIANCE, VENTED – An indirect-fired appliance provided with a flue collar to accommodate a flue pipe for transporting flue gases to the outer air.

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

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

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

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

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

3.13 BURNER, AUTOMATICALLY LIGHTED – One in which fuel to the main burner is normally turned on and ignited automatically.

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3.14 BURNER, MANUALLY LIGHTED – One in which fuel to the main burner is turned on only by hand and is ignited under supervision.

3.15 BURNER, MECHANICAL-ATOMIZING TYPE – A power-operated burner that prepares and delivers the oil and all or part of the air by a mechanical process in controllable quantities for combustion. Some examples are air atomizing, high and low pressure atomizing, horizontal rotary atomizing, vertical rotary atomizing, and vertical rotary wall-flame burners.

3.16 BURNER, MECHANICAL-DRAFT TYPE – A burner that includes a power-driven fan, blower, or other mechanism as the principal means for supplying air for combustion.

3.17 BURNER, NATURAL-DRAFT TYPE – A burner that depends principally upon the natural draft created in the flue to induce into the burner the air required for combustion.

3.18 CONTROL, LIMIT – A safety control responsive to changes in liquid level, pressure, or temperature, normally set beyond the intended operating range of the controlled appliance to limit its operation.

3.19 CONTROL, OPERATING – A control, other than a safety control or interlock, to start or regulate input according to demand, and to stop or regulate input upon satisfaction of demand. An operating control may also actuate auxiliary equipment.

3.20 CONTROL, PRIMARY SAFETY – A control that is directly responsive to flame properties and that senses the presence or absence of flame and, in event of ignition failure or unintentional flame extinguishment, causes safety shutdown.

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

3.22 DRAFT REGULATOR, BAROMETRIC (AUTOMATIC DAMPER) – A device that functions to maintain a desired draft in the appliance by automatically reducing excess chimney draft to the desired value.

3.23 ELECTRICAL CIRCUITS:

a) High-Voltage Circuit – A circuit involving a potential of no more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit (or an isolated limited secondary circuit);

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

c) Low-Voltage Circuit – A circuit involving a potential of no more than 30 volts rms alternating-current (42.4 volts peak) or direct current and:

1) Supplied by a Class 2 transformer, or by a battery, by a battery and fixed impedance, by a transformer and fixed impedance each of which complies with the requirements for a Class 2 transformer as specified in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; or

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2) Limited to a maximum of 100 volt-amperes. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit to limit the voltage and current, is not considered to be a low-voltage circuit;

d) Safety Control Circuit – A circuit involving one or more safety controls.

3.24 EXCESS AIR – Air that passes through the combustion area and the appliance flues in excess of that which is theoretically required for complete combustion.

3.25 FLUE, APPLIANCE – The flue passages within the appliance.

3.26 FLUE COLLAR – That portion of an appliance intended for attachment of the chimney or vent connector.

3.27 FURNACE, CENTRAL WARM-AIR – A self-contained indirect-fired appliance constructed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

3.28 FURNACE, DOWNFLOW – A forced-air type central furnace constructed with air flow through the furnace essentially in a vertical path, discharging air at or near the bottom of the furnace as shown in Figure 3.1.

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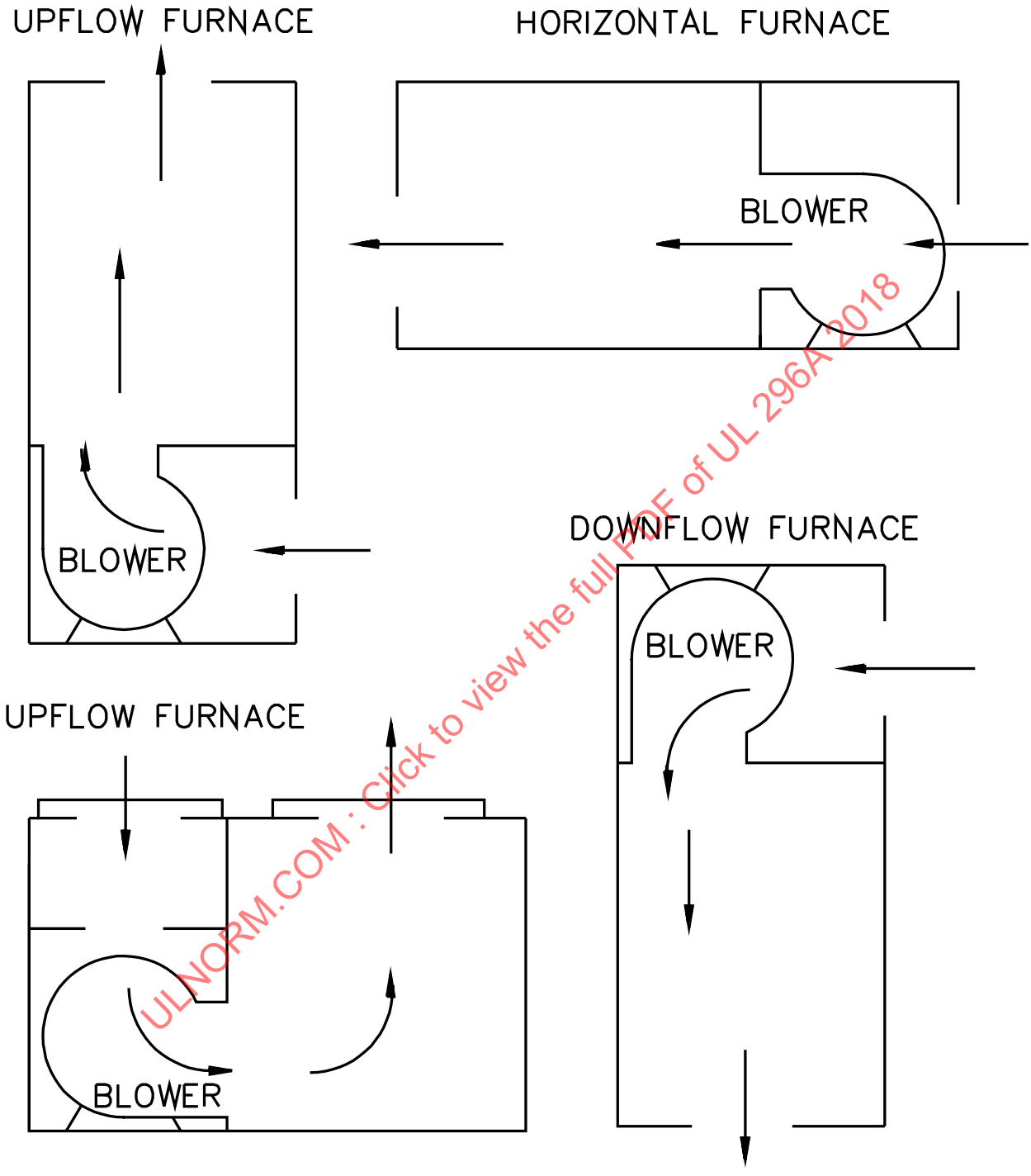
Figure 3.1
Types of forced-air central furnaces



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3.29 FURNACE, HORIZONTAL – A forced-air type central furnace constructed with air flow through the furnace essentially in a horizontal path as shown in Figure 3.1.

3.30 FURNACE, UPFLOW – A central furnace constructed with air flow through the furnace essentially in a vertical path, discharging air at or near the top of the furnace as shown in Figure 3.1.

3.31 IGNITION, INTERMITTENT – Ignition by an energy source that is continuously maintained throughout the time the burner is firing.

3.32 IGNITION, INTERRUPTED – An ignition system that is energized each time the main burner is to be fired and de-energized at the end of a timed trial-for-ignition period or after the main flame is established.

3.33 IGNITION, MANUAL – Ignition by an energy source that is manually energized and where the fuel to the pilot is lighted automatically when the ignition system is energized.

3.34 INTERLOCK – A control used to determine the physical state of a required condition and to signal that determination to the primary safety control of the appliance.

3.35 OIL, FUEL – Any hydrocarbon oil as defined by the Specifications for Fuel Oils, ANSI/ASTM D396.

3.36 OIL, WASTE – Used automotive crankcase oils (which may contain unburned gasoline, transmission fluids, or brake fluids). Waste oils may be a mixture of these fluids and may vary considerably in their chemical and physical properties.

3.37 PILOT – A flame that is used to ignite the fuel at the main burner or burners.

3.38 PILOT FLAME-ESTABLISHING PERIOD – The period of time fuel is permitted to be delivered to a proved pilot before the flame-sensing device is required to detect pilot flame.

3.39 PILOT, PROVED – A pilot flame supervised by a primary safety control that senses the presence of the pilot flame prior to permitting the main burner fuel to be delivered for combustion.

3.40 PUMP, OIL-TRANSFER – An oil pump, automatically or manually operated, that transfers oil through continuous piping from a supply tank to an oil-burning appliance or to an auxiliary tank and that is not intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the appliance.

3.41 RADIATION SHIELD – A separate panel or panels located between heating surfaces and adjacent objects to reduce heat transmission by radiation.

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

3.43 SERVICING – The periodic tasks performed to operate and maintain an appliance, such as air, fuel, pressure, and temperature regulation, cleaning, lubrication, and resetting of controls. Repair and replacement of parts other than those expected to be renewed periodically are not considered to be servicing tasks. Some examples of servicing are:

a) Cleaning or replacing nozzles, atomizers, and pilots;

b) Setting ignition electrodes;

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c) Cleaning strainers or replacing strainer or filter element;

d) Resetting a safety control; and

e) Replacing an igniter cable.

3.44 SPECIAL PARTS AND TOOLS – Those parts and tools that are not generally available on the open retail market.

3.45 STRAINER, PRIMARY – The strainer through which all oil first passes on the way to the burner and that is located upstream from any other strainer.

3.46 STRAINER, SECONDARY – A strainer downstream from the primary strainer that is located in the fuel line between the primary strainer and the point at which fuel is delivered for combustion.

3.47 TRIAL-FOR-IGNITION PERIOD – The period of time the main burner fuel is permitted to be delivered into the ignition zone before the main flame-sensing device is required to detect main flame.

3.48 UNIT HEATER – A self-contained, automatically controlled, indirect-fired air heating appliance that may be floor-mounted or of the suspended type. A unit heater is equipped with an integral fan or blower for circulation of air and is to be used for the heating of a nonresidential space. A unit heater may be equipped with louvers or face extensions by the manufacturer.

3.49 VALVE, MANUAL OIL SHUT-OFF – A manually operated valve in the oil line for the purpose of completely turning on or shutting off the oil supply to the burner.

3.50 VALVE, OIL CONTROL – An automatically or manually operated device consisting essentially of an oil valve for controlling the fuel supply to a burner:

a) Metering (Regulating) Valve – An oil control valve for regulating burner input;

b) Safety Valve – A normally closed valve of the ″on″ and ″off″ type, without any bypass to the burner, that is actuated by a safety control or by an emergency device.

4 Components

4.1 Except as indicated in 4.2, 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.

4.2 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.

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

4.4 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.

CONSTRUCTION

5 Protection of Users and Service Personnel

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

5.2 Service functions that may have to be performed with the equipment energized include:

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

b) Resetting control trip mechanisms;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

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

5.3 The requirements specified in 5.1 are not applicable to mechanical service functions that are not normally performed with the equipment energized. Such functions include adjusting or replacing belts and cleaning and replacement of strainers and oil filters.

5.4 Adjustable or resettable electrical control or manual switching devices may be located or oriented with regard to uninsulated high-voltage live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the intended direction of access if uninsulated high-voltage live parts or moving parts that may cause injury to persons are not located:

a) In front of the mechanism in the direction of access; and

b) Within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

5.5 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized (excluding voltage measurements other than for jacks or terminals specifically intended for that purpose) shall be located and mounted with regard to other components and with regard to grounded metal parts so that the component is accessible for electrical service functions without subjecting service personnel to:

a) The risk of electric shock from adjacent uninsulated live parts; or

b) Injury from adjacent moving parts.

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5.6 Accessibility and protection from the risk of electric shock and accidental contact with moving parts that may cause injury to persons may be accomplished by mounting the control components in an assembly so that unimpeded access is provided to each compartment through an access cover or panel in the outer cabinet or the cover of the control assembly enclosure, as shown in Figure 5.1, with the following arrangement:

a) The components are located with regard to the access opening in the outer cabinet so that the component in the control assembly that is located farthest from the access opening is no more than 14 inches (356 mm) from the plane of the access opening;

b) Uninsulated high-voltage live parts outside the control assembly projected clear space (except for live parts within a control panel) or unguarded moving parts are located at least 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure;

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

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

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

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

2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure as specified in 5.4, unless guarded.

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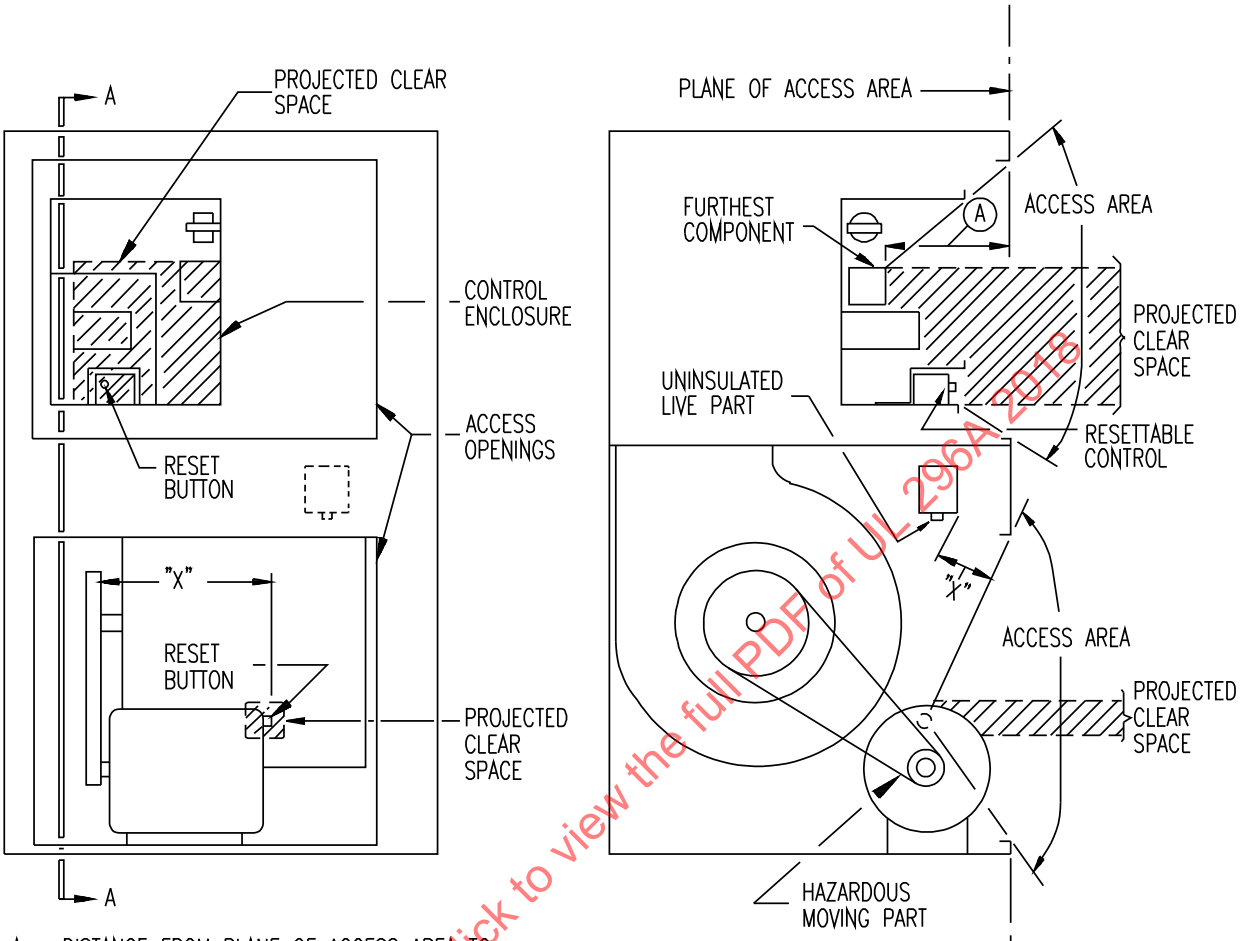
Figure 5.1
Accessibility and protection



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

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

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5.7 Components in a low-voltage circuit shall comply with the requirements specified in 5.5 in their relation to uninsulated live parts in a high-voltage circuit and to moving parts.

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

a) Coils of controllers;

b) Relays and solenoids;

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

d) Enclosed motor windings;

e) Insulated terminals and splices; and

f) Insulated wire.

5.9 Moving parts such as fan blades, blower wheels, pulleys, or belts that may cause injury to persons shall be enclosed or guarded.

5.10 If the removal of doors, panels, or shields will expose moving parts:

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

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

c) A warning marking as specified in 34.6 shall be provided where readily visible after installation to warn the user to shut off the equipment before removing or opening the cover or door.

5.11 The distance from an opening in a required guard or enclosure to the moving part indicated in 5.9 shall be in accordance with Table 5.1, and the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension between two of the values included in Table 5.1, the distance from the opening to the moving part shall be no less than that found by interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening shall be determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

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Table 5.1
Dimensions of openings in enclosure

Minor dimensions of opening[a]		Minimum distance from opening to moving part	
Inches	(mm)	Inches	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114)
1	(25.4)	6-1/2	(165)
1-1/2	(38.1)	10-1/2	(267)
2	(50.8)	14-1/2	(368)
3	(76.2)	30	(762)

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

5.12 If a moving part is unlikely to be contacted through the opening because of fixed components, including baffles, the moving part shall not be considered when determining compliance with 5.1 and 5.9.

6 Enclosures

6.1 General

6.1.1 Uninsulated high-voltage live parts shall be enclosed or guarded to reduce the risk of unintentional contact by persons during intended use of the equipment. This applies also to uninsulated high-voltage live parts located in a compartment into which access is required for servicing of the equipment, such as resetting controls, replacing filters, lubrication, and cleaning.

6.1.2 Among the factors taken into consideration when determining the acceptability of an enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability;

e) Resistance to corrosion; and

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

For a nonmetallic enclosure or nonmetallic part of an enclosure, all of these factors shall be considered with regard to thermal and chemical aging.

6.1.3 The enclosure shall prevent the emission of molten metal, burning insulation, flaming particles, or the like through openings onto flammable material, including the surface on which the equipment is mounted.

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

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

6.1.6 Sheet metal complying with Table 6.1 or 6.2, whichever is appropriate, is acceptable for the individual enclosure of electrical components.

6.1.7 If the construction and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of metal thinner than as specified in Table 6.1 or 6.2, whichever is applicable, may be used.

6.1.8 If insulating material other than electrical insulation is provided within the enclosure, the burning characteristics and flammability of the material and the proximity of an ignition source shall be considered.

6.1.9 Each intended mounting position of the unit shall be considered when determining if the unit complies with the requirement specified in 6.1.3.

6.1.10 A junction box that is formed in part by another part such as a fan scroll or a motor casing shall fit such that:

a) An opening between the box and motor frame having a dimension greater than 1/2 inch (12.7 mm) does not permit the entrance of a flat feeler gauge that is 5/64 inch (2.0 mm) thick by 1/2 inch (12.7 mm) wide; and

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

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Table 6.1
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			
Maximum width,[b] in		Maximum length[c] in		Maximum width[b] in		Maximum length in		Uncoated		Zinc coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inch	(mm)	Inch	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not Limited		0.020[d]	(0.51)	0.023[d]	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026[d]	(0.66)	0.029[d]	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)				
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)

Table 6.1 Continued on Next Page

Table 6.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b] in		Maximum length[c] in		Maximum width[b] in		Maximum length in		Uncoated		Zinc coated	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inch	(mm)	Inch	(mm)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)				
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be applied by the enclosure surface when it is deflected. An enclosure that is considered to have equivalent reinforcing may be accomplished by constructions that will produce a structure that is as rigid as one built with a frame of angles or channels. Constructions considered to be without a supporting frame include, a single sheet with single formed flanges (formed edges), a single sheet that is corrugated or ribbed, and an enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For a panel that is not supported along one side, such as a side panel of a box, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

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

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Table 6.2
Minimum thickness of sheet metal for electrical enclosures carbon steel or stainless steel

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

Table 6.2 Continued on Next Page

Table 6.2 Continued

Without supporting frame[a]				With supporting frame equivalent reinforcing[a]				Minimum thickness	
Maximum width[b] in		Maximum length[c] in		Maximum width[b] in		Maximum length in			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inch	(mm)

[a] A supporting frame is a structure of angle or channel or a folded section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be applied by the enclosure surface when it is deflected. An enclosure that is considered to have equivalent reinforcing may be accomplished by constructions that will produce a structure that is as rigid as one built with a frame of angles or channels. Constructions considered to be without a supporting frame include, single sheet with formed flanges (formed edges), a single sheet that is corrugated or ribbed; and an enclosure surface loosely attached to a frame, for example, with spring clips.

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

[c] For a panel not supported along one side, such as a side panel of a box, the length of the unsupported side shall be limited to the dimensions specified. unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

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

6.1.11 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with one of the following:

a) For an opening that has a minor dimension, as defined in 6.1.15, less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 6.1; and

b) For an opening that has a minor dimension of 1 inch or greater, such a part or wire shall be spaced from the opening as specified in Table 6.3.

Exception: An opening in an integral enclosure of a motor need not comply with these requirements if it complies with the requirements specified in 6.1.12.

Table 6.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening		Minimum distance from opening to part	
Inches[b]	(mm)[b]	Inches	(mm)
3/4	(19.1)[c]	4-1/2	(114.0)
1[c]	(25.4)[c]	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(191.0)
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	(445.0)
d		30	(762.0)

[a] See 6.15.

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

[c] Any dimension less than 1 inch applies to a motor only.

[d] More than 2-1/8 inches, but no more than 6 inches (152 mm).

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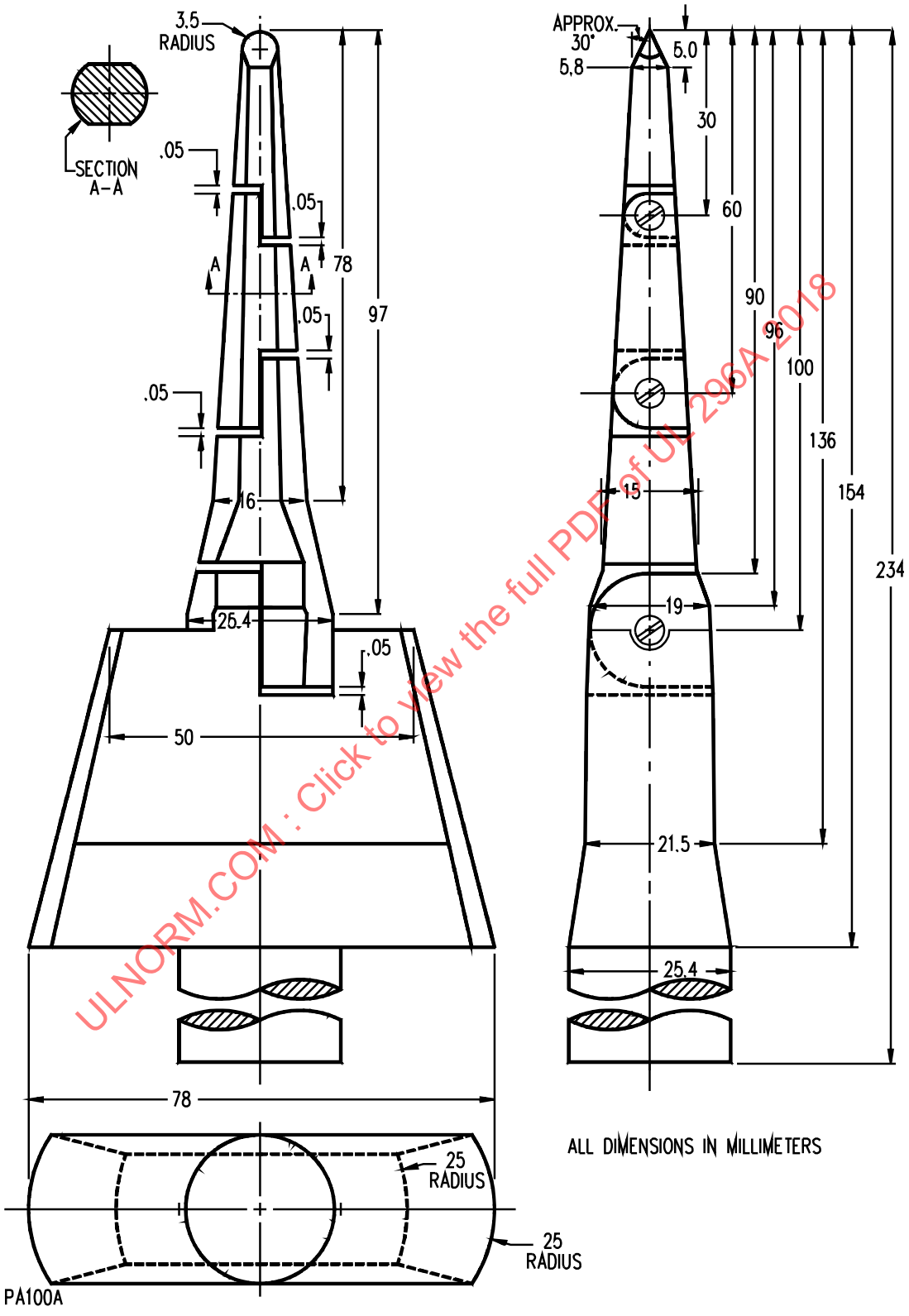
Figure 6.1
Articulate probe with web stop



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6.1.12 With regard to a part or wire as specified in 6.1.11, for an integral enclosure of a motor as specified in the exception of 6.1.11:

a) An opening that has a minor dimension, as defined in 6.1.15, less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 6.2;

2) In a directly accessible motor as specified in 6.1.16, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.3; or

3) In an indirectly accessible motor as specified in 6.1.16, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.4;

b) An opening that has a minor dimension of 3/4 inch or greater is acceptable if a part or wire is spaced from the opening as specified in Table 6.3.

Figure 6.2
Probe for film-coated wire

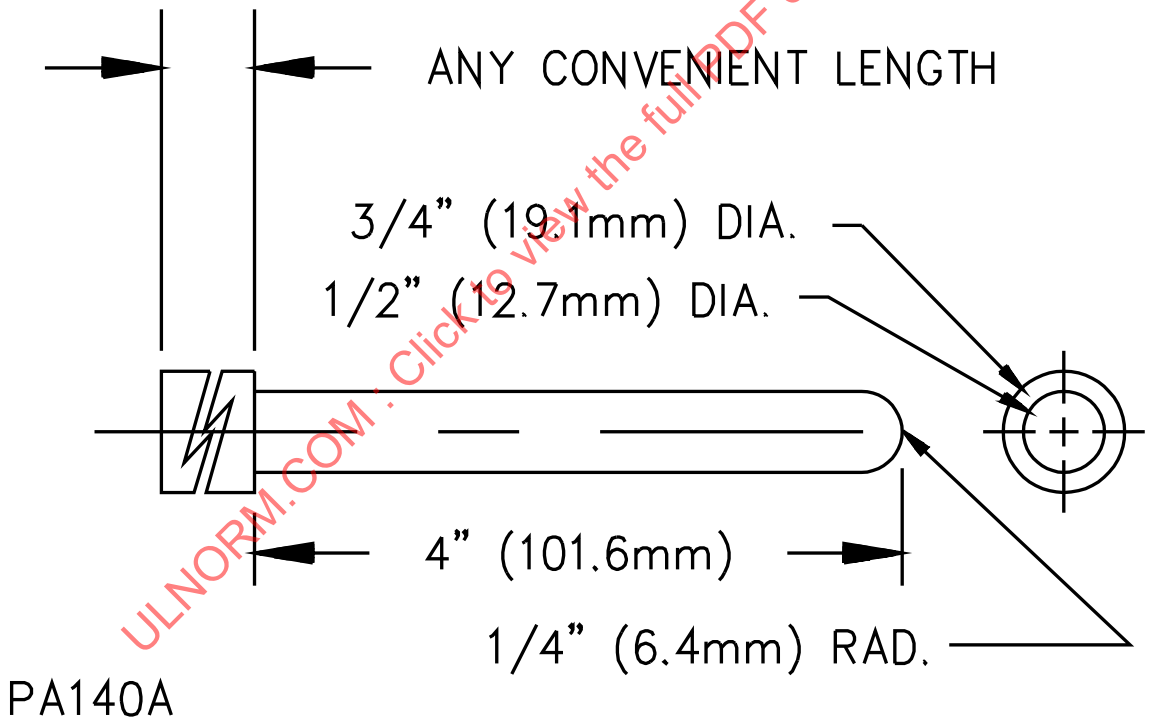

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Figure 6.3
Articulate probe

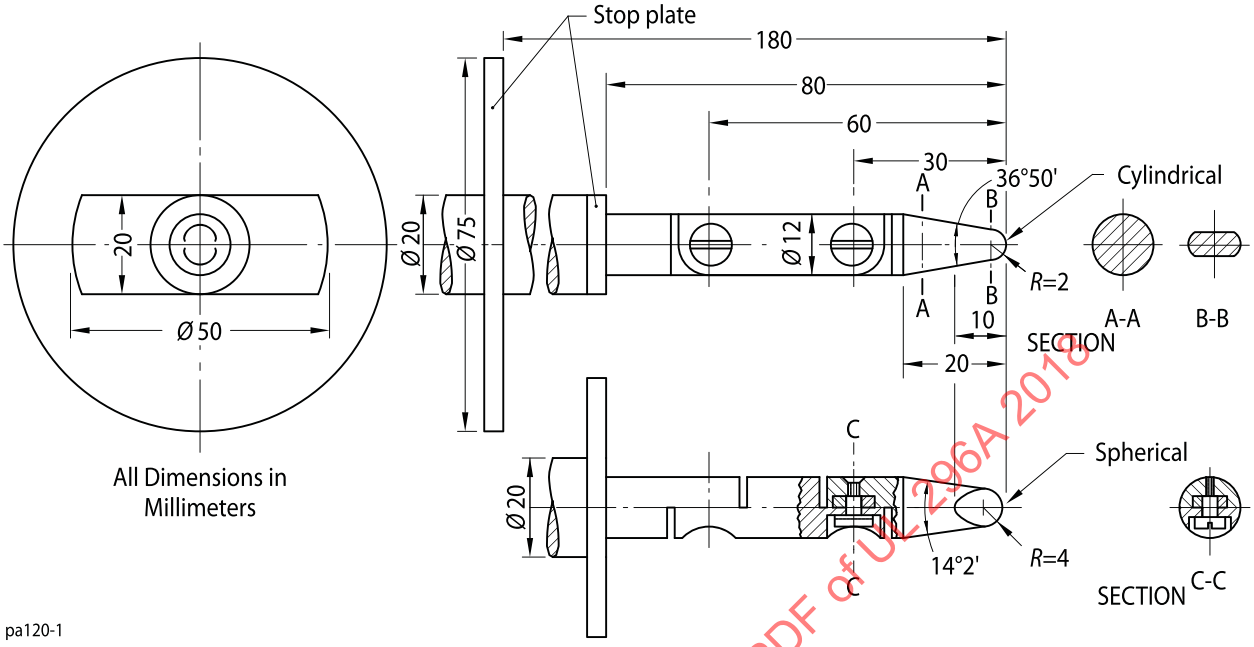

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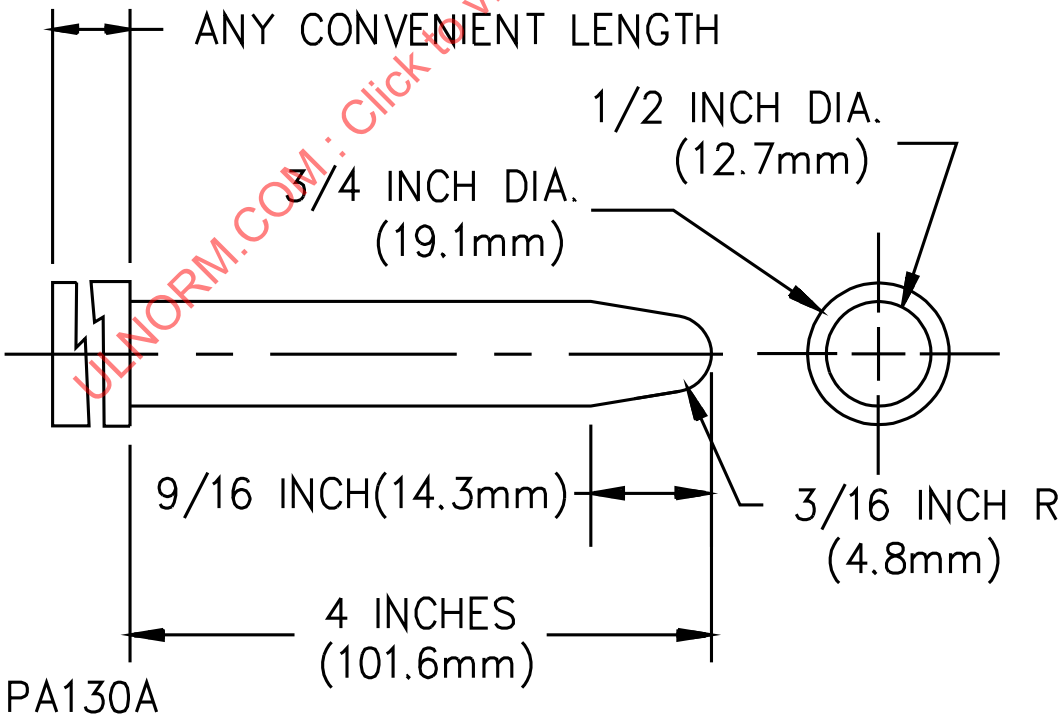
Figure 6.4
Probe for uninsulated live parts



6.1.13 The probes specified in 6.1.11 and 6.1.12 and illustrated in Figures 6.1 – 6.4 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 6.1 and 6.3 shall be applied in any possible configuration and, if necessary, the configuration shall be changed after insertion through the opening.

6.1.14 The probes specified in 6.1.13 and 6.1.15 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; the probes are to be applied with the minimum force necessary to determine accessibility.

6.1.15 With regard to the requirements specified in 6.1.11 and 6.1.12, 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.

6.1.16 With regard to the requirements specified in 6.1.12, an indirectly accessible motor is a motor that:

a) Is 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) Is 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:

1) Can be contacted without opening or removing any part; or

2) Is located so as to be accessible to contact.

6.1.17 To determine whether a product complies with the requirements specified in 6.1.11 or 6.1.12, a part of the enclosure that may be opened or removed by the user without the use of a tool is to be opened or removed.

6.1.18 With regard to the requirements specified in 6.1.11 and 6.1.12, insulated brush caps are not required to be additionally enclosed.

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6.2 Doors and covers

6.2.1 A cover or access panel of an enclosure for uninsulated high-voltage parts shall be provided with means for securing it in place.

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

6.2.3 The assembly shall be arranged so that an overcurrent protective device, such as a fuse, the protective functioning of which requires renewal, can be replaced and so that manual-reset devices can be reset without removing parts other than a service cover or panel and a cover or door enclosing the device. A cover or door enclosing the device shall be hinged as described in 6.2.7.

6.2.4 A required protective device shall be inaccessible from outside the appliance without opening a door or cover.

Exception: The operating handle of a circuit breaker, the reset button of a manually resettable motor protector, the reset button of a manually resettable limit control, and similar parts may project outside the appliance enclosure.

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

6.2.6 A fuseholder shall be constructed, installed, or protected so that adjacent uninsulated high-voltage live parts within 4 inches (102 mm), other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or equivalent material used for this purpose shall be no less than 0.028 inch (0.71 mm) thick.

6.2.7 Other than as specified in 6.2.8, the door or cover of an enclosure shall be hinged if:

a) The door or cover gives access to fuses or any motor overload protective device, the intended protective functioning of which requires renewal; or

b) It is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manual reset overload protective device.

6.2.8 A hinged cover is not required for an enclosure 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;

b) Supplementary-type fuses of 2 amperes or less for small auxiliary resistance heaters with a maximum rating of 100 watts;

c) An extractor-type fuse provided with its own enclosure; or

d) Fuses in low-voltage circuits.

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

6.2.10 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and will require some effort to open is considered to be an acceptable means for holding the door in place as specified in 6.2.9.

6.2.11 A door or cover providing direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4-inch (6.4-mm) rabbet or the equivalent or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box no less than 1/2 inch (12.7 mm). A construction that provides equivalent protection, such as a fuse enclosure within an outer enclosure or a combination of flange and rabbet, is acceptable.

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6.2.12 Strips used to provide rabbets or angle strips fastened to the edges of a door shall be secured at no less than two points that are no more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these end fastenings no more than 6 inches (152 mm) apart.

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

6.3 Field wiring system connections

6.3.1 Sheet metal to which a wiring system is to be connected in the field shall have a thickness no less than 0.032 inch (0.81 mm) if uncoated steel, no less than 0.034 inch (0.86 mm) if galvanized steel, and no less than 0.045 inch (1.14 mm) if nonferrous material.

6.3.2 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 used, there shall be no less than three and no more than five threads in the metal and the construction of the device shall be such that a conduit bushing can be attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be no less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors. The inlet hole shall provide protection to the conductors equivalent to that provided by a standard conduit bushing and shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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

6.3.4 A knockout in a sheet-metal enclosure shall be secured but shall be capable of being removed without deformation of the enclosure.

6.3.5 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those specified in Section 19, High-Voltage Circuits and Section 20, Low-Voltage Circuits.

6.3.6 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness of no less than:

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

b) 0.027 inch (0.69 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8-inch (34.9-mm) maximum dimension. A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be mechanically secured.

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7 Field Wiring

7.1 General

7.1.1 Provision shall be made for connection of a power supply wiring system in accordance with the National Electrical Code, ANSI/NFPA 70.

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

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

7.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be no less than that indicated in Table 7.1. A conductor passing through the box is counted as one conductor and each conductor terminating in the box is also counted as one conductor. A field-provided conductor for high-voltage circuits is considered to be no smaller than 14 AWG (2.1 mm^2).

Table 7.1
Size of junction boxes

Size of conductors		Free space within box for each conductor	
AWG	(mm^2)	cubic inches	(cm^3)
16 or smaller	(1.3 or Less)	1.5	(24.6)
14	(2.1)	2.0	(32.8)
12	(3.3)	2.25	(36.9)
10	(5.3)	2.5	(41.0)
8	(8.4)	3.0	(49.2)

7.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size specified in Table 7.2.

Table 7.2
Trade size of conduit in inches (mm OD)

Wire size		Number of wires									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
8	(8.4)	3/4	(26.7)	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)
6	(13.3)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)
4	(21.2)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)
3	(26.7)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	1-1/2	(48.3)
2	(33.6)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)
1	(42.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)	2	(60.3)
NOTES											

Table 7.2 Continued on Next Page

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Table 7.2 Continued

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
1 The values in this table are based on the assumption that all conductors will be of the same size and that there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying the total cross-sectional area of the wires by 2.5, based on the cross-sectional area of Type THW wire.						
2 Trade size per Specification for Zinc Coated Rigid Steel Conduit, ANSI C80.1.						

7.1.6 Wiring exterior to the appliance between the burner assembly and a limit control, a safety combustion control, or a motor controller, that can be readily made with Type T wire enclosed in conduit or with metal-clad cable need not be furnished by the manufacturer as part of the appliance if instructions for installing the wiring are provided with each appliance.

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

7.1.8 A box or enclosure in which field-installed conductors are to be connected as indicated in 7.1.6, 7.1.7, and 7.1.9 shall be located so that the temperature of conductors within the box or surfaces of the box likely to be in contact with the conductors will not exceed that specified for Type T wire when the appliance is tested to determine compliance with the requirements of this section.

7.1.9 Except as otherwise indicated in 8.1.4, wiring to be connected in the field between the appliance and devices that are attached to the appliance, or between separate devices that are field installed and located, shall comply with 7.1.6, 7.1.7, and 7.1.8 if the connection is made with Type T wire enclosed in conduit or with metal-clad cable.

7.1.10 The wiring of the product may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the product to the wiring system specified in 7.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 50.8 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, ANSI/NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product is no more than 6 feet (1.83 m);

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

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

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7.2 Leads and terminals

7.2.1 Wiring leads or terminals no less than 6 inches (152 mm) long shall be provided for connection of field-wiring conductors of at least the size required by the National Electrical Code, ANSI/NFPA 70, and corresponding to the marked rating of the assembly.

Exception: A lead may be less than 6 inches long if it is evident that the use of a longer lead may result in damage to the lead insulation.

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

7.2.3 A lead or terminal for the connection of a grounded conductor shall not be electrically connected to a single-pole manual switching device that has an off position or to a single-pole overcurrent (not inherent overheating) protective device.

7.2.4 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. Open slot-type connectors shall not be used unless they prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing or the equivalent if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be no less than 0.028 inch (0.71 mm).

7.2.5 Field-wiring terminals shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those specified in Section 19, High-Voltage Circuits or Section 20, Low-Voltage Circuits, as applicable. This may be accomplished by:

a) Two screws or rivets;

b) Square shoulders or mortices;

c) A dowel pin, lug, or offset;

d) A connecting strap or clip fitted into an adjacent part; or

e) Some other equivalent method.

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

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

7.2.8 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 7.2.5, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to secure the wire in position.

7.2.9 A wire binding screw at a high-voltage wiring terminal for field connection shall be no smaller than No. 10 (4.8 mm major diameter).

Exception No. 1: A No. 8 (4.2 mm major diameter) screw may be used for the connection of a conductor no larger than 14 AWG (2.1 mm^2).

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

7.2.10 A terminal plate for a wire-binding screw shall be of metal no less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm^2) or smaller wire and no less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG; and in either case there shall be no less than two full threads in the metal.

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

7.2.12 A wire-binding screw shall thread into metal.

8 Internal Wiring

8.1 General

8.1.1 The wiring of high-voltage and safety-control circuits shall comply with the requirements in 8.1.2 – 8.3.2.

8.1.2 Wiring shall be made with insulated conductors having a current-carrying capacity and voltage and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be no smaller than 18 AWG (0.82 mm^2).

8.1.3 Except as indicated in 7.1.6, the wiring for all appliance circuits shall be provided by the manufacturer as part of the appliance. If the appliance is not assembled and wired at the factory, such wiring shall be provided as a harness with each appliance and shall be located to facilitate attachment when the appliance is assembled. If the wiring is provided as a harness, a pictorial diagram showing the exact arrangement of the wiring shall be included with each appliance.

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8.1.4 If insulated conductors rated for use at temperatures exceeding 60°C (140°F) are required, such wiring shall be provided as part of the assembly. The devices to be connected by such wiring shall be factory-installed on the appliance.

8.2 Methods

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

8.2.2 Except as specified in 8.2.14 and 8.2.15, conductors shall be enclosed within conduit, electrical metallic tubing, a metal raceway, an enclosure, or metal-clad cable.

8.2.3 Group A of Table 8.1 identifies wiring materials suitable for use if enclosed as specified in 8.2.2.

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Table 8.1
Typical wiring materials

Group	Type of wire, cord, cable, or appliance wiring material with insulation thicknesses and corresponding wire sizes as indicated	Wire size		Insulation thickness	
		AWG	(mm^2)	inch	(mm)
A	RF2, FF2, FFH2, TF, TFF, TFN, TFFN, SF2, SFF2, RH, RHH, RHW, RUH, T, THW, XHHW, MTW, THW-MTW, THWN, TW, or thermoplastic appliance wiring material.	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.4)	3/64	(1.2)
		6	(13.3)	4/64	(1.6)
		4	(21.2)	4/64	(1.6)
		3	(26.7)	4/64	(1.6)
		2	(33.6)	4/64	(1.6)
		1	(42.4)	5/64	(2.0)
		1/0	(53.5)	5/64	(2.0)
		2/0	(67.4)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.0)	5/64	(2.0)
B	SO, ST, SJO, SJT, or appliance wiring material with thermoplastic or neoprene insulation	18	(0.82)	4/64	(1.6)
		16	(1.3)	4/64	(1.6)
		14	(2.1)	5/64	(2.0)
		12	(3.3)	5/64	(2.0)
		10	(5.3)	5/64	(2.0)
		8	(8.4)	6/64	(2.4)
		6	(13.3)	8/64	(3.2)

NOTE – Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for 16 or 18 AWG (1.3 or 0.082 mm^2) and 3/64 inch (1.2 mm) for 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm^2) are considered equivalent to the wiring material referenced in Group B when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type recognized for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, and flammability.

8.2.4 Flexible metal conduit shall be no smaller than nominal 3/8-inch electrical trade size as indicated in the Specification for Zinc Coated Rigid Steel Conduit, ANSI C80.1.

Exception: Parts of components, such as conduit protecting flame sensor leads, need not comply with this requirement.

8.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.4 m) and within 12 inches (305 mm) on each side of every junction box. If flexibility is necessary, flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet and within 3 feet (0.91 m) on each side of every junction box.

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

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

8.2.8 Splicing devices, such as fixture-type splicing connectors or pressure wire connectors, may be used if the devices have insulation rated for the voltage involved. Thermoplastic tape wrapped over a sharp edge is not an acceptable means of insulation.

8.2.9 Splices shall be located, enclosed, and supported to protect against damage resulting from flexing, motion, or vibration.

8.2.10 A splice is considered to be enclosed when installed in a junction box, control box, or other enclosed compartment in which high-voltage wiring materials, as specified in Group A of Table 8.1, may be used. Splices in enclosed machinery compartments shall be secured to a fixed member in the compartment so that the splices are not subject to movement or damage during servicing.

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

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

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

8.2.14 Factory wiring involving a potential of 300 volts or less between parts attached to the same assembly with a predetermined fixed relationship may be done with Type SO or ST cord if the wiring complies with the following:

a) It is not practical to do the wiring in accordance with 8.2.3;

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

c) The length of cord exterior to the assembly is no more than 4 inches (102 mm) and strain relief is provided.

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8.2.15 Cords or appliance wiring material as referenced in Group B of Table 8.1 may be used if the wiring is enclosed by the appliance casing or compartment complying with the following:

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

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

c) Openings in other than the bottom will not permit the entrance of a 1/2-inch (12.7-mm) diameter rod and openings for parts such as pipe or conduit are no more than 1/2 inch diameter larger than the object that will be inserted through the opening;

d) Openings are no closer than 6 inches (152 mm) to the wiring, unless metallic barriers or baffles are placed between the wiring and the openings. Louvered openings that serve to protect the wiring from mechanical damage from outside the compartment and that are formed so as to assist in confining an electrical disturbance to within the compartment need not comply with this requirement. To comply with these requirements, the louvers shall be constructed of drawn metal of a form that completely obscures viewing of the wiring within the compartment when viewed from the horizontal outside the compartment. The openings shall be located so that an object falling vertically cannot enter the compartment through the louvered opening; and

e) Flammable material, other than electrical insulation, located within the casing or compartment is separated from the wiring material. An air filter may be used within the enclosure.

8.2.16 With regard to of 8.2.15 (e), plastic materials shall be classified in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

8.2.17 Cords and appliance wiring material that comply with the requirements in 8.2.15 and 8.2.21 shall be located to avoid being damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

8.2.18 In applying the requirement specified in 8.2.15, an opening that is always intended to be connected to an air duct may be considered as closed.

8.2.19 Holes in walls or partitions through which insulated wires or cords pass and on which they may bear shall be provided with smooth, rounded bushings or surfaces that have been rolled or extruded upon which the wires or cords may bear, so that the insulation is not abraded. Bushings, if required, shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

8.2.20 A fiber bushing shall:

a) Be no less than 3/64 inch (1.2 mm) thick;

b) Be located so that it will not be exposed to moisture; and

c) Not be used where it will be subjected to a temperature higher than 90°C (194°F) under intended operating conditions.

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8.2.21 Factory wiring of a low-voltage safety circuit may be:

a) Type SP2 cord having only neoprene insulation;

b) Type SPT2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness; or

c) Low-energy safety control wire, if such wiring is located in a cavity or compartment of an appliance and is shielded from damage.

8.3 Short circuit protection

8.3.1 Except as indicated in 8.3.2, conductors of motor circuits having two or more motors, one or more of which is thermal or overcurrent protected, and wired for connection to one supply line shall withstand the conditions of the short-circuit test described in Section 28, Short-Circuit Test, without creating a risk of fire or electric shock.

8.3.2 Conductors that comply with the following need not be subjected to the short-circuit test described in Section 28, Short-Circuit Test:

a) Conductors that have no less than one-third the ampacity of the required branch-circuit conductors;

b) Conductors that are 18 AWG (0.82 mm^2) or larger and that are no more than 4 feet (1.2 m) long, provided that the circuit will be protected by a fuse or HACR Type circuit breaker that is rated 60 amperes or less as specified on the product nameplate or provided as part of the product and that is acceptable for branch-circuit protection; or

c) Conductors that serve as jumper leads between controls, provided the length of the leads does not exceed 3 inches (76.2 mm) or the conductors are located in a control panel.

9 Separation of Circuits

9.1 Unless provided with insulation for the highest voltage involved, insulated conductors of different internal wiring circuits shall be separated by barriers or segregated:

a) From each other; and

b) From uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

9.2 Insulated conductors shall be segregated by clamping, routing, or equivalent means that provide permanent separation from insulated or uninsulated live parts of a different circuit.

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

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

b) Uninsulated live parts of any other circuit; and

c) Uninsulated live parts the short-circuiting of which may permit unintended operation of the appliance.

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Exception: A construction in which field-installed conductors may make contact with wiring terminals may be provided if Type T or equivalent conductors are installed or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

9.4 Segregation between field-installed conductors and away from uninsulated live parts connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with regard to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits. The following shall be considered:

a) If the number of openings in the enclosure does not exceed the minimum required for intended wiring and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 9.3, that the conductors entering each opening will be connected to the terminals opposite the opening; and

b) If more than the minimum number of openings are provided, the likelihood of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated live parts connected to a different circuit is to be investigated.

9.5 To determine if a device complies with the requirements specified in 9.3, the device shall be wired as intended and any slack is to be left in each conductor, within the enclosure. No more than average care is to be exercised in placing this slack in the wiring compartment.

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

9.7 A metal barrier shall have a minimum thickness as specified in Tables 6.1 and 6.2, based on the size of the barrier. A barrier of insulating material shall be no less than 0.028 inch (0.71 mm) thick and shall be of a greater thickness if deformation of the barrier would defeat its purpose. Any clearance at the edges of a barrier shall be no more than 1/16 inch (1.6 mm) wide.

9.8 Openings in a barrier for the passage of conductors shall be no larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires that will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall be no larger than required for the passage of the necessary wires.

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

9.10 Two or more transformer devices supplying circuits classified as low-voltage circuits and provided as a part of the appliance shall be treated as two separate circuits. If more than one such circuit is to be field-wired, the several circuits shall be segregated or separated by barriers and the transformer output of each circuit shall be marked to warn that the separation shall be maintained.

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10 Grounding and Bonding

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

10.2 Except as specified in 10.3, uninsulated metal parts of cabinets, enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping, and valves shall be bonded for grounding if they may be contacted by the user or service personnel.

10.3 Metal parts, as described in items (a)– (d), need not be grounded:

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

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

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

d) Panels and covers that are insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material no less than 1/32 inch (0.8 mm) thick.

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

10.5 Splices shall not be used in wire conductors provided for bonding.

10.6 Metal-to-metal hinge bearing members may be considered as a means for bonding a door for grounding if a multiple bearing-pin type (piano type) hinge is used.

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

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

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

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

10.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if the connection complies with 10.11:

a) Under any degree of compression that may be applied by a variable clamping device; and

b) Following exposure to the effects of oil, grease, moisture, and thermal degradation that are likely to occur in service.

A clamping device shall be arranged for reassembly in its intended position following disassembly or removal for maintenance purposes.

10.10 If bonding relies on screw threads, two or more screws or two full threads of a single screw shall engage the bonding system to metal.

10.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than as specified in 10.12 – 10.14, the bonding connection shall be acceptable if the connecting means does not open:

a) When carrying, for the time indicated in Table 10.1, twice the rated current of the branch circuit overcurrent device required to protect the equipment; and

b) During the short-circuit test described in Section 28, Short-Circuit Test while in series with a fuse of proper rating.

Table 10.1
Duration of current flow, bonding-conductor test

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

10.12 The size of a conductor or strap used 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 10.11, the size of the conductor or strap shall be as specified in Table 10.2.

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Table 10.2
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

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

10.14 A bonding conductor connected to a component or electrical enclosure need be no larger than the size of the conductors supplying power to the component or components within the enclosure.

10.15 The following may be provided as the means for connection to a ground:

a) For equipment intended to be connected to a metal-enclosed wiring system, a knockout or equivalent opening in a metal enclosure intended to receive the power-supply system; or

b) For equipment intended to be connected by a nonmetal-enclosed wiring system, such as metal-clad cable, an equipment grounding terminal or lead.

10.16 A terminal for connection of an equipment grounding conductor shall be able to secure a conductor of the size required for the particular application, in accordance with the National Electrical Code, ANSI/NFPA 70.

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

10.18 A wire-binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for the connection of an equipment grounding conductor shall be identified by being marked ″G″, ″GR″, ″GROUND″, or ″GROUNDING″, or by a marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure and shall be located so that it will not need to be removed during servicing. For a wire-binding screw, upturned lugs or the equivalent shall be provided to retain the conductor. If a pressure wire connector is used adjacent to the connectors intended for the supply conductors involving the neutral of a grounded supply, a marking shall be additionally provided indicating ″EQUIPMENT GROUND″ or the connector shall be identified by a green color or by both the specified wording and a green color.

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

10.20 The potential drop of any single bonding joint of the friction or spring-action type shall not exceed 10 millivolts when tested with a current of 30 amperes flowing through the joint and shall not exceed 15 millivolts after 10 cycles of attachment and removal of the part being bonded.

ELECTRICAL COMPONENTS

11 General

11.1 Electrical equipment and wiring shall be located so that contact by water or oil is unlikely during intended use or when uncoupling of a connection is required for servicing.

11.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may result in unintended operation of the equipment.

12 Mounting of Electrical Components

12.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as specified in 12.2 and 12.3.

12.2 A switch need not be prevented from turning if the following conditions are met:

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

b) The means for mounting the switch is not subject to loosening as the result of operation of the switch:

c) Rotation of the switch does not result in a reduction of spacings below the values specified in Sections 19, High-Voltage Circuits, and Section 20, Low-Voltage Circuits; and

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

12.3 A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation of the lampholder will not result in a reduction of spacings below the values specified in Sections 19, High-Voltage Circuits and Section 20, Low-Voltage Circuits.

12.4 Friction between surfaces shall not be provided as the only means for preventing the turning of electrical components. A toothed lock washer that provides both spring take-up and an interference lock may be provided as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

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12.5 Uninsulated live parts shall be secured to the base or mounting surface to prevent the parts from turning or shifting in position if such motion may result in a reduction of spacings below the values specified in Sections 19, High-Voltage Circuits and Section 20, Low-Voltage Circuits.

12.6 Control equipment located within the plenum or return-air compartment of a furnace shall be constructed, enclosed, or protected so that dense smoke will not be generated and flame will not be emitted under any conditions that may occur in service.

13 Motors and Motor Overload Protection

13.1 All motors shall be protected by an integral thermal protector, by overload protective devices, or by a combination of these devices.

13.2 Overload protective devices as specified in 13.1 shall comply with the requirements of the National Electrical Code, ANSI/NFPA 70, as follows:

a) A separate overload device shall be responsive to motor current. The device shall be rated or selected to trip at no more than the following percentages of the motor full-load current rating:

1) 125 percent for motors with a marked service factor no less than 1.15;

2) 125 percent for motors with a marked temperature rise no more than 40°C (72°F); and

3) 115 percent for all other motors;

b) With regard to the requirement specified in item A, each winding connection of a multispeed motor shall be considered separately and the motor shall be protected at all speeds;

c) If the values specified for motor-running overload protection do not correspond to the standard sizes or ratings of fuses or magnetic or thermal overload protective devices, the next higher size or rating may be used but no higher than the following percentages of the motor full-load current rating:

1) 140 percent for motors with a marked service factor no less than 1.15;

2) 140 percent for motors with a marked temperature rise no more than 40°C; and

3) 130 percent for all other motors.

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13.3 An integral thermal protective device shall comply with the Standard for Thermally Protected Motors, UL 1004-3.

13.4 Separate overload devices, except when included as part of a magnetic motor controller, shall be assembled as part of the appliance and shall be identifiable as a part of the appliance after assembly. Such protection shall not include means for manually interrupting the motor circuit if such interruption may result in unintended operation of the appliance.

13.5 Three-phase motors shall be provided with overload protection as specified in either (a) or (b):

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

b) Thermal protectors, combinations of thermal protectors and overcurrent devices, or equivalent methods of protection may be provided if the specific protective arrangement has been investigated and found to provide protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies investigated as described shall be marked as specified in 35.10.

13.6 A motor provided in an attic, horizontal, or suspended furnace shall be of a totally enclosed construction if not wholly enclosed within the furnace casing.

13.7 In determining compliance with 13.6, there shall be no openings in portions of the motor frame exterior to the appliance when a totally enclosed motor is to be provided. Openings may be in the shaft end of a face-mounted motor that is bolted flush to the blower housing of an oil burner, but there shall be no openings in other portions of the motor frame.

13.8 Motors, such as direct-drive fan motors, that are not normally subjected to overloads and that are determined to be adequately protected against overheating due to locked-rotor current by a thermal or overcurrent protective device may be accepted under 13.3 if it is determined that the motor will not overheat under actual conditions of use.

13.9 Impedance protection shall not be provided for motors installed in compartments handling air for circulation to the conditioned space.

Exception: Impedance protection may be provided for motors that are determined to be adequately protected against overheating due to locked-rotor current if it is determined that the motor will not overheat during the performance requirements specified in this standard.

13.10 Fuses shall not be provided as motor overload protective devices unless the motor is adequately protected by the largest size fuse that can be inserted in the fuseholder.

13.11 The temperature of a motor shall not exceed the temperature rises indicated in Table 26.1.

13.12 A motor shall be intended for continuous duty which shall be indicated by the marking "CONTINUOUS" or "CONT." on the appliance nameplate.

13.13 The interruption of the circuit to a motor by the overload or overtemperature protective device shall not result in impaired operation of the equipment or the unintended discharge of fuel. If a burner depends solely upon an electric valve to stop the flow of fuel to the burner, the interruption of the circuit to the motor by the protective device shall also cause the interruption of the circuit to the valve.

13.14 Automatic-reset type protective devices shall not be used if the automatic reclosing of the circuit to the motor by the device may result in unintended operation of the equipment.

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13.15 The enclosure of a motor shall have no openings that will permit a drop of liquid or a particle falling vertically onto the motor to enter the motor as it is positioned on the assembly.

13.16 The motor frame or another enclosure, structure, shield, or a combination of two or more such items may be provided to protect the motor from liquid and particles as specified in 13.15.

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

13.18 With regard to the requirement specified in 13.17, a barrier of nonflammable material shall be provided under an open type motor unless:

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

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

1) Main winding opened;

2) Starting winding opened;

3) Starting switch short-circuited; and

4) Capacitor shorted (permanent split capacitor type);

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from exceeding:

1) 125°C (257°F) under the maximum load below which the motor will run without causing the protector to cycle; and

2) 150°C (302°F) with the rotor of the motor locked; or

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

13.19 The barrier specified in 13.18 shall:

a) Be horizontal;

b) Be located as indicated in Figure 13.1; and

c) Have an area no less than that described in Figure 13.1.

Openings for drainage and ventilation may be used in the barrier if such openings will not enable molten metal, burning insulation, or the like to fall on flammable material.

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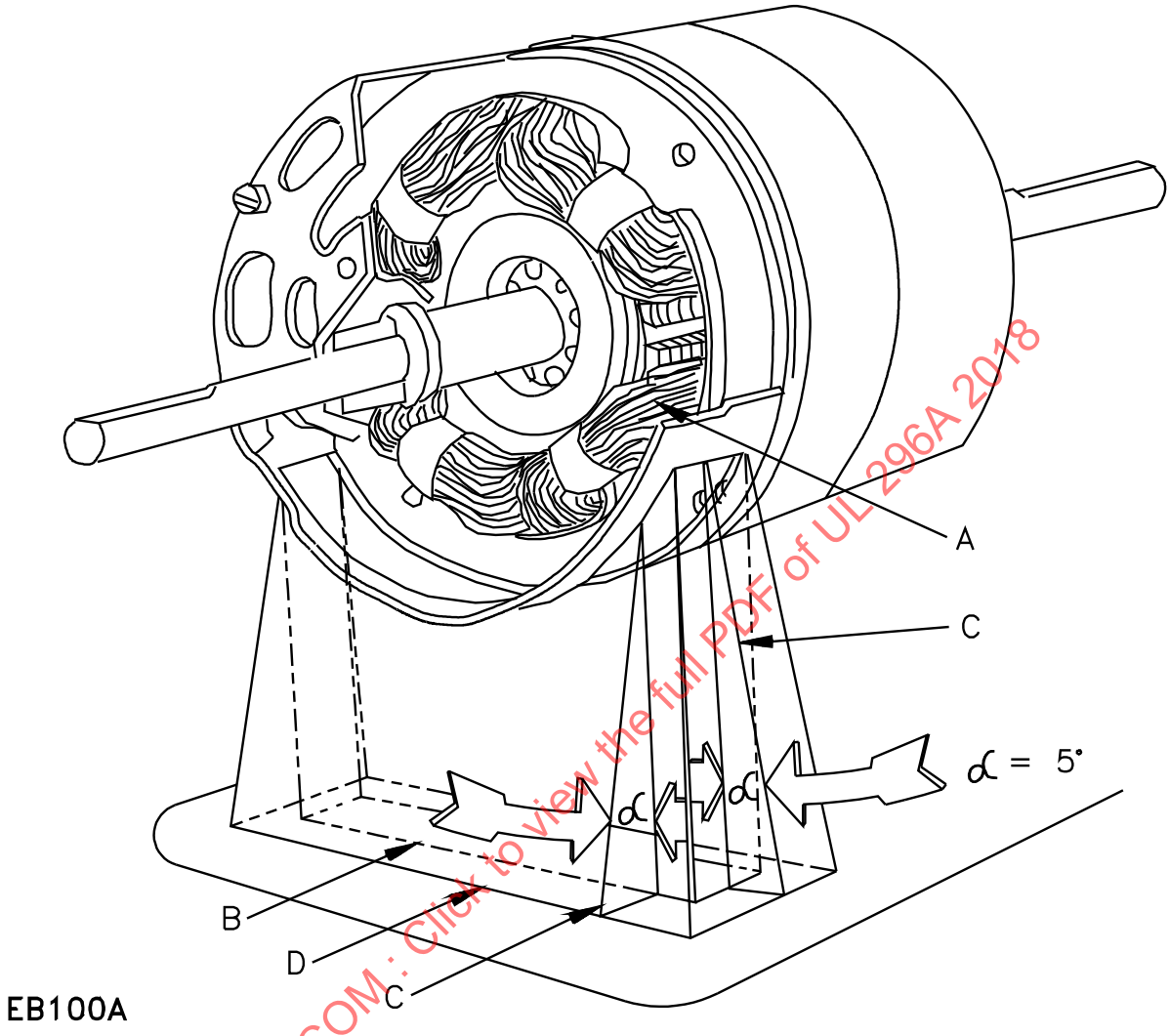
Figure 13.1
Location and extend of barrier



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

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

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

1) tangent to the motor winding;

2) five degrees from the vertical; and

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

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

13.20 Overcurrent protective devices and thermal protective devices for motors shall comply with the short-circuit test described in Section 28, Short-Circuit Test.

14 Overcurrent Protection of High-Voltage Control-Circuit Conductors

14.1 General

14.1.1 For the purpose of these requirements, a control circuit is a circuit that carries electric signals to operate a controller which, in turn, governs power delivered to a motor or other load in the appliance. A control circuit does not carry main-power current. A control circuit that is supplied through a transformer provided as part of the product shall also comply with the requirements for overcurrent protection of transformers specified in Section 15, Overcurrent Protection of Transformers.

14.1.2 These requirements apply to high-voltage control circuits that use 18, 16, 14, or 12 AWG (0.82, 1.3, 2.1, or 3.3 mm^2) conductors.

14.2 Direct-connected high-voltage control circuit

14.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is a circuit that:

a) Is supplied from a branch circuit separate from a branch circuit that supplies other loads within the product; and

b) Is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the appliance. A direct-connected high-voltage control circuit shall be marked as specified in 35.6.

14.3 Tapped high-voltage control circuits

14.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the product from the load side of the overcurrent device or devices for the controlled load.

14.3.2 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the values specified in Table 14.1.

Exception No. 1: A 18, 16, or 14 AWG (0.82, 1.3, or 2.1 mm^2) conductor that is no more than 4 feet (1.2 m) long between points of opposite polarity may be protected by a fuse or an HACR Type circuit breaker rated 60 amperes or less.

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as described in Section 28, Short-Circuit Test.

Exception No. 3: A conductor, other than as specified in exception No. 1, that is no more than 12 inches (305 mm) long need not be provided with overcurrent protection.

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

a) The protection complies with the requirements for overcurrent protection of transformers specified in Section 15, Overcurrent Protection of Transformers; and

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b) The protection does not exceed the control-circuit conductor ampacity multiplied by the ratio of secondary-to-primary rated transformer voltage.

Conductor ampacity is to be determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70, for the type of wire or cord used. If appliance wiring material is used, its ampacity is to be based on the values specified for the equivalent wire or cord.

Table 14.1
Overcurrent-protective device rating for control-circuit conductors

Tapped control-circuit conductor size,		Maximum rating of overcurrent protective device, amperes	
AWG	(mm^2)	Conductors contained in control equipment enclosure	Conductors extending beyond control-equipment enclosure
18	(0.82)	25	20
16	(1.3)	40	20
14	(2.1)	80	45
12	(3.3)	100	60

14.4 Overcurrent-protective devices

14.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as specified in 14.3.2, shall be provided as part of the product. If a fuse is used, the product shall be marked as specified in 35.4.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 14.1.

14.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size as specified in 14.3.2; and

c) Have a voltage rating no less than the circuit in which it is used.

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

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type if the fuse has a short-circuit rating acceptable for the circuit in which it is used, as indicated in Table 28.1. If the supplementary device used is a fuse, the product shall be marked as specified in 35.5.

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15 Overcurrent Protection of Transformers

15.1 High-voltage transformers

15.1.1 General

15.1.1.1 A transformer, other than as described in 15.2.1 and 15.2.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection as specified in 15.1.2.1;

b) Be protected by an overcurrent device or devices as specified in 15.1.3.1; or

c) Comply with the burnout test for high-voltage transformers described in Section 30, Burnout Test, High-Voltage Transformers.

15.1.2 Thermal protection

15.1.2.1 If a high-voltage transformer is provided with a thermal-overload protective device, the device shall interrupt primary current and shall limit temperatures of the transformer windings under overload conditions as described in Section 29, Overload Test, High-Voltage Transformers to those acceptable for the class of insulation used in the windings.

Exception: If the thermal-overload protective device provided is a nonrenewable thermal cutoff, the burnout test for high-voltage transformers described in Section 30, Burnout Test, High-Voltage Transformers, shall be conducted in place of the overload test.

15.1.2.2 A thermal cutoff shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manually or automatically reset thermal protector shall have an endurance rating of no less than 6000 cycles and shall comply with the requirements for calibration of temperature-limiting controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

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15.1.3 Overcurrent protection

15.1.3.1 If a high-voltage transformer is protected by an overcurrent device or devices, such protection shall comply with the requirements specified in 15.1.3.2 – 15.1.3.4 and 15.3.1 – 15.3.3.

15.1.3.2 A high-voltage transformer shall be protected by an overcurrent device or devices, as specified in 15.1.3.3, 15.1.3.4, and 15.3.1, that is located in the primary circuit and that is rated or set at no more than 125 percent of the rated primary current of the transformer.

Exception No. 1: If the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of a fuse or circuit breaker, the next higher standard rating of a protective device or devices may be used. Standard ratings of protective devices are specified in the National Electrical Code, ANSI/NFPA 70.

Exception No. 2: If the rated primary current of the transformer is less than 9 amperes, the primary overcurrent protection may be increased as indicated in Table 15.1.

Table 15.1
Primary overcurrent protection

Rated primary current, amperes	Maximum rating of overcurrent device, percent of transformer primary current rating
Less than 2	300
2 or more, but less than 9	167

15.1.3.3 If the circuit supplying a transformer is provided with overcurrent protection rated or set at no more than 250 percent of the rated primary current of the transformer, additional overcurrent protection need not be provided in the primary circuit if the secondary circuit is protected as specified in 15.3.2 at no more than 125 percent of the rated secondary current of the transformer.

Exception No. 1: If the rated secondary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of a fuse or circuit breaker, the next higher standard rating of a protective device or devices may be used in the secondary circuit.

Exception No. 2: If the rated secondary current of the transformer is less than 9 amperes, the overcurrent device or devices in the secondary circuit may be rated or set at no more than 167 percent of the rated secondary current.

15.1.3.4 If a transformer supplies only a motor-control circuit and is located in the same enclosure as the motor controller, the transformer may be provided with overcurrent protection in the secondary circuit as specified in 15.3.2 rated or set at no more than 200 percent of the rated secondary current of the transformer.

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15.2 Low-voltage transformers

15.2.1 Except as specified in 15.2.2, a transformer having a rated output of no more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device or devices located in the primary circuit as described in 15.3.1. The overcurrent device or devices shall be rated or set at no more than 167 percent of the primary current rating of the transformer.

15.2.2 A Class 2 transformer provided in accordance with 3.23(c) shall, in accordance with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers – UL 5085-3, either limit the output current (inherently-limiting transformer) or be provided with an overcurrent device or devices (noninherently-limiting transformer).

15.3 Overcurrent protective devices

15.3.1 Overcurrent protection in the primary circuit of a transformer, as described in 15.1.3.2 and 15.2.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in 15.1.3.2 or 15.2.1, as applicable.

15.3.2 Overcurrent protection in the secondary circuit of a transformer, as specified in 15.1.3.3 or 15.1.3.4, shall be provided as part of the equipment. If a fuse is used, the product shall be marked as specified in 35.4.

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

a) Be provided for all ungrounded conductors;

b) Be of a size as specified in 15.1.3.2 – 15.2.1, as applicable; and

c) Have a voltage rating no less than the circuit in which it is used.

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

Exception: If a transformer supply is tapped from a circuit supplying other loads in the unit, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used as specified in Table 28.1. If a supplementary-type fuse is provided, the product shall be marked as specified in 35.5.

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16 Switches and Controllers

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

Exception: A controller need not be provided for an assembly with more than one motor if the marked maximum fuse size does not exceed 20 amperes at 125 volts or less, or 15 amperes at 126 – 600 volts, and with no more than 6 amperes full-load current for each motor.

16.2 A single controller may control more than one motor if the controller is rated for the combined load controlled. The assembly is to be marked as specified in 35.1 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

16.3 A controller or switch shall be rated for the load that it controls.

16.4 The load controlled shall include any load external to the assembly for which connections in the controller or switch circuit are provided.

16.5 A controller that may be required to break a motor load under locked-rotor conditions shall have a current-interrupting capacity no less than the locked-rotor load of the motor controlled.

16.6 If the controller is cycled by the operation of an automatic-reset overload device, the controller is to withstand an endurance test under locked-rotor conditions without failure. The endurance test shall be determined by the requirements of the standard for the component as indicated in Section 4, Components.

16.7 The locked-rotor load of a motor is based on:

a) Six times the full-load current rating of the motor if for use with alternating current; and

b) Ten times the full-load current rating if for use with direct current.

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

16.9 Motor controllers shall simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

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17 Capacitors

17.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as specified in 17.2 and 17.3, the container shall be of metal providing strength and protection no less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

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

17.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead-metal parts as indicated in Table 19.1.

17.4 A capacitor using a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including the short-circuit test described in Section 28, Short-Circuit Test.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 28.1 but no less than the current established by dividing the circuit voltage by the impedance of the other component(s).

18 Electrical Insulating Materials

18.1 Material for the mounting of current-carrying parts shall be of moisture resistant material such as porcelain, phenolic, or cold-molded composition.

18.2 Vulcanized fiber may be used for the insulating bushings, washers, separators, and barrier, but not as the sole support for uninsulated live parts of other than low-voltage circuits.

SPACINGS

19 High-Voltage Circuits

19.1 Except as specified in 19.2, 19.3, and 19.5, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead-metal part shall be no less than the values indicated in Table 19.1.

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Table 19.1
Minimum spacings

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

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

[b] Includes metal fittings for conduit or cable which are factory installed or which may be field installed.

[c] If greater than 300 volts, spacings in the last line of table apply.

[d] The spacings between wiring terminals or opposite polarity, or between a wiring terminal and grounded metal, shall be no less than 1/4 inch (6.4 mm), except that if short circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greater than that indicated in the table. Wiring terminals are those connected in the field and not factory wired. Measurements are to be made with solid wire of adequate ampacity for the load connected to each terminal.

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

19.3 All uninsulated live parts connected to different circuits, except subdivided circuits or branch circuits of the same voltage and from the same feeder, shall be spaced from one another as though the parts are parts of opposite polarity in accordance with the requirements specified in 19.2 and shall be judged on the basis of the highest voltage involved.

19.4 For circuits not exceeding 300 volts, the over-surface spacings for glass-insulated terminals of motors may be 1/8 inch (3.2 mm) where 1/4 inch (6.4 mm) is specified in Table 19.1; and may be 1/4 inch where 3/8 inch (9.5 mm) is specified.

19.5 The spacing requirements indicated in Table 19.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component which shall be judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearance to dead metal or enclosures, shall be as indicated in Table 19.1.

19.6 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall be no less than 0.028 inch (0.71 mm) thick; except that a liner or barrier no less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of no less than one-half of the required through-air spacing. The liner shall be located so that it will not be damaged by arcing.

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19.7 Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties.

20 Low-Voltage Circuits

20.1 The spacings for low-voltage electrical components which are installed in a circuit that includes a motor overload protective device, or other protective device, in which a shorted or grounded circuit may result in a risk of fire or electric shock shall comply with 20.2 – 20.5.

20.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be no less than 1/8 inch (3.2 mm) and shall comply with 19.3.

20.3 The spacing between wiring terminals, regardless of polarity, and between a wiring terminal and a dead metal part (including the enclosure and fittings for the connection of conduit) that may be grounded when the device is installed shall be no less than 1/4 inch (6.4 mm).

20.4 The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the device is installed shall be no less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be maintained.

20.5 The spacings in low-voltage circuits that do not contain devices such as those indicated in 20.1 are not specified.

PERFORMANCE

21 General

21.1 A waste oil burning appliance shall operate as intended during the tests described in Sections 25 – 31, 57 – 70, 86 – 109, and 116 – 119 when firing each type of waste oil and additionally when firing a standard grade of fuel oil as marked on the appliance nameplate.

21.2 Each size and type of appliance, or a number of sizes and types to be representative of the entire range of sizes and types, shall be subjected to the applicable tests described in Sections 25 – 31, 57 – 70, 86 – 109, and 116 – 119. An appliance is to be tested with each piece of optional equipment, as recommended for use by the manufacturer, which may affect the performance of the appliance.

21.3 If any indications are observed during the tests described in Sections 25 – 31, 57 – 70, 86 – 109, and 116 – 119 that an appliance will not continue to comply with the requirements during intended use, supplementary tests shall be conducted as are determined to be necessary to ensure the intended performance in service.

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22 Test Fuels

22.1 The test fuel for an appliance marked for use with a standard grade of fuel oil shall be within the American Petroleum Institute (A.P.I.) degree range for the grade of fuel oil.

22.2 The test fuel for a waste oil burning appliance shall be the type of waste oil marked on the appliance nameplate as required by 34.1(c). If more than one type of fuel is specified including crankcase oil, the primary test fuel shall be crankcase oil; if other types of fuel are specified, they shall be included in the firing tests on a ″check test″ basis. The characteristics of the primary test fuel shall be determined by laboratory analysis and shall comply with the values specified in Table 22.1.

Table 22.1
Test fuel

Burner/appliance test	Impurity in test fuel	Percent dilution or concentration
Combustion (Sections 58 and 59) and Undervoltage Operation (Section 61)	Gasoline	2.0 maximum
Ignition – Reduced voltage, cold oil (65.1)	Gasoline	10 percent nominal, plus or minus 1.0 percent
All other tests	Gasoline	10.0 maximum
Any test of combustion or ignition	Water	0.1 minimum, 1.0 maximum
Any test of combustion or ignition	Ash	2.0 maximum
NOTE – The viscosity of the test fuel shall be within the range specified by the burner or appliance manufacturer when measured by an appropriate SAE or ASTM Standard.		

22.3 If other chemical elements are present in the test fuel, it is recommended that they be within the following limits, as determined by laboratory analysis of the test fuel:

a) Either:

1) Iron – 200 ppm minimum; or

2) Lead – 400 ppm minimum;

b) Aluminum – 10 to 20 ppm;

c) Copper – 20 to 50 ppm;

d) Magnesium – 200 ppm minimum;

e) Calcium – 100 ppm minimum;

f) Phosphorus – 800 ppm maximum;

g) Boron – 10 to 40 ppm;

h) Sodium – 100 to 250 ppm;

i) Nickel – 3 ppm minimum;

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j) Chromium – 3 ppm minimum;

k) Silicone – 10 to 50 ppm; and

l) Zinc – 400 ppm.

22.4 For the purpose of these requirements, the appliance input rate in gallons per hour when the appliance is firing waste oil is to be based on the nominal heating value of the heaviest standard grade of fuel oil selected in accordance with 21.1 for the appliance. Where BTU per hour input is specified in the requirement (see 87.3.4 and 88.7) the BTU per hour input rate shall also be based on this rate.

23 Instrumentation

23.1 Draft

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

23.2 Fuel input

23.2.1 The fuel input rate to a burner during a test is to be determined by a scale accurate to 0.01 pound (0.004 kg) or a burette capable of the same accuracy.

23.3 Power measurement

23.3.1 The total electrical input to an appliance is to be measured in amperes.

23.3.2 An electrical meter is to have a maximum scale range of no more than 1-1/2 times the value to be measured. The smallest scale division is to be no more than 1/50 of the maximum scale range.

23.4 Speed measurement

23.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or a mechanism driven by a motor. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is recommended for measuring the speed of a motor rated less than 1/8 horsepower (93 W output).

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23.5 Static pressure

23.5.1 An inclined draft gauge is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of ±0.0025 inch (±0.064 mm) and is to be capable of being read directly to 0.005 inch (0.13 mm).

23.5.2 The static pressure connection is to consist of one of the constructions shown in Figure 23.1.

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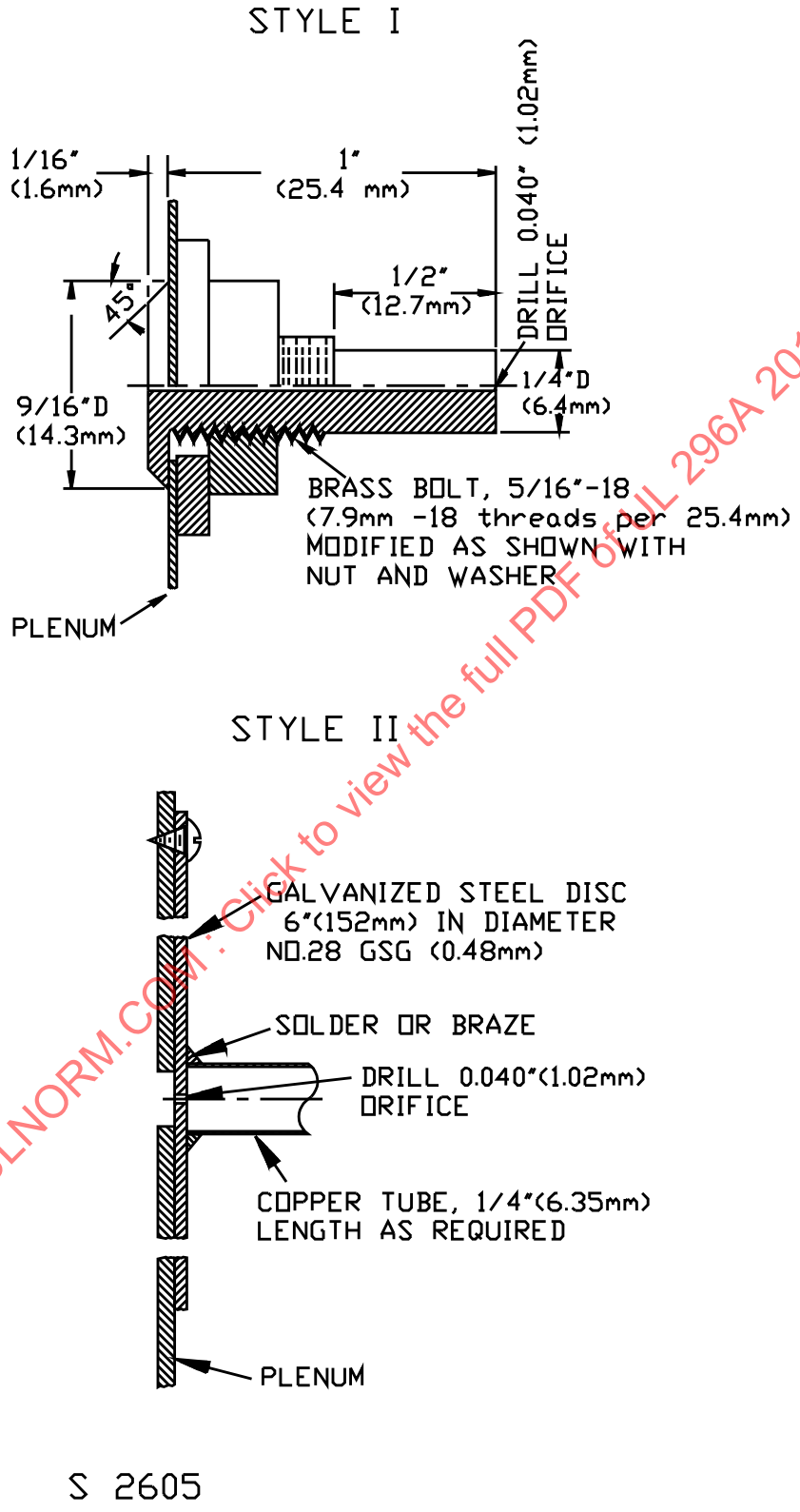
Figure 23.1
Static pressure pickup arrangements



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23.6 Temperature measurement

23.6.1 Temperatures shall be measured by means of a potentiometer and thermocouples except that the change-of-resistance method may be used to measure the temperature of motor windings or coils. The thermocouples shall consist of wire no larger than 24 AWG (0.21 mm^2) and no smaller than 30 AWG (0.05 mm^2). The thermocouple wire shall comply with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

23.6.2 If thermocouples are used in the determination of temperatures in connection with the heating of electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of indicating instrument. This equipment will be used whenever referee temperature measurements by means of thermocouples are necessary.

23.6.3 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those indicated in Table 26.1.

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

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

23.6.6 Thermocouples are to be attached to surfaces other than as described in 23.6.4 and 23.6.5 by being cemented or taped to the surface to provide thermal contact with the surface.

23.6.7 The flue-gas temperature is to be measured by a thermocouple, as illustrated in Figure 23.2, inserted into the chimney connector as shown in Figure 23.3. There is to be no draft control between the appliance and the point where the flue-gas temperature is measured. If a draft control is incorporated in the appliance, the draft control shall be reliably sealed in the position allowing maximum draft during all tests.

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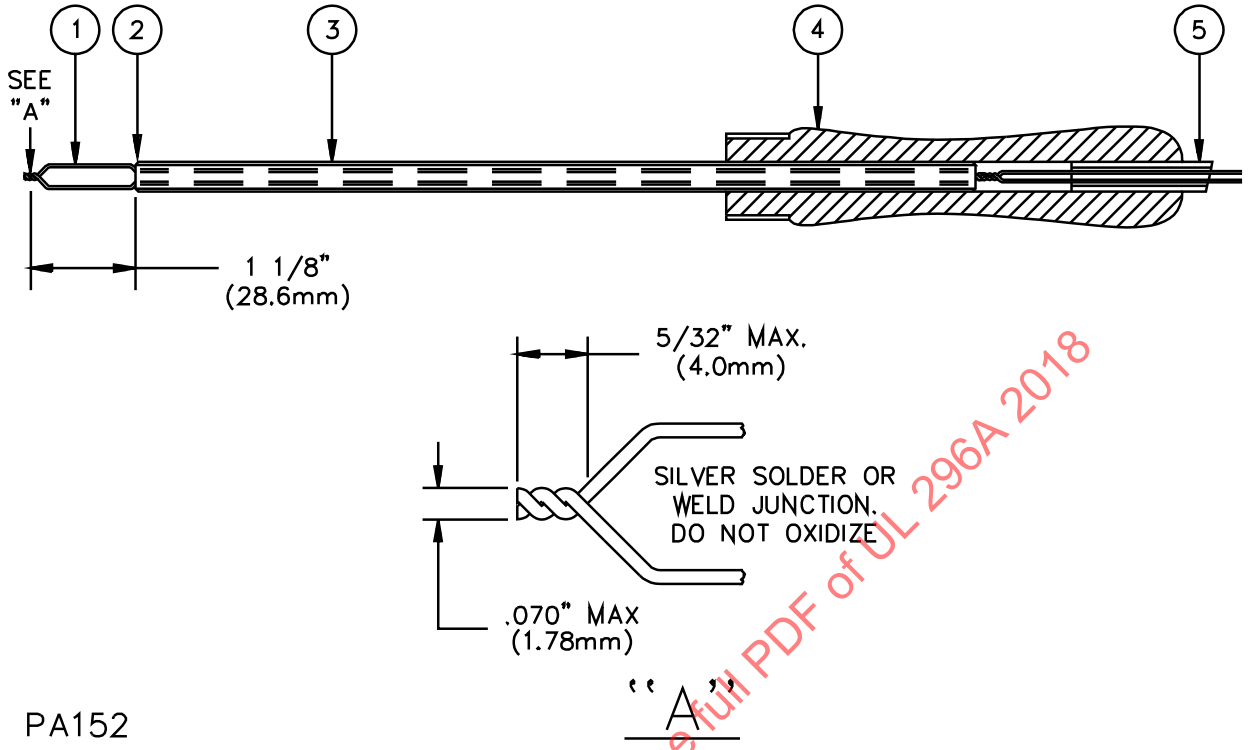
Figure 23.2
Standard thermocouple for flue-gas temperatures



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

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

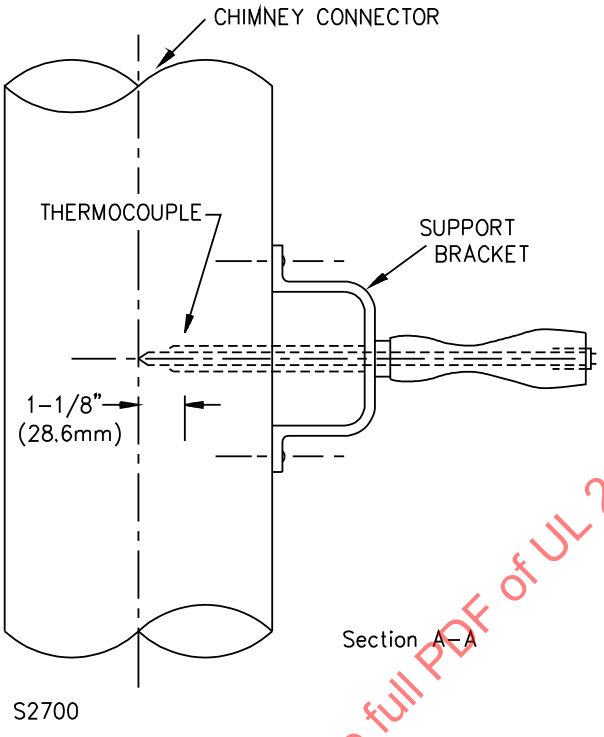
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

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

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

Figure 23.3
Flue gas thermocouple and support bracket



24 Test Voltage

24.1 Unless otherwise specified, appliances are to be tested at the potentials indicated in Table 24.1 for each test as specified in the paragraphs describing the test.

Table 24.1
Test voltages

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

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

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25 Power Input Test

25.1 The power input to an appliance shall be no more than 110 percent of the marked rating of the appliance.

25.2 To determine if an appliance complies with the requirement specified in 25.1, the power input is to be measured with the appliance at the temperature attained under intended operating conditions, full-load conditions, and while connected to a supply circuit of rated voltage as specified in 24.1.

26 Temperature Test

26.1 When an appliance is tested in accordance with these requirements, no part shall attain a temperature sufficient:

a) To damage required corrosion protection;

b) To adversely affect the operation of safety controls;

c) To impair the value of required thermal or electrical insulation; and

d) To cause creeping, distortion, sagging, or similar damage if such damage to the material or part may result in a risk of fire.

The temperature rises at specific points shall be no greater than those specified in Table 26.1 unless otherwise indicated.

Table 26.1
Maximum temperature rises

Device or material	Column 1		Column 2[a]	
	°C	(°F)	°C	(°F)
A. Motors[b,c]				
1. Class A insulation systems on coil windings of an alternating-current motor having a frame diameter of 7 inches (178 mm) or less (not including a universal motor)				
a. In an open motor –				
Thermocouple or resistance method	75	(135)	115	(207)
b. In a totally enclosed motor –				
Thermocouple or resistance method	80	(144)	115	(207)
2. Class A insulation systems on coil windings or an alternating-current motor having a frame diameter of more than 7 inches, of a direct-current motor, and of a universal motor				
a. In an open motor –				
Thermocouple method	65	(117)	115	(207)
Resistance method	75	(135)	115	(207)
b. In a totally enclosed motor –				
Thermocouple method	70	(126)	115	(207)
Resistance method	80	(144)	115	(207)
3. Class B insulation systems on coil windings of an alternating-current motor having a frame diameter of 7 inches or less (not including a universal motor)				
a. In an open motor –				

Table 26.1 Continued on Next Page

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Table 26.1 Continued

Device or material	Column 1		Column 2[a]	
	°C	(°F)	°C	(°F)
Thermocouple or resistance method	95	(171)	140	(252)
b. In a totally enclosed motor –				
Thermocouple or resistance method	100	(180)	140	(252)
4. Class B insulation systems on coil windings of an alternating-current motor having a frame diameter of more than 7 inches, of a direct-current motor, and of a universal motor				
a. In an open motor –				
Thermocouple method	85	(153)	140	(252)
Resistance method	95	(171)	140	(252)
b. In a totally enclosed motor –				
Thermocouple method	90	(162)	140	(252)
Resistance method	100	(180)	140	(252)
B. Components				
1. Capacitors				
Electrolytic type[d]	40	(72)	Not specified	
Other types[e]	65	(117)		
2. Field wiring	35	(63)	60	(108)
3. Relay, solenoid, and other coils with[c]				
a. Class 105 insulated winding –				
Thermocouple method	65	(117)	115	(207)
b. Class 130 insulated winding –				
Thermocouple method	85	(153)	140	(252)
4. Sealing compounds	40°C (104°F) less than its melting point			
5. Transformer enclosures[c] –				
a. Class 2 transformers	60	(108)	85	(153)
b. Power and ignition transformers	65	(117)	90	(162)
C. Insulated Conductors[f,g]				
1. Appliance wiring material				
75°C rating	50	(90)	65	(117)
80°C rating	55	(99)	70	(126)
90°C rating	65	(117)	80	(144)
105°C rating	80	(144)	95	(171)
200°C rating	175	(315)	200	(360)
250°C rating	225	(405)	250	(450)
2. Flexible cord – Tyes SO, ST, SJO, SJT	35	(63)	60	(108)
3. GTO cable	35	(63)	60	(108)
4. Wire, Code				
Types RF, FF, RUW	35	(63)	60	(108)
Types RH, RFH, FFH, RHW, THW, THWN	50	(90)	75	(135)
Types T, TF, TFF, TW	35	(63)	60	(108)
Type TA	65	(117)	90	(162)
5. Other types of insulated wires	See note[f]			
D. Electrical Insulation – General[g]				
1. Class C electrical insulation material	Not specified			
2. Class 180 electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	(117)	90	(162)
4. Phenolic composition used as electrical insulation or as a part whose failure would result in a hazardous condition	125	(225)	150	(270)

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Table 26.1 Continued on Next Page

Table 26.1 Continued

Device or material	Column 1		Column 2[a]	
	°C	(°F)	°C	(°F)
5. Thermoplastic material	25°C (77°F) less than its temperature rating			
6. Varnished cloth insulation	60	(108)	85	(153)
E. Metals				
1. Aluminum Alloys				
a. 1100	183	(330)	239	(430)
b. 3003	239	(430)	294	(530)
c. 2014, 2017, 2024, 5052	294	(530)	350	(630)
2. Aluminum-coated steel[h]	656	(1180)	767	(1380)
3. Carbon steel sheet, cast iron	517	(930)	683	(1230)
4. Carbon steel-coated with Type A19 ceramic	572	(1030)	683	(1230)
5. Galvanized steel[i]	267	(480)	350	(630)
6. Stainless steel				
Types 302, 303, 304, 316, 321, 347	767	(1380)	878	(1580)
Type 309	961	(1730)	072	(1930)
Type 310	1017	(1830)	1128	(2030)
Type 405	683	(1230)	795	(1430)
Types 403, 409, 410, 416	572	(1030)	683	(1230)
Type 430	711	(1280)	822	(1480)
Type 442	878	(1580)	933	(1680)
Type 446	961	(1730)	072	(1930)
7. Zinc castings	89	(160)	145	(260)
F. General				
1. Air filter	50	(90)	97	(175)
2. Flue gases	517	(930)	738	(1330)
3. Surfaces of heater at points of zero clearance to test structure	50	(90)	97	(175)
4. Surface of floor beneath and within 3 feet (0.91 m) of heater to be classified for installation on combustible floors	50	(90)	97	(175)
5. Surfaces of test enclosure (ceiling, walls, and the like)	50	(90)	97	(175)

[a] The temperature rises indicated under Column 2 apply as specified in Sections 96 – 98, 104, 108, and 109.

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

[c] Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation such as more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil (not including universal motors) where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum by the following amounts, provided that the temperature rise of the coil as measured by the resistance method is no more than that specified in this table.

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

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

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Table 26.1 Continued on Next Page

Table 26.1 Continued

Device or material	Column 1		Column 2[a]	
	°C	(°F)	°C	(°F)
[e] A capacitor that operates at a temperature higher than 65°C rise may be judged on the basis of its marked temperature rating.				
[f] For standard insulated conductors other than those specified, reference should be made to the National Electrical Code, ANSI/NFPA 70; the maximum allowable temperature rise in any case is 25°C (77°F) less than the temperature limit of the wire in question where Column 1 temperature rises are specified, and the maximum allowable temperature rise where Column 2 rises are specified is to be based on the heat resistant properties of the insulation.				
[g] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to have heat resistant properties.				
[h] When the reflectivity of aluminum-coated steel is utilized to reduce the risk of fire, the maximum allowable temperature rise is 461°C (839°F).				
[i] The specified maximum temperature rises apply if the galvanizing is required as a protective coating, or the reflectivity of the surface is utilized to reduce the risk of fire.				

26.2 The specific conditions of the temperature test for central furnaces and unit heaters are covered in Sections 94 – 98 and 106 – 109, respectively. The specific conditions of the continuous operation temperature test for a burner is covered in Section 63, Continuous Operation Temperature Test.

27 Stalled Fan Motor Test

27.1 This test is to be conducted on fan-type appliances only if the impedance of the fan motor provides the overcurrent protection for that motor. Only the fan-motor temperatures need be recorded.

27.2 The appliance is to be operated under the conditions described in 96.1 and 96.2.

27.3 The rotor of the fan motor is to be locked while the circuit is temporarily de-energized. The circuit is to be immediately re-energized and allowed to remain energized until the fan-motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test. The maximum temperature rise above room temperature attained by the motor during the test is to be no more than 125°C (225°F).

28 Short-Circuit Test

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

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

b) A branch-circuit protective device of the type and maximum rating specified on the product nameplate. There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line and low-voltage circuits.

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28.2 For the purpose of these tests;

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

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

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

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

28.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the appliance as indicated in Table 28.1. The appliance full-load current is determined by adding the motor full-load current of each motor, as determined in accordance with the National Electrical Code, ANSI/NFPA 70, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current is to be used as the basis for selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit.

Table 28.1
Short-circuit test currents

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

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28.4 Except as indicated in 28.6 – 28.9, an overcurrent protective or a thermal protective device in an appliance having more than one motor wired for connection to one supply line shall withstand short-circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

28.5 The nearest standard size fuse, rated no higher than the current indicated in 28.4 but no less than 15 amperes, is to be used for the test. The maximum fuse size marked on the appliance, as specified in 34.8, is not to exceed this value.

28.6 With reference to 28.4, the protective device may be tested with a fuse having a lower rating than indicated if the appliance:

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

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

28.7 The test specified in 28.1 need not be conducted if:

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

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

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

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 8.2.16; and

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

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

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

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

28.9 Short circuit tests need not be conducted on an assembly provided with more than one motor if the motors have full-load current or horsepower rating(s) in excess of those ratings specified in 28.8 if:

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

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

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

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

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

28.13 For the test referenced in Exception No. 2 of 14.3.2, three samples of each conductor under consideration are to be subjected to each test condition specified and a new protective device is to be used for each test. The conductor and connection to be tested are to be connected in series with the overcurrent-protective device. Consideration is to be given to both short-circuit and ground-fault conditions. The capacity of the circuit is to be based on the ratings of the unit in accordance with Table 28.1 and is to be measured without the lead to be tested in the circuit. The voltage source for the test circuit is to be as specified in Table 28.1 and the power factor is to be 0.9 – 1.0 unless a lower power factor is determined to be acceptable. None of the conductors or lead terminations shall be damaged as a result of the test.

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

29 Overload Test, High-Voltage Transformers

29.1 A high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type mentioned in the Exception of 15.2.1 shall be subjected to the test described in 29.4 and 29.5.

29.2 Temperatures of a thermally protected high-voltage transformer, as measured on the surface of the windings, are not to exceed the insulation-temperature rating. The insulation-temperature rating is defined as the rating for the class of insulation; such as 105°C for Class 105 insulation and 130°C for Class 130 insulation.

29.3 The transformer shall comply with the dielectric voltage-withstand test described in Section 31, Dielectric Voltage-Withstand Test – Appliance immediately following the test described in 29.4 and 29.5.

29.4 Three samples of the transformer-protector combination are to be tested. Average temperatures of the three samples are not to exceed the winding-insulation rating and the temperature of any one sample is not to exceed the insulation rating by more than 5°C (9°F).

29.5 A variable-resistance load is to be connected to the output terminals and the transformer is to be operated continuously at the normal test voltage specified in Table 24.1. If the protective device controls a switching device that in turn interrupts primary current to the transformer, the switching device is to be in the circuit. The ambient (room) temperature during the test is to be approximately 25°C (77°F). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 10°C (18°F) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

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30 Burnout Test, High-Voltage Transformers

30.1 A high-voltage transformer shall be subjected to the test described in 30.2 and 30.3. There shall be no emission of flame or molten metal from the transformer enclosure.

Exception: A high-voltage transformer that is provided with thermal-overload protection of other than the nonrenewable thermal cutoff type, as specified in the Exception of 15.2.1 or that is protected by an over-current device or devices, as specified in 15.3.1, need not be tested.

30.2 Three samples of the transformer are to be operated continuously at the normal test voltage specified in Table 24.1, and at rated frequency, with the enclosure grounded. The test is to be conducted at an ambient (room) temperature of approximately 25°C (77°F) and operation is to be continued until:

a) Burnout occurs; or

b) Constant temperatures are indicated by a thermocouple secured to the transformer enclosure.

The test circuit is to be protected by fuses rated no less than required for the product.

30.3 The load connected to the output terminals of the transformer is to be the highest of the following and is to be readjusted, if necessary, to the specified value after 2 minutes of operation, with no further readjustment during the remainder of the test:

a) A resistance load that draws a current equal to three times the full rated transformer secondary current;

b) If the transformer supplies a motor with or without additional loads, a resistance load that draws a current equal to the motor locked-rotor current plus any additional loads; or

c) If the transformer supplies an inductive load (other than a motor), such as the coil of a relay or a solenoid, a resistance load that draws a current equal to the sum of such loads with the armature of the largest blocked open.

Exception: A transformer that cannot provide the output current specified in items (a) – (c) is to be tested with the output terminals of the transformer short-circuited.

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31 Dielectric Voltage-Withstand Test – Appliance

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

a) 1000 volts plus twice the rated voltage; or

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

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

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

31.4 The dielectric voltage-withstand test between low-voltage live parts of opposite polarity need not be conducted on the complete assembly if the components have been separately subjected to this test condition and if the wiring material is as indicated in Table 8.1.

31.5 A transformer rated 500 volt amperes or more, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 31.1 – 31.3. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute.

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

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MANUFACTURING AND PRODUCTION TESTS

32 General

32.1 To determine compliance with these requirements in production, the manufacturer of the appliance shall check, inspect, and test the components and assemblies of each as specified in 32.2.

32.2 Factory inspections and tests shall include the following:

a) Inspection of all raw materials;

b) Inspection of combustion chambers and heat exchangers to determine compliance with manufacturing specifications;

c) In the case of power-operated burners not separately inspected, each burner or the essential components of a burner are to be tested to determine and eliminate the following:

1) Oil leaks;

2) Electrical defects;

3) Misalignment;

d) Each burner not separately inspected is to be checked to determine:

1) Proper oil pressure;

2) Total motor input;

3) Proper adjustment of igniters;

e) If appliances are not assembled at the factory, the manufacturer is to periodically assemble an appliance from production to check compatibility of the subassemblies. The components are to be capable of being readily assembled. It is suggested that one unit be so checked for each 100 units produced, but no more than one for each week of production; and

f) A dielectric voltage-withstand test on each assembled appliance incorporating a high-voltage electrical circuit(s).

The test shall be conducted as described in the production line dielectric voltage-withstand test in Section 33, Production Line Dielectric Voltage-Withstand Test. The burner may be tested as a separate assembly.

33 Production Line Dielectric Voltage-Withstand Test

33.1 The manufacturer shall conduct a dielectric voltage-withstand test on each appliance. A 60 hertz potential as indicated in (a) and (b) shall be applied between high-voltage live parts and dead metal parts for a period of 1 minute:

a) 1000 volts plus twice the rated voltage; or

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

Exception: The application of the potential may be reduced to a period of 1 second if the value of the test potential is 120 percent of the value specified in (a) or (b).

33.2 For an appliance using a low-voltage circuit, the test is to be conducted with the low-voltage circuit connected to the cabinet, chassis, or other dead metal part so that the potential that is applied between the high-voltage live parts and dead-metal parts will simultaneously be applied between high-voltage live parts and the low-voltage circuits.

33.3 If an appliance is provided with components, such as a solid state control which can be damaged by the dielectric potential, the test may be conducted before the component(s) is electrically connected. However, to determine compliance with 33.1, a random sampling of each day's production is to be tested with the components electrically connected.

33.4 A transformer rated 500 volt amperes or more, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 33.1.

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

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33.5 The test equipment used for the test described in 33.1 is to include a visible indication of application of the test potential and an audible, visible, or both audible and visible indication of breakdown. In the event of breakdown, manual-reset of an external switch is to be required or an automatic reject of an appliance under test is to result.

MARKINGS

34 Nameplate

34.1 The following information shall be legibly and permanently marked on each heating appliance:

a) The manufacturer's or private labeler's name or trademark and a distinctive type, model, or catalog designation;

b) The electrical ratings, including the voltage, frequency, number of phases if polyphase, and the individual or total load rating according to 34.7. If the assembly includes provisions for more than one supply circuit, the rating of each circuit shall be marked;

c) ″For use with waste ____″ or the equivalent. The blank space is to be filled in with the type of waste fuel for which the heating appliance is recommended, such as ″crankcase oil,″ ″automatic transmission oil,″ or the like;

d) ″For use with No. ____ grade fuel oil″ or the equivalent. The blank is to be filled in with the number indicating the standard grade of fuel oil for which the heating appliance is rated;

e) The maximum firing rate of the burner expressed to the nearest 0.1 gallon per hour (0.379 liter per hour). The rate shall be marked for each type of waste oil and standard grade fuel oil the appliance is intended to fire unless the rate is the same for each type of fuel;

f) The manufacturer's recommended fuel supply or nozzle pressure in pounds per square inch (psig) (6.8948 kPA) for each type of fuel the appliance is intended to fire;

g) The manufacturer's recommended atomizing air supply pressure in psig for each type of fuel the appliance is intended to fire;

h) If a forced-air central furnace is tested without circulating air filters to determine compliance with these requirements, the furnace shall be marked to specify that the furnace is not to be used with air filters and the construction of the furnace shall incorporate no provision for the mounting of air filters;

i) The type of flooring, combustible or noncombustible, and the minimum clearances to adjacent construction to be provided when the appliance is installed;

j) The intended maximum outlet-air temperature of a furnace, if 200°F (93°C) or less. Furnaces provided with a limit control that functions to limit the outlet-air temperature between 165°F (74°C) and 200°F shall be marked ″Intended maximum outlet-air temperature – 200°F (93°C) or less″. Furnaces provided with a limit control that functions to limit the outlet-air temperature to 165°F or less shall be marked ″Intended maximum outlet-air temperature – 165°F (74°C) or less″;

k) An appliance tested for operation at an external static pressure in excess of that indicated in Column II of Table 88.1 shall be marked to specify the static pressure at which the furnace was tested;

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l) ″For commercial and industrial use only″; and

m) The date or other dating period of manufacture not exceeding any consecutive three months. The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer if the code:

1) Does not repeat in less than 20 years; and

2) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.

34.2 All required nameplate markings shall be readily visible after installation of the heating appliance. A location within a burner compartment provided with a door or removable panel for access is considered readily visible after installation. The marking shall be permanent, as afforded by a metal nameplate or a decalcomania transfer or pressure-sensitive material.

34.3 Among the factors taken into consideration when determining the acceptability of a nameplate secured by adhesives are the adhesive properties and the resistance to defacement or removal at temperatures and in atmospheres to which the nameplate may be subjected under conditions of intended or abnormal use.

34.4 Each major assembly not a part of the appliance shall be marked with the manufacturer's or private labeler's identification and catalog designation.

34.5 If a manufacturer produces appliances at more than one factory, each assembly shall have a distinctive marking to identify it as the product of a particular factory.

34.6 An appliance in which moving parts are exposed to the user when a door, panel, or shield is removed shall be marked where readily visible after installation with the word ″WARNING″ and the following or the equivalent: ″Shut off the equipment before removing or opening the cover or door″.

34.7 An appliance shall have the individual loads marked:

a) In full-load amperes and horsepower for motors; and

b) In amperes or watts for a resistance heating element.

The marking shall clearly indicate which loads operate concurrently unless it is evident that the total load is the sum of the individual loads.

Exception No. 1: A motor rated less than 1/8 horsepower (93.2 watts output) and heater circuits may be marked in watts.

Exception No. 2: A heater load of less than 1 ampere and pilot duty loads need not be so marked.

Exception No. 3: The nameplate ampere rating for appliances provided with a single power supply and consisting of more than one motor or a motor and other loads, such as heaters, may be a single ampere value rather than separate ratings for the individual loads under both of the following conditions:

a) The single load rating in amperes, the marked maximum size of the supply circuit overcurrent device, and the marked minimum circuit ampacity do not exceed the values in Table 34.1.

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b) The single marked ampere rating is no less than the sum of the individual load ratings (at the maximum concurrent load condition) which would be required to be marked on the appliance if the individual load ratings were indicated.

Table 34.1
Load Ratings

Maximum ampere rating	Maximum voltage rating	Phase	Maximum rating of overcurrent protective device and minimum circuit ampacity, amperes
12	600	1 or 3	15
16	120	1	20

34.8 The nameplate of an appliance shall be marked to indicate the minimum circuit ampacity and the maximum rating of the circuit protective device if the appliance:

a) Is provided with more than one motor incorporating inherent overheating or overcurrent protection; and

b) Is to be operated from a single supply line. If an appliance is intended for use on two or more circuits, the nameplate shall indicate the minimum circuit ampacity and the maximum rating of the circuit protective device for each circuit.

34.9 The minimum circuit ampacity shall be equal to the sum of the following loads (which may operate concurrently):

a) Full load current rating of each motor;

b) 25 percent of the full load current rating of the largest motor; and

c) Ratings of all other loads.

34.10 The marking specified in 34.8 shall specify a fuse as the protective device but may additionally specify a maximum HACR Type circuit-breaker size if the required short-circuit tests have been conducted in accordance with 28.1 using a HACR Type circuit breaker.

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35 Supplementary

35.1 If a motor that is connected in a circuit as described in 16.2 is installed remote from its controller, the rating of the remote motor, the size of the conductors supplying the motor, and reference to the location of the disconnect device for the remote motor shall be shown on the unit or on a wiring diagram attached to the unit.

35.2 If more than one disconnect switch may be required to disconnect all power within a control assembly or compartment, the assembly or compartment shall be so marked. The marking shall be in letters no less than 1/8 inch (3.2 mm) high, preceded by the word ″CAUTION,″ and shall be readily visible before or immediately after exposing the live parts that may be connected to different circuits.

35.3 Instructions for replacing the air filter with equivalent material shall be permanently marked or imprinted adjacent to or on the filter service panel. The marking is to be readily visible during replacement. Directions for installing the air filter when not factory-installed shall also be marked on the appliance if safe operation in accordance with these requirements is obtained only when the filter is so installed.

35.4 A fuse-replacement marking shall be provided for a replaceable fuse that is part of the appliance or is part of a remote-control assembly. The marking shall specify the current rating of the fuse in amperes and shall be visible when the cover or door of the fuse compartment is open.

35.5 If a supplementary fuse is provided in accordance with the exception of 14.4.2 or 15.3.3, the marking specified in 35.4 shall also include the identification of suitable fuses by manufacturer's or private labeler's name, catalog designation, and voltage rating.

35.6 If an appliance is provided with a direct-connected high-voltage control circuit as specified in 14.2.1, the appliance shall be marked to indicate the maximum size of an overcurrent device or devices for that control circuit. The rating of an overcurrent device shall be:

a) No more than 20 amperes for 18, 16, and 14 AWG (0.82, 1.3, and 2.1 mm^2) conductors; and

b) Based on the ampacity of the control circuit conductors in accordance with the ampacity tables in the National Electrical Code, ANSI/NFPA 70. The marking shall appear on the wiring diagram, adjacent to the field wiring terminals, or on the appliance nameplate.

35.7 Unless proper field-wiring connections are evident, a wiring diagram shall be provided on the appliance. A paper sticker glued or shellacked to an accessible cover is considered acceptable.

35.8 If the appliance requires a time-delay fuse for proper start up, the appliance shall be so marked.

35.9 An appliance intended for connection to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is intended. The marking shall be located so that it will be visible when power supply connections are made to the appliance.

35.10 An appliance provided with a 3-phase motor which has been investigated as specified in 13.5(b) shall be marked to indicate that the motor is protected under primary single-phasing conditions. The marking shall be a paper sticker or decal or shall be provided on a wiring diagram attached to the appliance.

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35.11 If an air-atomizing burner is not provided with means to supply atomizing air, the assembly shall be marked with the minimum volume of air in cubic feet (m^3) per minute and the minimum operating pressure of air to be supplied.

35.12 Terminals for field wiring shall be marked ″USE COPPER CONDUCTORS ONLY″, ″FOR USE WITH ALUMINUM OR COPPER CONDUCTORS″, or with an equivalent statement, as applicable. This marking shall be independent of any marking on the terminal connectors.

INSTRUCTIONS

36 General

36.1 A copy of the manufacturer's operating and installation instructions intended to be provided with each waste oil burning appliance shall be used as a guide in the examination and test of the appliance.

36.2 The instructions shall include directions and information to cover the intended installation, maintenance, and use of the waste oil burning appliance and shall include the following:

a) Statements that the appliance is for commercial or industrial use only and that the installation shall be in accordance with the Standard for the Installation of Oil Burning Equipment, ANSI/NFPA 31; the National Electrical Code, ANSI/NFPA 70; and the requirements of the inspection authorities having jurisdiction;

b) A statement that the appliance shall be installed only by a qualified installer, such as one who is engaged in, responsible for, or thoroughly familiar with the installation and operation of oil-fired appliances; who is experienced in such work and is familiar with the precautions required; and who will comply with all the requirements of the authority having jurisdiction over the installation;

c) Information on the general characteristics of waste oils, including statements that:

1) Such oils may contain gasoline; and

2) Specific precautions on the handling and storage of waste oils;

are to be observed;

d) If specific precautions must be taken during cleaning and servicing of a combustion chamber liner, a statement that the combustion chamber and liner must be inspected periodically for any deterioration and instructions for the inspection and replacement, if necessary, of the liner; and

e) The following statement or the equivalent: ″For your protection – Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance″.

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PART II – BURNERS

CONSTRUCTION

37 General

37.1 In addition to the requirements specified in Sections 1 – 36, a burner shall comply with the requirements specified in Sections 37 – 70.

37.2 Fuel-confining parts or operating parts shall not sag, distort, melt, oxidize, show leakage of fuel, or prevent a safety device from functioning during any of the tests described in Sections 57 – 70.

37.3 To comply with 37.2, a material shall have a melting point, solidus temperature, of no less than 950°F (510°C) and a tensile strength no less than 10,000 pounds per square inch (69 MPa) at 400°F (204°C).

37.4 Fuel-confining parts that do not comply with 37.2 and 37.3 may be used if a fusible-link valve or the equivalent is included in the assembly of the burner to shut off the fuel supply in the event of excessive temperature or fire in the vicinity of such parts.

37.5 A burner part intended for the handling of fluids under pressure shall withstand, without rupture, a hydrostatic pressure equivalent to five times the maximum working pressure.

37.6 Soft solder shall not be used on any fuel-handling parts if melting of the solder may allow leakage of fuel. Soft-soldered joints, where permitted, shall be made mechanically secure before soldering.

37.7 The burner shall function to minimize the generation of unburned vapors and shall not include chambers or pockets in which unburned vapors may accumulate. An oil-conveying pipe or passage shall not be exposed to temperatures which may result in carbonization or clogging when the burner is tested in accordance with the tests described in Sections 57 – 70.

37.8 A fuel-handling component shall be rated for use with fuel oil of the numerical grade recommended by the manufacturer of the appliance and shall have a working pressure or design pressure no less than the maximum pressure to which the component is exposed during the tests described in Sections 57 – 70. For purposes of applying this requirement, waste oils shall be graded according to Table 37.1.

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Table 37.1
Waste oil grades

Grade of oil	Viscosity, S.S.U. at 100°F (38°C)[a]	
	Minimum	Maximum
2	34	40
4	45	125
5	150	800
6	45[b]	300[b]

[a] S.S.U. – Saybold Seconds Universal
[b] Measured in Saybold Seconds Furol (S.S.F.) at 122°F (50°C)

38 Materials

38.1 An elastomeric material used in a component of a burner that is exposed to waste oil fuel shall be tested for resistance to gasoline if shrinkage or swelling of the part may:

a) Cause external leakage of oil from the component involved;

b) Stop operation of a power-operated pump;

c) Prevent an automatic valve from functioning as a safety shut-off valve; or

d) Result in unstable operation of the burner during any of the tests conducted on the appliance.

39 Assembly

39.1 A burner shall be factory-built as a group assembly and shall include all the parts necessary for its intended function when installed as intended. The equipment may be shipped as two or more subassemblies.

Exception: The equipment necessary to supply atomizing air to an air-atomizing burner need not be provided with the assembly if the burner is marked in accordance with 35.11.

39.2 The burner equipment, if not assembled by the manufacturer as a unit, shall be constructed in as few subassemblies as practicable. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, threading, welding, or similar tasks by the installer. Two or more subassemblies, which must bear a definite relationship to each other for the intended operation of the equipment, shall be arranged and constructed so that they can be incorporated into the complete assembly without need for alteration or alignment only in the correct relationship with each other; or such assemblies shall be assembled, tested, and shipped from the factory as part of the burner assembly.

39.3 The burner shall provide a uniform and definite supply of fuel and air for combustion when installed and adjusted in accordance with the manufacturer's installation instructions. The means for regulating the supply of air and oil shall be constructed so that the adjustments may be fixed or restricted to prevent unintentional changes in settings.

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39.4 A burner of the ″swing-type″ shall be provided with means for locking the burner in the firing position and, for an automatically-lighted burner, to prevent it from discharging fuel when in other than the firing position.

39.5 An adjustable or moveable part shall be provided with a locking device to prevent unintentional shifting.

39.6 After removal and replacement, screws or bolts used to attach parts that are detached for servicing of the burner shall continue to secure such parts upon the application of the torques indicated in Table 39.1.

Table 39.1
Torque requirements for screws or bolts

American standard screw size		Torque		I.S.O. Screw size	Torque	
No.	**mm**	**Lb-In**	**N·m**	**mm**	**N·m**	**Lb-In**
–	–	–	–	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
Inch	**mm**					
1/4	6.4	100	11.3	6	8.7	77
–	–	–	–	7	15.0	133
5/16	7.9	200	22.6	8	23.5	208
–	–	–	–	9	33.6	297
3/8	9.5	350	39.6	10	45.2	400
7/16	11.1	575	65.0	12	81.0	715
1/2	12.7	850	96.0	14	128.0	1130
9/16	14.3	1200	136.0	–	–	–
5/8	15.9	1600	181.0	16	185.0	1640

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40 Accessibility for Servicing

40.1 All parts requiring adjustment or manipulation by the user in the course of operation of the burner shall be accessible and easily moved. Any part that may normally come in contact with the operator's hand during usage shall be free from sharp edges or projections and from projecting sharp screw ends.

40.2 All burner parts, controls, and safety devices requiring servicing shall be accessible. The disposition of parts in the assembly removed for servicing shall be such that the restoration of such parts, following removal, will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special facilities that may be required for servicing to be performed by the operator shall be shipped with each appliance.

40.3 A firing assembly, atomizer and nozzle assemblies, and the like that are intended to be removed and replaced for servicing shall be constructed so that, upon replacement, the assembly will self-restore the atomizer or nozzle to its correct position.

41 Fan Housings and Air Tubes

41.1 A fan housing and an air tube shall be made of noncombustible material having the strength and durability to not be damaged when subjected to the tests described in Sections 57 – 70.

41.2 A fan housing in which oil leaking from any oil-handling part of the assembly may accumulate shall be provided with an open drain such as an inverted fan housing on a gun-type burner.

41.3 An air tube of a gun-type oil burner shall prevent the accumulation of oil within the air tube. Any drippage from the nozzle shall drain to the fire box. A drain shall be located to avoid blockage by refractory or cement.

41.4 The exterior portion of a firing head within 6 inches (152 mm), measured parallel to its axis, of the firing end and all parts that may be in contact with masonry when the burner is installed as intended shall be made of iron or steel. Interior parts shall be made of materials that comply with 37.2 – 37.6.

41.5 An outer shell of a blast tube or firing head, if made of sheet metal, shall provide the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a thickness of no less than 0.053 inch (1.35 mm) or Type 309 stainless steel having a thickness of no less than 0.026 inch (0.66 mm).

42 Combustion Air Controls

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

42.2 The air inlet shall be capable of supplying sufficient air for complete combustion under the specified draft condition and at the maximum rate of firing when the burner is installed as intended. All the air required for complete combustion shall be introduced to maintain thorough mixing of the fuel and air in order to complete the combustion within the combustion zone.

42.3 An air shutter shall provide a smooth surface between the shutter and the matching face.

42.4 Sheet metal air shutters shall be no less than 0.0254 inch (0.65 mm) thick. If sheet metal air shutters are less than 0.0508 inch (1.29 mm) thick, the outer edge of the shutters shall be turned at right angles or reinforced in an equivalent manner.

42.5 An air shutter, by its construction or assembly and selection of materials, shall resist sticking or corroding in position. Screws or bolts used for attaching or adjustment of an air shutter shall be of corrosion-resistant material.

42.6 An adjustable part shall be guided to prevent movement from its intended path during adjustment and the means for adjusting the part shall be accessible during servicing.

42.7 A burner constructed to change the firing rate automatically shall automatically proportion the air supply with the fuel, if necessary, to produce stable combustion at all firing rates allowed by the automatic control.

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42.8 Linkage for operating air and fuel controls shall maintain the intended fuel-air ratio and shall resist unintentional damage and disengagement.

43 Fuel Strainers

43.1 A waste oil burner shall be provided with a primary strainer assembly which complies with the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331. The materials used in the strainer assembly that are exposed to waste oil fuel shall be tested for resistance to gasoline as described in 38.1.

43.2 A small orifice or other opening in an oil-supply system shall be protected by a strainer as specified in 43.3 – 43.13.

43.3 The largest opening of the strainer element shall be of such size that its larger dimension will be no greater than 90 percent of the smaller dimension of the smallest fixed opening protected by the screen.

43.4 For the purpose of these requirements, a metering valve, a float valve, and an automatic safety valve shall be considered as a fixed opening having a diameter of 1/32 inch (0.8 mm) when Nos. 1 and 2 oils are used and 1/16 inch (1.6 mm) when Nos. 4, 5, and 6 oils are used.

43.5 If the strainer assembly is provided with a screen-type element, the effective area of the screen (total area of screen openings) shall be no less than as indicated in Figure 43.1, 43.2, or 43.3, as appropriate for the grade of fuel oil and the maximum firing rate.

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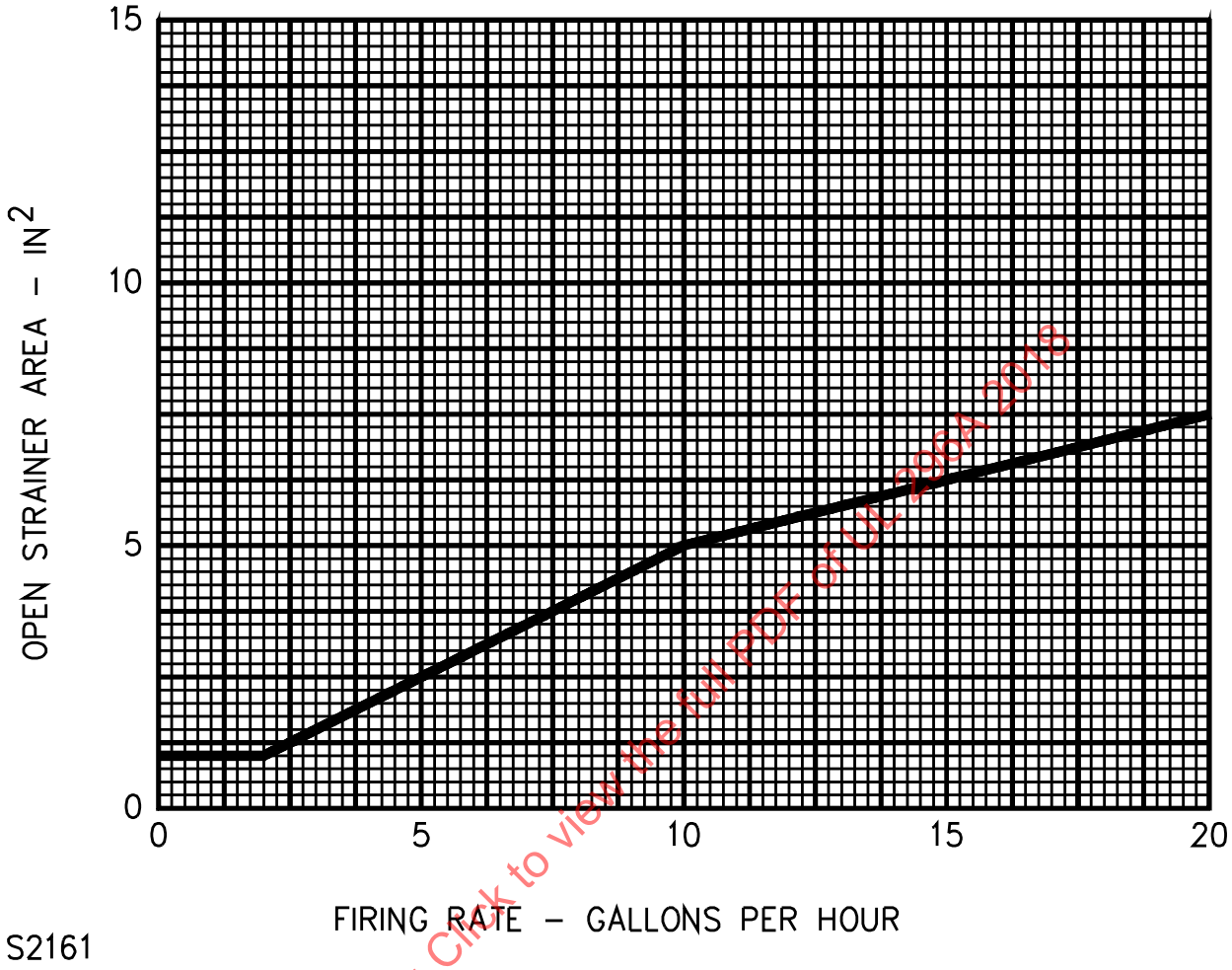
Figure 43.1
Strainer area for No. 1 fuel oil[a]



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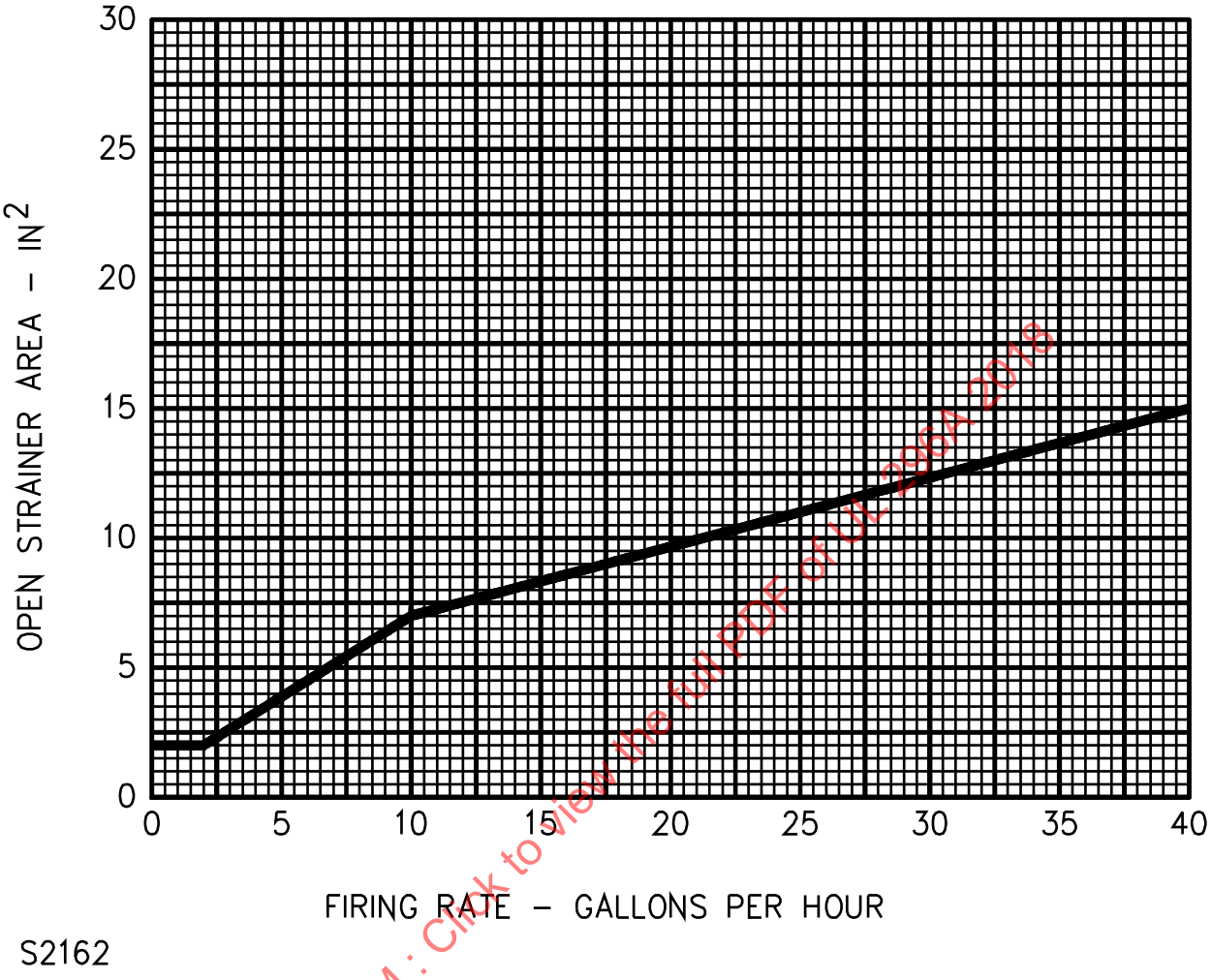
Note:

1 square inch = 6.45 cm^2

1 gallon = 3.79L

[a] As designated by the Specification for Fuel Oils, ANSI/ASTM D396

Figure 43.2
Strainer area for No. 2 Fuel oil[a]



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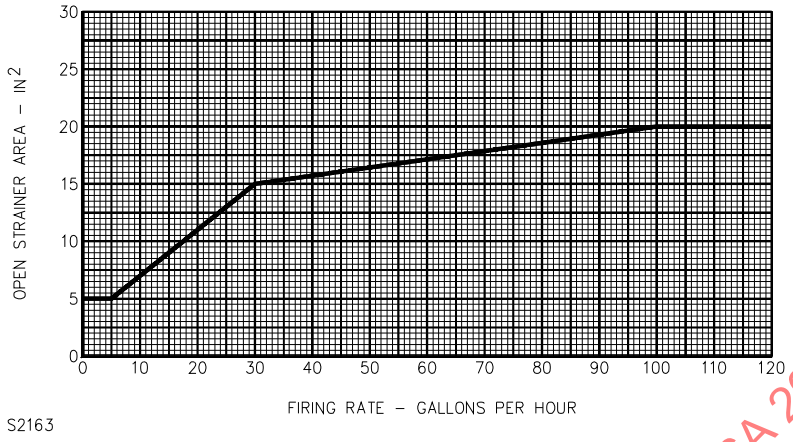
Note:

1 square inch = 6.45 cm^2

1 gallon = 3.79L

[a] As designated by the Specification for Fuel Oils, ANSI/ASTM D396

Figure 43.3
Strainer area for Nos. 4, 5, 6 fuel oils[a]



Note:

1 square inch = 6.45 cm^2

1 gallon = 3.79L

[a] As designated by the Specification for Fuel Oils, ANSI/ASTM D396

43.6 The effective area of a screen (total area of screen openings) is not required to be greater than the maximum value shown in Figures 43.1 – 43.3, regardless of the burner firing rate, but in any case the strainer shall not impair the flow of fuel supplied to fire the burner at maximum rated input.

43.7 A strainer provided with an element other than a screen shall be suitably rated for the heaviest grade of fuel oil being handled and shall have a rated capacity no less than the maximum firing rate of the burner to which it is attached.

43.8 When two strainers installed in series are provided instead of a single primary strainer, each strainer shall be of approximately equivalent size and the screen area or rated capacity of each shall be 1.4 times that required for a single strainer. The strainer downstream from the other shall be provided with a screen or element in which the size of the individual straining opening is no larger than 90 percent of the size of the straining opening in the element of the other strainer.

43.9 A secondary strainer, one supplementary to the main strainer, smaller in area than specified in 43.5 may be used in the fuel line downstream from the primary strainer.

43.10 A strainer shall be attached to permit the removal and replacement of the straining element. The force necessary to open a strainer shall not permanently distort the lines or assembly to which it is attached.

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43.11 A strainer required for the protection of an automatic safety valve or a float valve shall be provided as part of the assembly incorporating the valve.

43.12 Pipe or other fuel conduit used to connect a float valve, metering valve, or safety valve to the protecting strainer shall be free of dirt and scale at the time of assembly.

43.13 A strainer shall be applied so that there will be no air trapped to affect the rate of fuel flow to the burner or to reduce the effective area of the straining element.

44 Fittings, Piping, and Tubing

44.1 An opening threaded for pipe connection shall be threaded in accordance with the Standard for Pipe Threads (except dryseal), ANSI B2.1 .

44.2 An opening for field attachment to a pipe larger than a nominal 3 inch pipe size, as specified in the Standard for Pipe Threads, ANSI B2.1, shall be provided with a flanged pipe connection complying with the Standard for Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, ANSI B16.1.

44.3 A fitting, other than one complying with the appropriate American National Standard, having openings threaded for pipe connections shall be capable of withstanding, without damage or leakage, the torque as indicated in Table 44.1, exerted as if to screw the fitting onto a pipe or into a pipe fitting.

44.4 A tool that fits snugly about the fitting or to a section of the shank shaped for a wrench, if such a section is provided, is to be used to apply the torque. The torque is to be applied to the hex of the fitting adjacent to where it is attached to piping or, if no hex is provided in this position, to the body of the fitting. The measured torque specified in Table 44.1 is to be applied to screw the fitting onto an extra-heavy pipe or into a pipe fitting of appropriate size. After the force has been applied, the fitting shall not leak when subjected to a hydrostatic pressure equivalent to 1-1/2 times the maximum working pressure.

Table 44.1
Torque requirements for pipe connections

Pipe size, ANSI B36.10 Nominal inches	Outside diameter		Torque	
	Inches	(mm)	Pound-inches	(N·m)
1/8	0.405	(10.29)	150	(17)
1/4	0.540	(13.72)	250	(28)
3/8	0.675	(17.15)	450	(51)
1/2	0.840	(21.34)	800	(90)
3/4	1.050	(26.67)	1000	(113)
1	1.315	(33.40)	1200	(137)
1-1/4	1.660	(42.16)	1450	(164)
1-1/2	1.900	(48.26)	1550	(175)
2	2.375	(60.33)	1650	(186)
2-1/2	2.875	(73.03)	1750	(198)
3	3.500	(88.90)	1800	(203)
4	4.500	(114.30)	1900	(215)

44.5 Pipe and pipe fittings shall be wrought iron or steel or iron-pipe-size brass or copper complying with the applicable American National Standard. Unions, where used, shall be the ground-joint type or the equivalent.

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44.6 Tubing shall be located to reduce the risk of being physically damaged, such as by following the contour of the burner assembly.

44.7 Seamless drawn aluminum or copper tubing and steel tubing of the seamless, brazed, or welded type used in the fabrication of factory-assembled equipment shall have a wall thickness of no less than that specified in Table 44.2.

44.8 Aluminum tubing shall not be exposed to condensation or to temperatures exceeding 700°F (371°C) and shall not be acceptable for use where it passes through insulating material of other than a neutral reaction unless the tubing is protected from the insulation.

44.9 Steel tubing having a wall thickness of 0.053 inch (1.35 mm) or less shall be constructed of corrosion-resistant material such as stainless steel or shall be plated, dipped, coated, or otherwise treated to resist external corrosion.

44.10 Cadmium plating shall have a thickness of no less than 0.0003 inch (0.008 mm) and zinc plating shall have a thickness of no less than 0.0005 inch (0.013 mm).

Exception: The thickness of the cadmium or zinc plating shall be no less than 0.00015 inch (0.0038 mm) on parts where threads constitute the major portion of the area.

Table 44.2
Wall thickness for aluminum, copper, and steel tubing

Outside diameter,		Minimum wall thickness, Inch (mm)[a]			
		Aluminum and copper		Steel	
Inches	(mm)				
1/8	(3.18)	0.029	(0.74)	0.028	(0.71)
3/16	(4.76)	0.029	(0.74)	0.028	(0.71)
1/4	(6.35)	0.029	(0.74)	0.028	(0.71)
5/16	(7.94)	0.029	(0.74)	0.028	(0.71)
3/8	(9.53)	0.032	(0.81)	0.028	(0.71)
7/16	(11.11)	0.032	(0.81)	0.028	(0.71)
1/2	(12.70)	0.035	(0.89)	0.028	(0.71)
9/16	(14.29)	0.038	(0.97)	–	–
5/8	(15.88)	0.038	(0.97)	0.035	(0.89)
3/4	(19.05)	0.045	(1.14)	0.035	(0.89)
7/8	(22.23)	0.045	(1.14)	0.049	(1.24)
1	(25.40)	0.049	(1.24)	0.049	(1.24)
1-1/8	(28.58)	0.049	(1.24)	0.049	(1.24)
1-1/4	(31.75)	0.055	(1.40)	0.049	(1.24)
1-3/8	(34.93)	0.055	(1.40)	–	–
1-1/2	(38.10)	–	–	0.065	(1.65)

[a] Nominal wall thickness of tubing shall be greater than the thickness indicated to maintain the minimum wall thickness.

44.11 Flexible-metallic hose shall not be used as a substitute for rigid piping or tubing as ordinarily used. The use of flexible-metallic hose shall be restricted to applications in which rigid piping or tubing is impractical and in which flexible connections cannot be avoided. Flexible-metallic hose shall not be subjected to torsional, tensile, or bending stresses or to abrasion and shall not be used in conjunction with safety devices or where bending is caused by automatic operation.

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44.12 A fuel line shall terminate in a manner that will permit connection to the burner. A fuel-line opening shall be plugged or capped to prevent the entrance of foreign material prior to installation.

44.13 A coupling or union that is disconnected for service shall be located so that any oil dripping from the connection will not drip or run onto electrical parts.

45 Valves

45.1 The pressure rating of a valve shall be no less than the maximum operating pressure of the burner.

45.2 An automatic safety valve shall shut off in no more than 5 seconds after being de-energized and shall be constructed so that it may not be restrained or blocked in the open position.

45.3 A safety valve shall close upon being de-energized, regardless of the position of an operating lever or reset handle.

45.4 An electrically-operated safety valve shall not depend on electricity to shut off the oil flow.

45.5 A safety valve responding to pressure variations in a hydraulic or pneumatic remote control system shall close upon failure of pressure in the control system.

45.6 A manually-operated fuel-metering valve shall be provided with a means, which may be set by the installer or manufacturer, to restrict the maximum amount of fuel delivered to the burner to an amount which can be consumed as intended, or the means for adjustment shall be enclosed or shielded to discourage tampering after adjustment has been made by the installer.

45.7 A plug or rotating-disc type valve, using the bearing surface of the plug or disc as the liquid seal to the exterior of the valve body, shall not be used in a fuel oil line.

45.8 A pet-cock or valve which, when open, will permit the discharge of fuel oil into the room shall not be used.

45.9 A pressure-regulating valve shall incorporate a means of shielding or locking the adjustment to discourage tampering by unauthorized persons after being set. The valve shall be constructed so that the maximum pressure of oil at the maximum valve setting does not exceed the intended maximum pressure for the burner.

45.10 A nozzle shutoff valve of the automatic type shall close at a pressure above the minimum atomizing pressure of the burner.

45.11 A pressure-relief device shall be connected into a fuel line in which pressure may build up in excess of that necessary for normal operation; for example, due to the closing of any valve in the assembly of the burner or when the oil is heated by a preheater. A pressure relief valve shall be set to initiate its function at a pressure no greater than the design pressure of any part of the oil heating system.

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46 Gauges

46.1 A glass gauge or sight feed, the breakage of which will allow the discharge of fuel oil from the fuel supply system, shall not be used.

46.2 A pressure gauge, when used, shall have a scale range of at least 1-1/2 times the maximum intended operating pressure of the burner and greater than the maximum operating pressure as well as the pressure obtained at the maximum setting of any relief or pressure-regulating valve included as part of the burner equipment.

47 Ignition Systems

47.1 The ignition system of an automatically-lighted burner shall be activated only before or simultaneously with the delivery of fuel to the ignition zone and shall remain active during the trial-for-ignition period. If ignition is cut off at the termination of the trial-for-ignition period, the ignition shall remain off for the duration of that firing cycle unless the ignition is fully restored within 0.8 seconds after unintentional extinguishment of the main burner flame.

47.2 An igniter, pilot, and pilot supervisor shall be constructed and supported so that each is fixed in its intended position.

47.3 The means for ignition shall be located so as to avoid the collection of carbon and other material or the dislocation, distortion, or burning of parts when the burner is tested in accordance with 47.1.

47.4 The construction of an oil burner shall be such that the igniter assembly may be removed from and replaced in the burner assembly during servicing of the burner without resulting in:

a) Reduction of the clearances between bare current-carrying parts, electrodes, and grounded metal parts;

b) Changes in the air-gap at electrode tips;

c) Reduction of the spacings between the high-potential cables and grounded metal parts; and

d) Changes in the position of the igniter or pilot relative to the area at which ignition is to be initiated.

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48 Electric High-Tension Ignition

48.1 Assembly

48.1.1 A high-tension current-carrying part, such as a bus bar, electrode, or terminal, shall be enclosed or insulated to provide protection against the risk of unintentional contact.

48.1.2 The ignition system shall be subjected to the test specified in 68.2.1 and 68.2.2.

48.1.3 If an adjustable air deflector or similar part is used in the vicinity of high-tension parts, the construction shall be such that the deflector cannot be located in a position that may cause the deflector to not comply with the requirement specified in 68.2.1.

48.2 Electrode and bus bars

48.2.1 Bare high-tension conductors shall be self-supporting when in place.

48.2.2 An electrode or a bus bar supporting an electrode shall be constructed so that, while fixed in the intended position, the electrode or bus bar will maintain the intended gap.

48.2.3 The use of a setscrew bearing directly against an insulator shall not be used as a means for securing an ignition assembly. The construction shall be such that an insulator cannot be damaged when tightening the securing means.

48.2.4 An electrode shall be prevented from rotating within its insulator unless such rotation will not result in any change in spacing or alignment.

48.2.5 An electrode tip shall be of a material such as high-temperature alloy steel or equivalent material so that burning of the point of the tip will not be evident while the burner is being tested in accordance with these requirements.

48.2.6 An electrode slanting downward toward its insulator shall be provided with a drip loop or the equivalent to prevent oil running down the electrode from reaching the insulator.

48.3 Insulators

48.3.1 An insulator shall be made of ceramic insulating material or the equivalent that is impervious to oil and moisture and cleanable by wiping.

48.3.2 An insulator shall be subjected to the test specified in 68.3.1 and 68.3.2.

48.3.3 An insulator shall provide a distance, as measured across the surface of the insulator, between the nearest point of bare current-carrying parts and the nearest grounded metal surface as indicated in Table 48.1.

Exception: An insulator included in a proved gas pilot assembly to be energized by a transformer having a secondary voltage of no more than 6,000 volts need not comply with this requirement if ignition is to be for combustible air-gas mixtures only within or adjacent to a pilot tip or nozzle handling mixtures under pressures of no less than a 1/4 inch water column (62.3 Pa).

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Table 48.1
Spacing over surface of insulators

Secondary voltage of ignition transformer, volts	Minimum surface distance over insulation	
	Inches	(mm)
No more than 10,000	1-1/2	(38.1)
No more than 15,000	2	(50.8)
NOTE – Except as indicated in the exception of 48.3.3, an insulator included in the assembly of a spark-ignited gas pilot shall have an over surface spacing of no less than 1 inch (25.4 mm) if the secondary voltage of the ignition transformer is 6000 volts or less.		

48.3.4 An insulator shall be located so that no detrimental accumulations of carbon will form on its surfaces when the burner is tested in accordance with these requirements.

48.4 Leads

48.4.1 Ignition cable shall have a voltage rating greater than or equal to the rated secondary voltage of the ignition transformer. Each end of a high-tension lead shall be provided with a fixed loop, eyelet, or connector to facilitate proper connection to the terminal. A high-tension lead or cable shall be run individually in a manner to avoid sharp bends and shall be arranged and supported to maintain a spacing of no less than 1/4 inch (6.4 mm) through air from grounded metal parts.

48.4.2 Insulators for the support of ignition cable made of porcelain or molded phenolic having a wall thickness of 1/8 and 1/16 inch (3.2 and 1.6 mm), respectively, are considered to have insulating properties equivalent to that provided by a 1/4-inch (6.4-mm) air spacing.

48.5 Transformers

48.1.5 A transformer shall be mounted as closely as possible to the spark gap to avoid long leads. The location of the transformer shall be such that it will not be placed within 1 inch (25.4 mm) of the floor when the burner is installed in accordance with the manufacturer's installation instructions.

Exception: A transformer need not be located more than 1 inch above the floor if that portion of the case within 1 inch of the floor is waterproof.

48.5.2 A spacing of no less than 1/8 inch (3.2 mm) shall be provided between a transformer high-tension insulator and any adjacent metal part other than the transformer case.

48.5.3 The requirements specified in 48.1.1 – 48.5.2 are based upon the use of ignition energy that is essentially sinusoidal. Other types of systems using ignition energy that is not essentially sinusoidal may be considered. Among the factors taken into consideration in determining the acceptability of such systems are dielectric properties, electrical spacings, the true root mean square (rms) value, the peak voltage of the system, the average pulse power, time between pulses, duration of the pulses, and duty cycles.

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49 Gas Pilots

49.1 A pilot burner shall be located so that fuel oil will not accumulate on or in the burner while firing or when the burner fails to ignite.

49.2 A pilot burner on a waste oil burner shall be a type intended for such use and shall be automatically lighted.

49.3 A pilot burner, an electric igniter, and pilot supervision means shall be supported in a manner such that their position relative to each other and to the flame of the main burner or burners will remain fixed.

50 Control Applications

50.1 A safety-control circuit shall:

a) Be two-wire;

b) Have one side grounded; and

c) Have a nominal voltage of 120 volts.

A safety control or protective device shall interrupt the ungrounded conductor.

50.2 The control circuit shall be constructed so that a safety control or protective device cannot be rendered ineffective by a short-circuit to ground. Safety-control circuit constructions other than as specified in 50.1 shall provide equivalent protection.

50.3 The requirement specified in 50.1 does not apply:

a) To a supervised circuit within a safety control; or

b) To the extension of such a circuit to a separate element of the control, such as a flame-sensing device.

50.4 A control circuit shall be constructed so that when the burner is connected to a power-supply branch circuit, the control circuit will be protected against overcurrent at no more than the value appropriate for the rating of any control included in the circuit in accordance with the National Electrical Code, ANSI/NFPA 70.

50.5 All safety controls shall be accessible.

50.6 A safety control and its sensing element shall be supported to remain in the intended position. It shall be possible to determine by observation or test whether or not each control is in its intended location.

50.7 No means shall be provided to enable any safety control to be rendered ineffective or to enable firing of the burner without the protection of each of the required safety controls.

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50.8 A burner not provided with automatic restarting means shall be constructed to require manual restart following the functioning of a control that causes the fuel supply to be shut off and following restoration of an interrupted power supply.

50.9 A burner circuit shall be constructed to prevent feedback by a motor, capacitor, or similar device from energizing a fuel valve or ignition device after a control functions to shut off the burner.

51 Primary Safety Controls

51.1 A burner shall be provided with a primary safety control that provides the nominal safety timings indicated in Table 51.1.

Table 51.1
Safety control timing

Maximum main flame hourly input gallons (gph)[b]	Ignition	Nominal maximum timings in seconds[a]	
		Main-flame establishing period[c,d]	Flame-failure reaction time[e]
3 (1.4 liters/hrs) (approximately 400,000 Btu (421,600 kj) or less	Unproved igniter or pilot	45	45
7 (26.6 liters/hr) (approximately 1,000,000 Btu) (1,106,000 kJ) or less	Unproved igniter or pilot	30	30
20 (76 liters/hr) (approximately 3,000,000 Btu) (3,160,000 kJ) or less	Unproved igniter or pilot	15	3[f]

[a] The nominal time is the intended duration of the period determined at rated voltage of the control in a room temperature of 70°F (21.1°C). Allowable factory tolerance may be additional.

[b] Corresponding to the gph input when the burner is fired with the standard grade of fuel oil for which the burner is rated.

[c] The maximum input for determining the main-flame establishing period for a burner not equipped as indicated in item d is to be the maximum input of the burner.

[d] The maximum input for determining the main-flame establishing period and for determining if a proved pilot or igniter is required for a burner equipped to start on low fire only is to be the input to the largest fire that can be initially ignited, provided the input to that fire cannot be increased until ignition of the low fire is established and proved.

[e] The flame-failure reaction timing is to be based on the burner's maximum input. The flame-failure reaction time is the interval between the occurrence of flame extinguishment and the time the safety shutoff device is de-energized. For burners having an hourly input of 3 gph (400,000 Btu) or less, the timing may be the interval measured from the time the sensing device first detects loss of flame to the time the safety shutoff device is de-energized.

[f] A flame-failure reaction time may be more than 3 seconds, but no more than 15 seconds, if intermittent ignition is used of if the ignition system is re-energized in no more than 0.8 seconds after flame extinguishment occurs.

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52 Oil Atomization Control

52.1 A burner:

a) That uses a medium such as air or steam for atomizing the fuel oil; and

b) In which the atomizing medium is obtained from a source separate from the assembly shall be provided with interlock means to shut off the delivery of fuel to the firing portion of the burner if the atomizing medium is not provided.

53 Interlocks

53.1 A control device provided as an interlock in the burner fuel supply-combustion air system, fuel supply-atomizing air system, or for a similar purpose shall comply with the requirements specified in the Standard for Limit Controls, UL 353.

54 Oil Heating Equipment

54.1 For a burner provided with integral means for preheating the fuel oil, the oil heating equipment shall comply with the requirements specified in the Standard for Electric Oil Heaters, UL 574.

54.2 A burner provided with preheating means for the fuel oil may be provided with an interlock device to prevent delivery of the oil to the firing portion of the burner until the oil has reached a predetermined minimum temperature. The location where the oil temperature is monitored shall be between the preheater and the firing portion of the burner.

54.3 On a burner that is not equipped with oil preheating equipment, an oil temperature interlock device as mentioned in 54.2 shall either:

a) Not be provided on the burner; or

b) If provided, be bypassed during any firing tests of the burner.

55 Air Atomizing Equipment

55.1 For a burner provided with integral means for pumping air for atomizing the fuel oil, the air pump shall comply with the performance requirements specified in the Standard for Pumps for Oil-Burning Appliances, UL 343.

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56 Combination Gas-Oil Burners

56.1 A combination burner intended to burn only one fuel at a time shall be constructed so that the fuel not being fired will be shut off automatically when the burner for that fuel is not in firing position or is not intended to be fired.

56.2 A combination burner intended to burn only one fuel at a time and equipped to change automatically from one fuel to another, shall be constructed so that the fuel being fired is shut off before the other fuel is delivered to the ignition zone. The ignition system for the fuel to be fired shall provide a predetermined trial-for-ignition period and shall be activated simultaneously with or before the initial delivery of the fuel to the ignition zone.

56.3 A burner intended to burn both gas and oil simultaneously shall be constructed so that the maximum operating input cannot exceed the maximum capacity of the burner as fired.

56.4 An automatically or remotely lighted combination burner shall be constructed so that no gas can flow to the main burner or burner group operating as a unit unless satisfactory ignition of the main gas burner is ensured (proved pilot).

PERFORMANCE

57 General

57.1 The performance of a waste oil burner is to be judged on the basis of operation tests conducted on the burner using each type of fuel recommended for use by the manufacturer of the burner. Each size and type of burner, or a sufficient number of sizes and types to be representative of the entire range of sizes and types submitted, are to be subjected to all or part of the tests described in Sections 58 – 70, as applicable.

57.2 The burner, when tested as described in Sections 58 – 70, shall be uniform and reliable in operation and free from carbonization or other conditions that may adversely affect the intended operation of the burner. See 58.1.2.

57.3 Burners provided, or intended to be provided in the field, with preheaters to heat the fuel oil before it is delivered for combustion are not required to burn cold oil. Such burners shall be constructed so that no oil can be delivered to the burner for combustion until it has been heated to the intended temperature.

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58 Combustion Tests

58.1 Mechanical-atomizing burners general

58.1.1 Combustion shall be stable and complete at all firing rates over the operating range of the burner without generating smoke and without causing the formation of carbonization in excess of the limits specified in 58.1.2.

58.1.2 The performance of a burner during the extended operation test described in 58.2.1 – 58.2.11 is considered to comply with 58.1.1 if:

a) Automatic ignition is obtained on each cycle within the intended period of time;

b) Ignition is obtained at each cycle without backfire, flash, or ″puff″;

c) Stable combustion is obtained at all operating firing rates and burner flames do not flash outside the heating appliance being fired;

d) The observed smoke density at all firing rates during the tests described does not exceed that indicated by a number 4 spot for burners firing any type of waste oil fuel, a number 2 spot for burners firing a distillate-type standard grade fuel oil and a number 4 spot for burners firing a residual-type standard grade fuel oil on the Shell-Bacharach scale with the Model RDC smokemeter;

e) Combustion at all firing rates is complete and uniform during the test;

f) No excess soot is deposited on surfaces of the heat exchanger, flue passages, or the flue pipe of the heating appliance. Any tar or flocculent soot accumulation is considered excessive;

g) Surfaces of the fire box, hearth, nozzles, electrodes, and igniters and their insulators are free from the formation of carbon, soot, and tar; and

h) A pilot does not deposit carbon when adjusted according to the manufacturer's instructions.

58.2 Extended operation

58.2.1 The test burner is to be installed as specified in the instructions furnished by the manufacturer of the burner.

58.2.2 All heating surfaces of the burner in contact with combustion products and the flue pipe of the appliance are to be thoroughly cleaned before the combustion test is begun.

58.2.3 The burner is to be fired with the different types of waste oil fuel the appliance is rated for use with that are likely to produce the most severe conditions with regard to sooting and deterioration of the combustion chamber and heat exchanger surfaces exposed to products of combustion. The firing rate shall be within the firing rate range of the burner.

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58.2.4 The burner air-fuel ratio is to be adjusted in accordance with the instructions provided by the manufacturer. The draft over fire is to be the minimum value recommended in the instructions and the supply voltage is to be adjusted to the normal test voltage specified in Table 24.1.

58.2.5 The burner is to be fired until steady-state combustion conditions exist. Observations are to be made for each operating fire. For a modulating burner, these observations are to be made at minimum, intermediate, and maximum operating fires. The observed smoke density is to be no more than that specified in 58.1.2(d).

58.2.6 An automatically-lighted burner of the ″on″ and ″off″ type is to be fired intermittently, 10 minutes on and 10 minutes off.

58.2.7 An automatically-lighted modulating-burner is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off.

58.2.8 During the test period, daily observations and recordings are to be made of the draft on each operating fire, ignition, and combustion characteristic, combustion chamber conditions, and any abnormal performance.

58.2.9 The fuel-burning rate, draft over fire, smoke, and carbon dioxide (CO^2) on each operating fire are to be observed and recorded at the beginning of the test, following each 50 hours of operation, and at the end of the test.

58.2.10 The duration of these tests is to be that required to obtain conclusive performance data and is anticipated to be until 250 hours of ″on″ operation have been completed.

58.2.11 A supplemental operation test shall be conducted on a burner intended for use with the standard grade of fuel oil marked on the appliance. The duration of this test may be for less than 250 hours of ″on″ operation.

58.2.12 At the conclusion of the operation test, the combustion chamber of the appliance and the fire box lining material shall not show evidence of deterioration that would cause a risk of fire or asphyxiation due to the escape of products of combustion (such as gases) during further use of the appliance.

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59 Combustion Air Failure Test

59.1 A mechanical draft burner shall operate as specified in 59.3 or 59.4 during interruption and upon restoration of the combustion-air supply.

59.2 The initial conditions for the test are to be as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. While the burner is being fired at any operating fire, the fan supplying air for combustion is to be stopped, such as by disconnecting the fan motor only from the electrical circuit, by disconnecting any flexible coupling, or by removing any belt needed to drive the fan. Fuel to the main burner is to be shut off as specified in 59.3 or combustion, if continued, is to be as specified in 59.4.

59.3 If the main burner flame is extinguished following interruption of the air supply, the fuel is to be shut off by the inherent design of the burner or by action of a safety control within the safety control timing period specified in Table 51.1. The burner is to require manual restart to fire the burner upon restoration of the air supply or an automatically-lighted burner may restart automatically upon restoration of the air supply if the intended automatic reignition is obtained.

59.4 If combustion is continued following interruption of the air supply, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the combustion air supply is to be restored and the burner is to be reignited if the flame has been extinguished. The performance of the burner is to be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the air supply, the combustion, if maintained, is to be such that the burner flame does not produce smoke in excess of that specified in 58.1.2(d);

b) Flames are not expelled at any time from the burner or the heating appliance;

c) Combustion is complete and stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash, or ″puff″; and

e) Soot does not accumulate in the appliance or in the flue pipe to the extent that stable combustion cannot be obtained.

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60 Interruption of Atomization Test

60.1 A burner using air, steam, or a mechanical device for atomizing fuel shall be constructed to shut off the delivery of fuel for combustion upon interruption of the atomizing means or stopping operation of the mechanical device.

60.2 The initial conditions for the test are to be as described in the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. While the burner is being fired at any operating fire, the atomizing means or operation of the mechanical device is to be interrupted, such as by disconnecting from the electrical circuit only the motor driving a device providing the atomizing means, by disconnecting any flexible coupling or removing any belt needed to drive such device, or by stopping the flow of the atomizing means provided by a source other than the burner. Fuel to the main burner flame is to be shut off by the inherent design of the burner or by action of a safety control within the safety control timing period specified in Table 51.1. The burner is to require manual restart upon restoration of the atomizing means or an automatic restart upon restoration of the atomizing means if the intended automatic reignition is obtained.

61 Undervoltage Operation Test

61.1 A burner shall operate as specified in 61.2 when tested at an undervoltage as specified in Table 24.1.

61.2 The initial conditions for test are to be as described in the combustion tests described in Section 58 Combustion Tests – Mechanical-Atomizing Burners, except that the test voltage shall be regulated to maintain the appropriate undervoltage specified in Table 24.1. The test may be conducted during the course of the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. The performance of the burner at each test voltage shall be such that:

a) Ignition of the main burner flame is effected without backfire, flash, or ″puff″;

b) Flames are not expelled from the burner or the heating appliance being fired for the test;

c) Combustion is complete and stable at all times during the test;

d) Flames at all allowable firing rates do not produce smoke in excess of that specified in 58.1.2(d); and

e) The burner is capable of operation without interruption.

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62 Power Interruption Test

62.1 A burner shall operate in accordance with the requirements specified in 62.3 or 62.4 during interruption and upon restoration of the power supply.

62.2 The initial conditions for test are to be as described in the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. While the burner is being fired at any operating fire, the power supply is to be interrupted. The power is then to be restored after being interrupted for any period of time. Fuel to the main burner is to be shut off immediately as specified in 62.3, or combustion, if continued, is to be as specified in 62.4.

62.3 If the main burner flame is extinguished immediately following interruption of the power supply, the oil shall be automatically shut off by the inherent design of the burner or by action of a safety control. The burner is to require manual restart to fire the burner upon restoration of the power supply, or an automatically-lighted burner may restart automatically upon restoration of the power supply if the intended automatic reignition is obtained.

62.4 If combustion is continued following interruption of the power supply, the burner is to be allowed to function as it will for at least 48 hours. At the end of that period, the power supply is to be restored and the burner is to be ignited if the flame has been extinguished. The performance of the burner shall be such that:

a) During that portion of the test period beginning 3 hours immediately following interruption of the power supply, the combustion, if maintained, is to be such that the burner flame does not produce smoke in excess of that specified in 58.1.2(d);

b) Flames are not expelled at any time from the burner or the heating appliance;

c) Combustion is complete and stable at all times during the test;

d) The reignition of the main burner flame is effected completely and without backfire, flash, or ″puff″; and

e) Soot does not accumulate in the appliance or in the flue pipe to the extent that stable combustion cannot be obtained.

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63 Continuous Operation Temperature Test

63.1 The maximum temperature rise attained by burner parts shall be no more than the temperature rise indicated for such parts in Column 1 of Table 26.1, while the burner is fired continuously at any rate of firing specified for the test described in Section 58 Combustion Tests – Mechanical-Atomizing Burners, or during the period immediately following termination of such firing. Also, the maximum temperature on any handle that the operator may need to touch to regulate or shut off the burner shall exceed room temperature by no more than 60°F (33°C) for metallic parts and by no more than 80°F (44°C) for nonmetallic parts.

63.2 The burner, as constructed and installed for the test described in Section 58 Combustion Tests – Mechanical-Atomizing Burners, is to be fired at any test rate specified until thermal equilibrium is attained. Room temperature is to be measured at a shielded thermocouple located directly opposite and 18 inches (457 mm) in front of the center of the burner assembly. Temperatures are to be observed and recorded while the burner is firing and after the firing is discontinued.

64 Ignition Tests, Multiple Igniters

64.1 A burner provided with multiple igniters, each of which is capable of functioning independently of the others, shall be constructed so that when the burner is tested in accordance with the requirements specified in Sections 65 – 68, any one igniter will cause ignition while the other burners are inactive.

65 Ignition Tests, Electric High-Tension

65.1 Reduced voltage – cold oil

65.1.1 A high-tension ignition system for an automatically- or remotely-lighted burner shall cause the intended ignition of the fuel as introduced into the ignition zone when:

a) A voltage equivalent to 70 percent of normal test voltage is impressed on the primary circuit of the ignition system;

b) The combustion air supply and burner are at room temperature; and

c) The temperature of the oil supplied to the burner is reduced to the value specified in 65.1.2.

65.1.2 The burner, constructed and installed as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners, is to be tested after it has been subjected to the combustion tests and the test voltages are to be as indicated in 65.1.4. If an oil-temperature-regulating control is provided for a burner intended to burn preheated oil, it is to be set for the minimum temperature recommended in the manufacturer's instructions for the type or grade of fuel oil being used for the test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but a gap is to be no less than 1/8 inch (3.2 mm), if the burner is to use an ″interchangeable″ transformer.

65.1.3 The temperature of the oil as supplied to any parts of the burner, except those located downstream from a preheater, is to be 35 ±5°F (1.7 ±3°C). If the burner is equipped with a preheater, the temperature of the oil at the inlet to the preheater is to be no less than 20°F (11°C) above the pour point of the test fuel. If an oil temperature interlock is provided as specified in 53.1, it shall be set at the minimum temperature recommended for delivery of oil to the firing portion of the burner.

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65.1.4 The voltage of the power supply to the ignition system is to be regulated to 70 percent of normal test voltage and the voltage of the power supply to the primary safety control is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of normal test voltage for direct current.

Exception No. 1: If the burner is provided with a primary safety control that can be connected only for interrupted ignition, the voltage of the power supply to both the ignition system and primary safety control shall be regulated to the minimum voltage necessary to initiate a trial-for-ignition.

Exception No. 2: If the burner is provided with a primary safety control that includes an integral ignition system, the voltage of the power supply shall be regulated to the minimum voltage necessary for the control to operate, but no less than 70 percent of the normal test voltage.

65.1.5 The burner and ignition circuits are to be energized and allowed to remain energized for the trial-for-ignition period. Five trials are to be made. If the burner is to be provided with an "interchangeable" transformer, the appropriate "interchangeable" test transformer is to be applied to the burner and five additional trials for ignition are to be made.

65.1.6 During each trial, ignition is to be effected so that no flame is expelled from the burner or the heating appliance being fired for the test.

65.1.7 Following the last trial for ignition, the burner is to be fired at the high-fire rate for at least 15 minutes, during which stable combustion is to be maintained.

65.2 Combustion detectors

65.2.1 The combustion detector of a primary safety control that is capable of detecting the presence of ignition spark shall be positioned so that the combustion detector senses only the presence or absence of flame.

65.2.2 The test is to be conducted in conjunction with the combustion test described in 58.2.1 – 58.2.11. Before a test is begun, a minimum pilot condition shall be established with the safety control operating at the appropriate overvoltage as specified in Table 24.1. The minimum signal strength, current or voltage, capable of permitting the flame relay to remain energized shall be recorded. The fuel supply to the pilot, if provided, is then to be shut off and the voltage reduced to normal test voltage. Five trials are to be made to determine that ignition spark, or a reflection of the spark from any part of the burner or appliance, cannot be detected by the combustion detector at a value greater than 50 percent of the recorded signal strength capable of pulling in and holding in the flame relay.

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66 Ignition Tests, Gas Pilot

66.1 Reduced voltage

66.1.1 A pilot flame for an automatically- or remotely-lighted burner shall effect ignition of the fuel as introduced into the ignition zone as specified in 66.1.4 when the voltage of the power supply to the burner is 85 percent of rated voltage for alternating current and 80 percent of rated voltage for direct current and the temperature of the oil supplied to the burner is reduced to the value specified in 66.1.2.

66.1.2 The burner, constructed and installed as for the combustion tests described in Section 58 Combustion Tests – Mechanical-Atomizing Burners, is to be tested after it has been subjected to the combustion test. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions. The temperature of the oil supplied to any parts of the burner, except those located downstream from the preheater, is to be 35 ±5°F (1.7 ±3°C). If a burner is provided with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at room temperature.

66.1.3 The voltage of the power supply to the burner is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of rated voltage for direct current.

66.1.4 The burner is to be energized and allowed to remain energized for the intended trial-for-ignition period. Five trials are to be made. During each trial, ignition shall be effected so that no flame is expelled from the burner or heating appliance being fired for the test.

66.1.5 Following the last trial for ignition, the burner is to be fired at the high-fire rate for 15 minutes during which stable combustion is to be maintained.

66.2 Pilot supervision

66.2.1 Pilot supervision by a primary safety control shall be only at a point where the pilot flame will effectively ignite the oil at the main burner or burner group when the gas supply to the pilot is reduced so that the flame is just sufficient to actuate the primary safety control.

66.2.2 Tests to determine compliance with 66.2.1 are to be made in conjunction with the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. Initially, the trial to ignite the main burner fuel is to be made with the fuel to the pilot regulated to produce a pilot of the minimum size which can be detected by the combustion detector of the primary safety control. The pilot flame size is then to be increased in small increments to the maximum pilot size, and trials to ignite the main burner fuel are to be made with each pilot size. At least five trials to ignite the main burner fuel shall be made with the minimum pilot and with any other size pilot that could produce more severe test results.

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66.3 Flame failure response

66.3.1 A burner using steam for an atomizing means shall not provide a false indication of pilot or main flame due to the atomizing means.

66.3.2 The test is to be conducted in conjunction with the combustion tests described in Section 58 Combustion Tests – Mechanical-Atomizing Burners. Before the test is begun, the fuel supply to the pilot is to be regulated to provide the minimum pilot flame required to actuate the primary safety control. During the initial start up, the main manual fuel shutoff valve is to be closed and after the pilot flame is supervised, the pilot fuel supply is to be shut off by the manual valve. The primary safety control shall actuate to de-energize the pilot safety valve.

66.3.3 As a continuation of this test and provided that the safety control responded to shut off the pilot safety valve, the burner assembly is to be operated at the high-fire rate for at least 15 minutes after which time the fuel to the main burner is to be shut off by the action of a manual valve. The primary safety control shall actuate to de-energize the main fuel safety valve.

66.4 Stability

66.4.1 A continuous or intermittent pilot flame shall not be extinguished unintentionally when the main burner or burners are turned on or off in the intended manner, either manually or by automatic controls.

66.4.2 Observations are to be made in conjunction with the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners.

67 Ignition Test, Gas-Electric System

67.1 A burner provided with a gas-electric ignition system shall not ignite when a trial-for-ignition is made with no gas available, with the combustion air supplied at room temperature, and with the oil at the intended operating temperature.

Exception: A burner provided with a proved pilot or a control that prevents a trial-for-ignition when no gas is available need not comply with this requirement.

67.2 The burner is to be constructed and installed as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions. The oil supplied to any parts of the burner, except those located downstream from a preheater, is to be at room temperature. If a burner is provided with a preheater, the temperature of the oil at the outlet of a preheater is to be the maximum recommended in the manufacturer's instructions for the grade of fuel being used for the test.

67.3 The voltage of the power supply to the burner is to be regulated to 110 percent of normal test voltage. The gas supply to the ignition system is to be shut off. The burner is to be energized and allowed to remain energized for the intended trial-for-ignition period. Five trials are to be made and there is to be no ignition of oil.

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68 Ignition Tests, Gas-Electric High-Tension System

68.1 Reduced voltage – cold oil

68.1.1 A gas-electric high-tension ignition system for an automatically- or remotely-lighted burner shall ignite the pilot immediately upon admission of pilot gas with a voltage equivalent to 70 percent of normal test voltage in the primary circuit of the ignition system. The pilot shall effect ignition of the oil fuel as introduced into the ignition zone when the combustion air is supplied at room temperature and the temperature of the oil supplied to the burner is reduced to the value specified in 68.1.2.

68.1.2 The burner, constructed and installed as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners, is to be tested after it has been subjected to the combustion test, except that the test voltage is to be as indicated in 68.1.3. The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of fuel oil being used for the test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but a gap is to be no less than 1/16 inch (1.6 mm). The temperature of the oil as supplied to any parts of the burner, except those located downstream from a preheater, is to be 35 ±5°F (1.7 ±3°C). If a burner is provided with an oil preheater, the temperature of the oil at the inlet to the preheater is to be no less than 20°F (11°C) above the pour point of the test fuel.

68.1.3 The voltage of the power supply to the ignition system is to be regulated to 70 percent of rated voltage, and the voltage of the power supply to the safety control circuits is to be regulated to 85 percent of normal test voltage for alternating current and 80 percent of rated voltage for direct current.

68.2 Dielectric voltage-withstand – burner

68.2.1 The ignition system shall be capable of withstanding for 1 minute, without breakdown, the application of a 60 hertz potential of:

a) 150 percent of the maximum voltage to ground between high-tension live parts and noncurrent-carrying parts; and

b) 150 percent of the maximum voltage between live parts of opposite polarity.

68.2.2 To determine if an appliance complies with 68.2.1, the ignition transformer shall be disconnected. An arc occurring during the test at a location adjacent to the electrode tips that will result in effective ignition shall not be considered a failure.

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68.3 Dielectric voltage-withstand – electrode insulators

68.3.1 An insulator shall successfully withstand for 1 minute without breakdown, through the wall of the insulator, a 60 hertz potential of three times the maximum open-circuit voltage to ground of the ignition transformer provided with the oil burner.

68.3.2 The test to determine compliance with 68.3.1 shall be conducted immediately after the insulator has been conditioned for 24 hours in air having a relative humidity of 85 ±5 percent at a temperature of 90 ±3°F (32 ±2°C).

69 Ignition Test, Multiple-Atomizer Burner

69.1 An automatically-lighted atomizing burner provided with multiple atomizers, jets, or nozzles shall be constructed so that, when tested in accordance with 69.2 and 69.3, the atomized oil delivered for combustion by each atomizer will be ignited by the flame at each other atomizer. No incomplete ignition or combustion is to be obtained when the fuel delivered by any one or more atomizers is interrupted during an ignition or firing cycle.

69.2 The burner is to be constructed and installed as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. If more than one igniter is provided, all but one igniter is to be deactivated unless all igniters become ineffective when one is deactivated. The burner is to be energized to fire in accordance with its intended sequence of operation. Five trials-for-ignition are to be made. If more than one igniter capable of functioning independently of the others is provided, the test is to be repeated with each additional igniter in turn activated while all others are deactivated. During each trial, ignition of the fuel as introduced into the ignition zone by each atomizer is to be effected as intended, no flame is to be expelled from the burner or the heating appliance being fired for the test, and stable combustion is to be maintained.

69.3 As a continuation of the test described in 69.2, the burner is to be shut off and all igniters activated. One atomizer is to be prevented from delivering fuel for combustion. The burner is to be energized to fire in accordance with its intended sequence of operation. Five trials-for-ignition are to be made. The test is to be repeated with each other atomizer being blocked one at a time and with two or more atomizers blocked at one time until all combinations, including one or more blocked atomizers, are tested. No ignition of the oil as introduced into the ignition or combustion zone is to be considered acceptable if the burner is shut off by its safety control within the intended period. If any ignition occurs, such ignition is to be effected as intended, no flame is to be expelled from the burner or the heating appliance being fired for the test, and stable combustion is to be obtained.

69.4 During this test, multiple burners with more than one igniter capable of functioning independently are to light as intended when all but one igniter is deactivated. The automatically-lighted multiple burner delivering fuel through more than one nozzle is to be provided with an igniter capable of providing the intended ignition and combustion when the nozzle of one burner adjacent to the igniter is plugged and with the initial plugged nozzle relieved and any other one nozzle plugged. The other nozzle is to ignite as intended.

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70 Abnormal Operation Test – Oil Heating

70.1 The test is to be conducted on a burner provided with an oil heating system that relies upon the position of a manual selector switch to energize the heating system when waste oil fuel is fired.

70.2 The burner is to be constructed and installed as for the combustion tests described in Section 58, Combustion Tests – Mechanical-Atomizing Burners. The test is to be conducted:

a) With the burner constructed for firing the unheated standard grade of fuel oil marked on the appliance and with the oil heating system energized; and

b) With the burner constructed for firing waste oil fuel and with the oil heating system not energized. Observations are to be made of each firing condition.

70.3 There shall be no evidence of unsafe operation, such as continued on-off ignition of the fuel or pulsation during firing. Failure of the fuel to ignite and automatic shutoff of the fuel by the burner primary safety control are considered to be acceptable results.

PART III - BOILERS, FURNACES, AND HEATERS

CONSTRUCTION

71 Assembly

71.1 In addition to the requirements specified in Sections 1 – 36, a boiler assembly shall comply with the Construction requirements of the Standard for Oil-Fired Boiler Assemblies, UL 726, applicable to the following types:

a) High pressure steam boiler,

b) High temperature water boiler,

c) Hot water boiler, and

d) Low pressure steam boiler.

71.2 In addition to the requirements specified in Sections 1 – 36, a furnace or a heater shall comply with the requirements specified in Sections 71 – 109.

71.3 A furnace or a heater shall be factory-built as a group assembly and shall include all the essential components necessary for its intended function when installed as intended. A furnace or heater may be shipped as two or more major subassemblies.

71.4 A furnace or heater, if not assembled by the manufacturer as a unit, shall be constructed in major subassemblies. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting or drilling (except to the extent indicated in 71.6), threading, welding, or similar tasks by the installer. Two or more subassemblies that must bear a definite relationship to each other for the intended installation or operation of the furnace shall be constructed so that when installed in the complete assembly, there is only one relationship of the assemblies that does not require alteration or alignment. Subassemblies that do not comply with this requirement shall be assembled, tested, and shipped from the factory as one assembly.

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71.5 With regard to 71.4, major subassemblies of a furnace or heater are considered to be:

a) The burner;

b) The heat exchanger, including its base, combustion chamber, casing, and safety controls;

c) The blower assembly, including the base, filters, and casing; and

d) The blower motor if not included as part of the blower assembly. A wiring harness may be packaged with one of the major subassemblies.

71.6 Cutting or drilling that is required:

a) For the attachment of a return or supply plenum or an optional filter rack; or

b) To cut a return air opening in a furnace casing;

is considered to comply with 71.4.

If a return air opening is to be cut in the casing panel by the installer, suitable instructions and a template shall be provided with the furnace or the corners of the opening shall be embossed in knock-out form.

71.7 A radiation shield or baffle provided to prevent temperatures in excess of those intended shall be:

a) Assembled as part of a furnace or heater, or be part of a subassembly that must be attached to the unit for its intended operation; or

b) Constructed so that the unit cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

71.8 The construction of a furnace or heater shall be such that, for any intended installation, the alteration or removal of a baffle, insulation, or a radiation shield provided to reduce the risk of temperatures that may result in a risk of fire, electric shock, or injury to persons, is not required.

71.9 A horizontal furnace and a unit heater intended for suspended installation shall be provided with brackets or hangers to support the furnace from its basic frame or structure.

71.10 Parts of a furnace or heater that require attention or manipulation by the user during intended use shall be accessible to the user for convenient operation.

71.11 Adjustable or moveable parts shall be provided with locking devices to reduce the risk of unintentional shifting.

71.12 Screws or bolts used to attach parts that are detached for maintenance or servicing of the appliance shall not be loosened by the application of the torques indicated in Table 71.1 after removal and replacement.

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Table 71.1
Maximum torque requirements for screw or bolts

American standard screw size		Torque		I.S.O. screw size	Torque	
No.	mm	Lb-In	N·m	mm	N·m	Lb-In
–	–	–	–	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
				6	8.7	77
Inch	mm			7	15.0	133
				8	23.5	208
1/4	6.4	100	11.3	9	33.6	297
5/16	7.9	200	22.6	10	45.2	400
3/86	9.5	350	39.6	12	81.0	715
7/16	11.1	575	65.0	14	128.0	1130
1/2	12.7	850	96.0	16	185.0	1640
9/16	14.3	1200	136.0			
5/8	15.9	1600	181.0			

71.13 Any external door shall be self-closing if the door provides access into the combustion chamber of a furnace or a heater intended for installation with a clearance of less than 24 inches (610 mm) from the face of the door or 48 inches (1.22 m) above the door.

71.14 A furnace intended for installation in the cooled-air path, downstream from a cooling coil, shall comply with the following:

a) All interior surfaces of the heat exchanger, the combustion chamber (including its bottom), radiators, and flues shall be resistant to corrosion by moisture;

b) The firebox liner shall resist deterioration from being wetted by condensation;

c) Condensation shall not drip on burner parts or other parts subject to corrosion if corrosion of any such parts may cause operation that results in a risk of fire, electric shock, or injury to persons; and

d) The heat exchanger and appliance flue shall contain no traps or pockets in which condensation may collect.

71.15 A burner shall be secured so that it will not twist, slide, or drop out of position.

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72 Accessibility for Servicing

72.1 A furnace or a heater shall be provided with means of access for cleaning parts such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers, without major dismantling of the unit or removing of parts required to be factory-assembled.

72.2 The removal of access panels, burners, blowers, caps, plugs, and the like for servicing and the detachment of the chimney connector are not considered as major dismantling of the unit as specified in 72.1.

72.3 Accessibility shall be provided for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the furnace or heater is installed as intended by the manufacturer. The disposition of parts in the assembly removed for servicing shall be such that their restoration, following removal, will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special facilities required for servicing to be performed by the operator shall be provided with the furnace or heater and shall be attached to or placed near the furnace or heater at the time of installation as specified in the instructions.

73 Disposal of Combustion Products

73.1 The construction of a furnace or a heater shall not enable the products of combustion to become mixed with the circulating air.

74 Base

74.1 The base of a furnace shall be constructed of metal or other nonflammable material to provide support for the furnace. The assembly shall be constructed so that there will be no open passages in the floor through which flame or hot gases from a fire originating in the space below the floor can travel to the room above when the furnace is installed as intended.

74.2 A sub-base, if provided as a separate assembly of a furnace, shall be assembled for attachment to the furnace in the intended position only and in a manner that will establish and maintain correctly the position of the furnace with respect to the sub-base.

74.3 The base and sub-base of a downflow furnace intended for installation on combustible flooring material shall establish and maintain no less than the required clearance between the floor construction and vertical surfaces of the plenum or duct to be attached to the base or sub-base. A spacer shall extend at least 3 inches (76.2 mm) below the upper surface of the floor on which the furnace is to be installed. An acceptable base construction is shown in Figure 74.1.

74.4 Spacers in the form of separate blocks or shims, as shown in Figure 74.2, shall not be provided as a base as specified in 74.3.

74.5 The base of a floor-mounted unit heater shall be constructed of metal or other nonflammable material to provide support for the heater.

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Figure 74.1
Acceptable base construction for downflow furnace

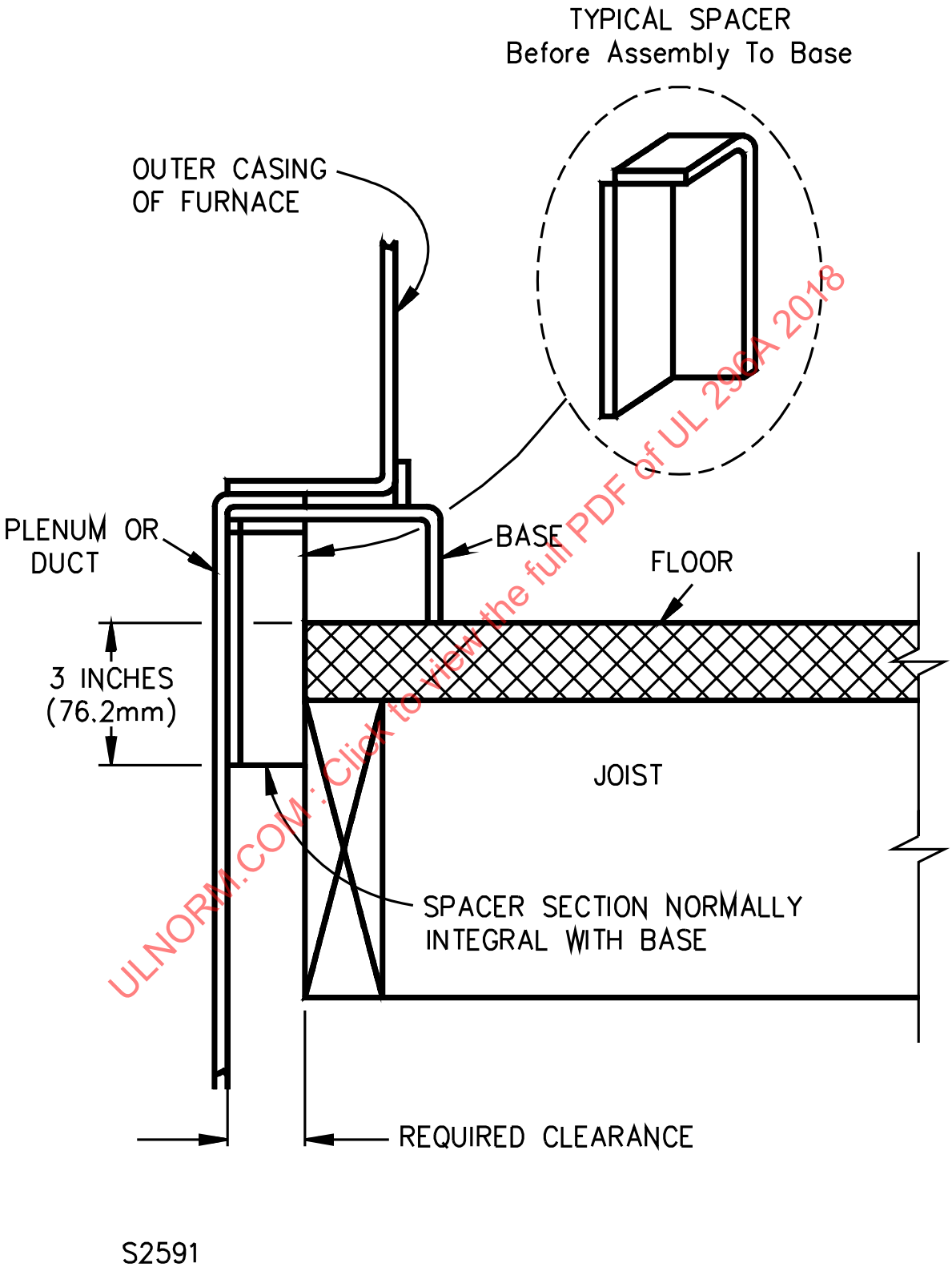

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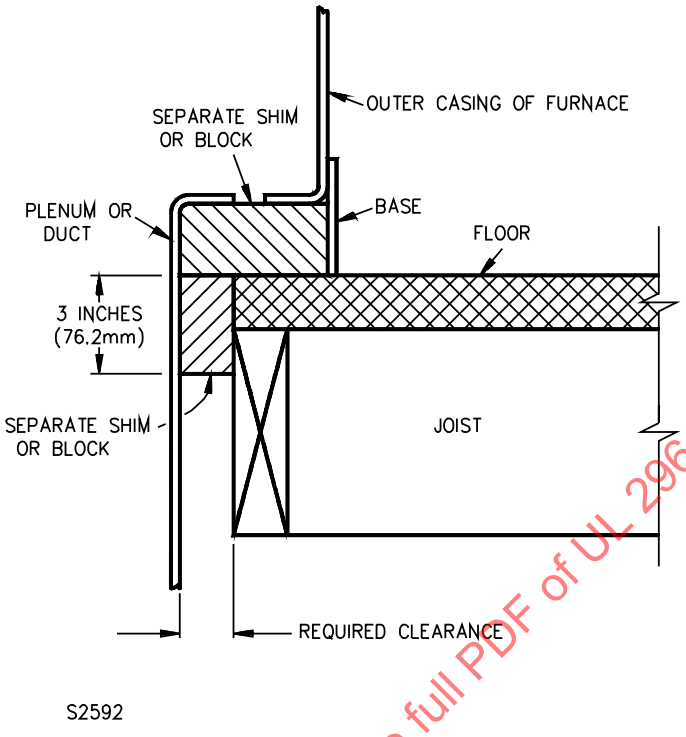
Figure 74.2
Unacceptable base construction for downflow furnace



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75 Casing

75.1 An outer casing or jacket shall be made of steel or equivalent material and shall be braced, reinforced, or formed to reduce the risk of damage from handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) if uncoated or 0.023 inch (0.58 mm) if galvanized, or of nonferrous sheet metal having an average thickness of no less than 0.029 inch (0.74 mm).

75.2 Access panels that may be removed for servicing and accessibility shall be constructed to permit removal and replacement repeatedly without causing damage or impairing any required insulating properties.

75.3 A removable panel through which air is drawn for combustion shall be constructed so as to prevent the panel from being attached in a manner that may affect the intended performance of the furnace or heater.

75.4 A removable panel shall be constructed so that the panel will not be interchangeable with other panels on the same furnace or heater if interchange may affect the intended operation of the unit.

75.5 The casing of a furnace or a floor-mounted unit heater intended for installation on combustible flooring material shall completely close the bottom or shall be constructed to provide an effective radiation barrier between the heat exchanger and the floor.

Exception: An opening in the casing of a furnace or a floor-mounted unit heater intended to be permanently connected to a circulating-air distribution duct may be provided.

75.6 The casing of a forced-air type furnace shall have no uncovered openings connecting to the circulating air compartments unless such openings are intended to be permanently connected to a circulating air distribution duct.

75.7 A furnace or a heater shall be constructed so that a negative pressure created by an air-circulating fan will not affect the combustion air supply or draw products of combustion into the circulating air.

75.8 A connection between the heat exchanger and the casing which encloses circulating air shall be constructed to prevent leakage of combustion products into the circulating air.

75.9 An access opening to a return-air compartment of a furnace shall be completely covered.

75.10 A furnace shall provide for the attachment of warm-air outlet and cold-air return ducts.

Exception: A furnace intended for an installation that does not include outlet or return air ducts may be tested for such restricted use.

75.11 An integral plenum of a furnace intended for alcove or closet installation shall have no more than one outlet-air opening unless each additional opening is provided with means supplied at the factory to close the openings in the casing and any insulation or liner.

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76 Radiation Shields or Liners

76.1 A radiation shield or liner shall be constructed, formed, and supported to provide for the intended positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may result in excessive temperatures when the furnace or heater is tested as described in Sections 86 – 109, as applicable. A finish that provides the required resistance to corrosion shall not be damaged by heat when the unit is tested under these requirements.

77 Materials in Air Handling Compartments

77.1 Materials in a compartment handling air for circulation through a duct system shall have a flame spread rating not exceeding 25 and shall have a smoke developed rating not exceeding 50 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723.

Exception: The following parts need not comply with this requirement:

a) Air filters, drive belts, wire insulation, and paint provided for corrosion protection;

b) Gaskets forming air or water seals between metal parts;

c) Miscellaneous small parts such as resilient or vibration mounts, wire ties, clamps, labels, and the like;

d) An adhesive that, when tested in combination with the specific insulating material, complies with this requirement; and

e) Molded or formed components made of polymeric materials, not including liners, in which the total surface area of such materials in the compartment does not exceed 10 square feet (0.93 m^2). These materials shall comply with the flame spread rating and flammability test requirements specified in 77.7.

77.2 The supporting surface to be used in the surface burning characteristics test of adhesives is to be of asbestos-cement board or metal. Other materials requiring support may be supported using metal rods or bars or 2-inch (50.8-mm) hexagonal mesh-wire with metal bars or rods.

77.3 Exposed unimpregnated asbestos material shall not be used in an air-handling compartment. The unprotected edge of a gasket fitted between two parts is considered to be exposed.

77.4 Thermal or acoustic insulating material shall be secured in position if loosening:

a) May reduce or block air flow resulting in temperatures in excess of those acceptable in the temperature tests; or

b) Will result in reduction of electrical spacings below the required values, short-circuiting, or grounding.

Leading edges of insulation shall be protected against damage from the effects of the velocity of moving air.

77.5 Mechanical fasteners for securing the insulating liner in position shall be used for each square foot (0.09 m^2) unless the liner is retained in position under all test conditions by fewer fasteners because of its inherent rigidity. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads provides protection for leading edges against damage from the effects of the velocity of moving air.

77.6 An adhesive required for securing insulation shall retain its adhesive qualities:

a) At any temperature attained by the adhesive when the unit is tested under the performance requirements specified in Sections 86 – 109; and

b) At 0°F (minus 17.8°C) or minus 20°F (minus 28.9°C) for outdoor-use equipment.

77.7 The polymeric materials specified in 77.1(e) shall have a flame spread rating not exceeding 25 or shall comply with the flammability test requirements specified in 77.8 – 77.12.

77.8 Samples shall consist of at least three of each part, or sections of each part, and shall be 5 by 1/2 inches (127 by 12.7 mm) or as large as is practical to test. Sections shall include the thinnest portions of the parts.

77.9 The test flame shall be obtained by means of a Tirrill or Bunsen laboratory type burner having a nominal tube diameter of 3/8 inch (9.5 mm) and a length above the primary air inlets of approximately 4 inches (102 mm). The flame is to be adjusted to an overall height of 5 inches (127 mm) with an inner blue cone of 1-1/2 inches (38.1 mm). The area in which the test is to be conducted shall be shielded from drafts.

77.10 The part or section is to be located with the major axis of the sample area vertical, exposing thin sections to the maximum sweep of flame if practical. The test flame is to be applied to a lower edge of the specimen with the flame 20 degrees from the vertical. The flame is to be applied for 5 seconds and removed for 5 seconds until five such cycles of exposure have been completed. The specimen shall not continue to burn for more than 1 minute following the last exposure to the flame nor shall any material fall from the specimen during the test. Complete destruction of the sample shall not be an acceptable test result.

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77.11 A set of identical samples is to be aged in a full-draft, circulating air oven at the aging temperature and time determined by the intended use of the finished part as indicated in Table 77.1.

Table 77.1
Aging temperature and time

Maximum intended operating temperature,		Aging temperature,		Aging time, days
°C	(°F)[a]	°C	(°F)	
50	(122)	75	(167)	60
75	(167)	100	(212)	60
100	(212)	121	(250)	60

[a] If the intended operating temperature is between two values shown in this table, the higher of these two values is used in determining the aging conditions.

77.12 Samples shall be removed from the oven at the end of 60 days of exposure and subjected to the flammability test described in 77.9 and 77.10. The samples shall not show weakening, embrittlement, or other evidence of deterioration and shall comply with the requirements of the flammability test.

78 Air Filters

78.1 An air filter, if provided as a part of a furnace or heater, shall be accessible for inspection or replacement without the use of special tools and without dismantling the unit.

79 Combustion Chamber

79.1 A combustion chamber and flueway within the air handling compartment shall be constructed of cast iron, sheet steel, or equivalent material. Sheet steel, if used, shall provide the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a minimum thickness of 0.042 inch (1.07 mm).

79.2 A combustion chamber (firebox) lining material, if used, shall be secured in place and shall be accessible for replacement with an equivalent type of lining material.

80 Radiators

80.1 A radiator shall be made of material no lighter than that specified for a combustion chamber in 79.1 and shall be accessible for cleaning.

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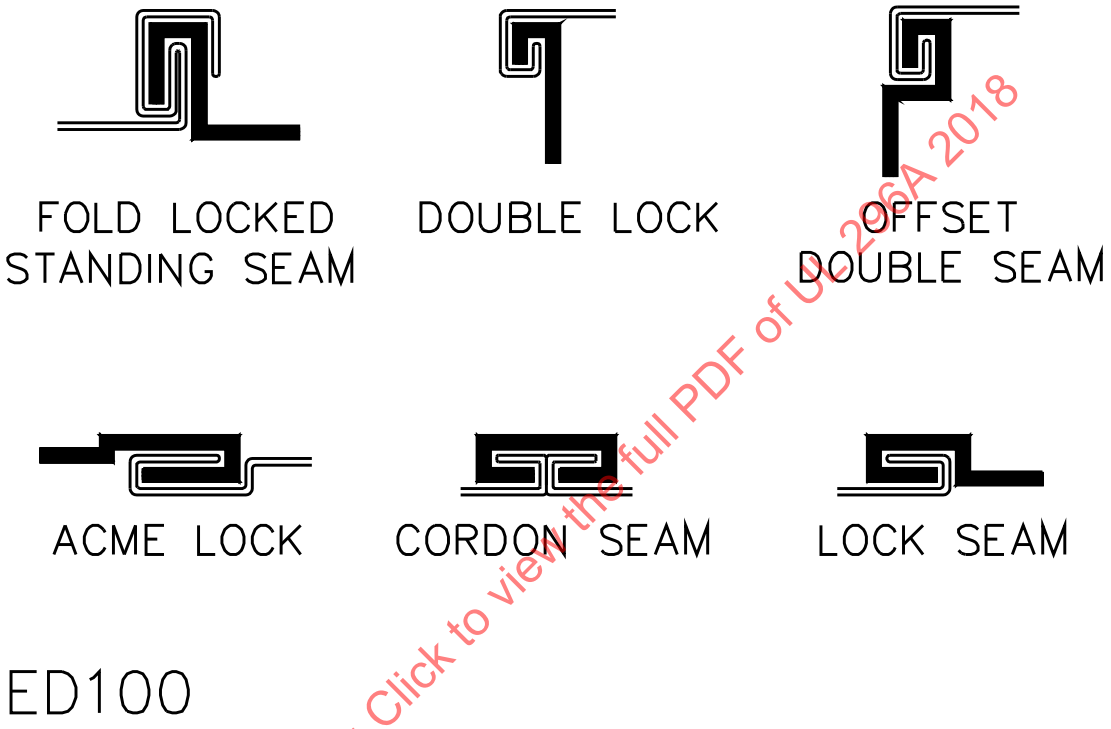
81 Heating Surface Joints

81.1 Joints in heating surfaces shall be welded, locked-seamed, machined and bolted, or riveted. The tightness of a joint shall be equivalent to that provided by a lock-seam, as shown in Figure 81.1, and shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

Figure 81.1
Types of acceptable lock-seams



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82 Baffles

82.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI C1010 sheet steel having a minimum thickness of 0.042 inch (1.07 mm) unless its deterioration will not result in excessive temperatures when the furnace or heater is tested as specified in Sections 86 – 109. A furnace or heater provided with a baffle that may deteriorate shall be tested both with and without the baffle installed.

82.2 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall facilitate its removal and shall permit replacement only in its intended position.

83 Flue Collars

83.1 A flue collar shall be constructed and located to permit the attachment of the chimney connector.

83.2 A flue collar, flue collector parts, or extensions exterior to the air handling compartment shall have rigidity, heat, and corrosion resistance at least equivalent to that of sheet steel having a thickness of no less than 0.016 inches (0.41 mm).

83.3 A flue collar or flue collector parts within the air handling compartment shall have rigidity, heat, and corrosion resistance at least equivalent to that of sheet steel having a thickness of no less than 0.042 inches (1.07 mm).

84 Dampers and Draft Regulators

84.1 An adjustable damper shall be provided with minimum and maximum operating stops. The minimum operating stop for an adjustable damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

84.2 An automatically operated damper shall maintain the intended damper opening at all times and shall be constructed to prevent starting of the burner unless the damper is in the intended position for starting.

84.3 A furnace or heater intended to be provided with a barometric draft regulator shall be constructed so as not to require the regulator to be installed in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

85 Controls

85.1 Application

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

Exception: A circuit within a safety control or the extension of such a circuit to a separate element of the control, such as a flame-sensing device, need not comply with this requirement.

85.1.2 A short circuit shall not render a safety control or protective device inoperative.

85.1.3 A control circuit shall be constructed so that when the furnace or heater is connected to a power-supply branch circuit, the control circuit will be protected against overcurrent at no more than the value appropriate for the rating of any control included in the circuit.

85.1.4 All safety controls shall be accessible.

85.1.5 A safety control and its sensing element shall be supported to remain in their intended positions. It shall be possible to determine by observation or test whether or not each control is in its intended position.

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85.1.6 No means shall be provided to permit any safety control to be rendered ineffective or to allow firing of the furnace without the protection of each of the required safety controls.

85.2 Limit control

85.2.1 A furnace and a heater shall be provided with a limit control to prevent excessive temperatures.

85.2.2 The maximum setting of a limit control determined by a fixed stop shall permit an outlet-air temperature of no more than the temperature specified in 90.1.

85.2.3 An automatically lighted furnace or heater shall be provided with an automatic-reset type limit control. An auxiliary limit control may be of the manual-reset type.

85.2.4 A downflow or horizontal furnace shall limit the air temperature build-up in the return air duct opening under conditions of reverse air flow as described in Section 93, Airflow Tests – Downflow and Horizontal Furnaces.

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

85.2.6 The purpose of the requirement specified in 85.2.5 is to avoid interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to prevent. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the safety circuit when it is necessary to interrupt:

a) A single-phase circuit carrying a load greater than the capacity of available limit controls; or

b) A multiphase circuit.

85.2.7 The limit control or controls for an attic, downflow, or horizontal furnace; for a furnace intended to operate with an outlet-air temperature of no more than 200°F (93°C); or for a furnace intended for alcove or closet installation shall be factory-located on the furnace or its location shall be factory-predetermined by a bracket or an equivalent means supplied as part of the furnace. The bracket or equivalent means shall be marked to identify its purpose and the assembly shall be such that omission of the bracket is evident.

85.2.8 The limit control or controls for a heater shall be factory-mounted on the heater.

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85.3 Fan control

85.3.1 A furnace and a heater shall be provided with a fan control that controls the operation of the circulating air fan so that the operation of the unit is continuous as specified in 90.2 at all settings of the fan control. The fan control shall comply with the requirements for a fan control as specified in the Standard for Limit Controls, UL 353.

PERFORMANCE – CENTRAL FURNACES

86 General

86.1 A central furnace shall comply with the applicable requirements when tested as described in Sections 87 – 98.

86.2 A floor-mounted furnace of the upflow or downflow type shall be tested for installation on noncombustible floors and with clearances to combustible walls and ceilings as indicated in Table 86.1. Such a furnace is classified under Form I or Form III, depending on its physical size as noted in Table 86.1. At the option of the manufacturer, a floor-mounted furnace may be tested for installation on combustible floors and when so tested is classified under Form Ia or Form IIIa, depending on its physical size.

Table 86.1
Standard clearances

Type of furnace	Minimum clearance, inches (mm)											
	A		B		C		D		E		F	
	Above		Front		Chimney connector		Rear		Sides		Below	
Form I	2	(51)	24	(610)	18	(457)	6	(152)	6	(152)	NC	
Form Ia	2	(51)	24	(610)	18	(457)	6	(152)	6	(152)	C	
Form IIa	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	O	(0)
Form IIb	6	(152)	24	(610)	18	(457)	6	(152)	6	(152)	6	(152)
Form III	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	NC	
Form IIIa	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	C	
Form IIIb	18	(457)	48	(1219)	18	(457)	18	(457)	18	(457)	18	(457)

C – Combustible

NC – Noncombustible

Forms I and Ia – Warm-air furnaces, upflow, or downflow types no larger than 100 cubic feet (2.8 m^3) in size (excluding blower compartments and burner).

Forms IIa and IIb – Horizontal forced warm-air furnaces no larger than 100 cubic feet in size (excluding blower compartments and burner).

Forms III and IIIa – Low-heat industrial appliances and floor-mounted types that include furnaces not classified under Forms I and Ia.

Form IIIb – Low-heat industrial appliances and suspended types that include furnaces not classified under Form IIb.

86.3 A horizontal furnace is normally tested with clearances below and to walls and ceilings as indicated in Table 86.1. Such a furnace is classified under Form IIb or Form IIIb, depending on its physical size as noted in Table 86.1. At the option of the manufacturer, a horizontal furnace normally classified under Form IIb may be tested for zero clearance below and when so tested is classified under Form IIa.

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86.4 At the option of the manufacturer, any furnace may be tested with clearances less than those indicated in Table 86.1 and shall not deliver air at a temperature in excess of 200°F (93°C) when tested as described in 90.1.

86.5 If an appliance is to be tested in a partial enclosure at less than the standard clearances specified in Table 86.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are to be no less than 9 inches (229 mm). When the chimney connector clearances are less than the standard clearances indicated in Table 86.1, the connector arrangement is to be as specified in 87.6.5 and Figure 87.8. The tests are then to be conducted as described for standard clearances.

86.6 The standard clearances indicated in Table 86.1 are based on a furnace installed in a room that is large compared to the size of the furnace. All clearances indicated in Table 86.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

87 Test Installation for Standard Clearances

87.1 Downflow and upflow furnaces enclosure

87.1.1 The furnace is to be placed in a partial enclosure in the as-received condition as described in 87.1.2 – 87.1.4. The distance from the back, sides, and top of the furnace and from the chimney connector to the walls and ceiling of the enclosure is to be as indicated in Table 86.1. A side of the furnace that may create a higher wall temperature than the other side of the furnace, is to be directly opposite one wall of the enclosure.

87.1.2 The furnace is to be level. Leveling means, if provided, are to be removed if detachable, or are to be adjusted if nondetachable, to place the base of the furnace the minimum possible distance above the floor.

87.1.3 The partial enclosure is to be formed by two walls of nominal 1-inch (25.4-mm) thick wooden boards or 3/4-inch (19.1-mm) thick plywood, set at right angles and finished in flat black as shown in Figure 87.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to provide the minimum clearance above the furnace specified in Table 86.1 and in accordance with 86.2. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the furnace. The walls are to be the minimum distance specified in Table 86.1 from the side and back of the furnace, except that when the flue outlet is horizontal, the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow as specified in 87.2.1.

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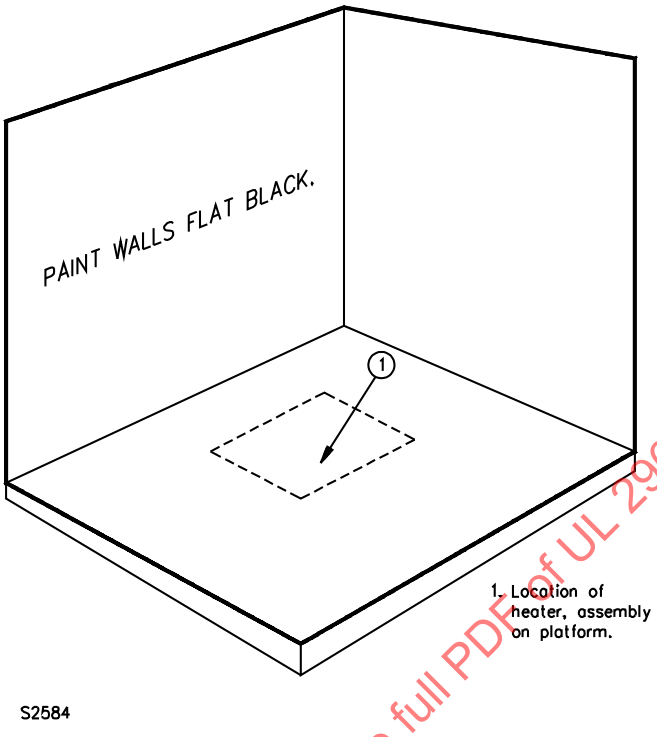
Figure 87.1
Test enclosure for standard clearances downflow and upflow furnaces



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

87.2 Chimney connector

87.2.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe no heavier than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure and be directly connected to and extended vertically from a vertical flue collar or outlet and connected to a horizontal flue collar or outlet by using a 90-degree sheet-metal elbow at the bottom of the vertical section as shown in diagrams A and B of Figure 87.2.

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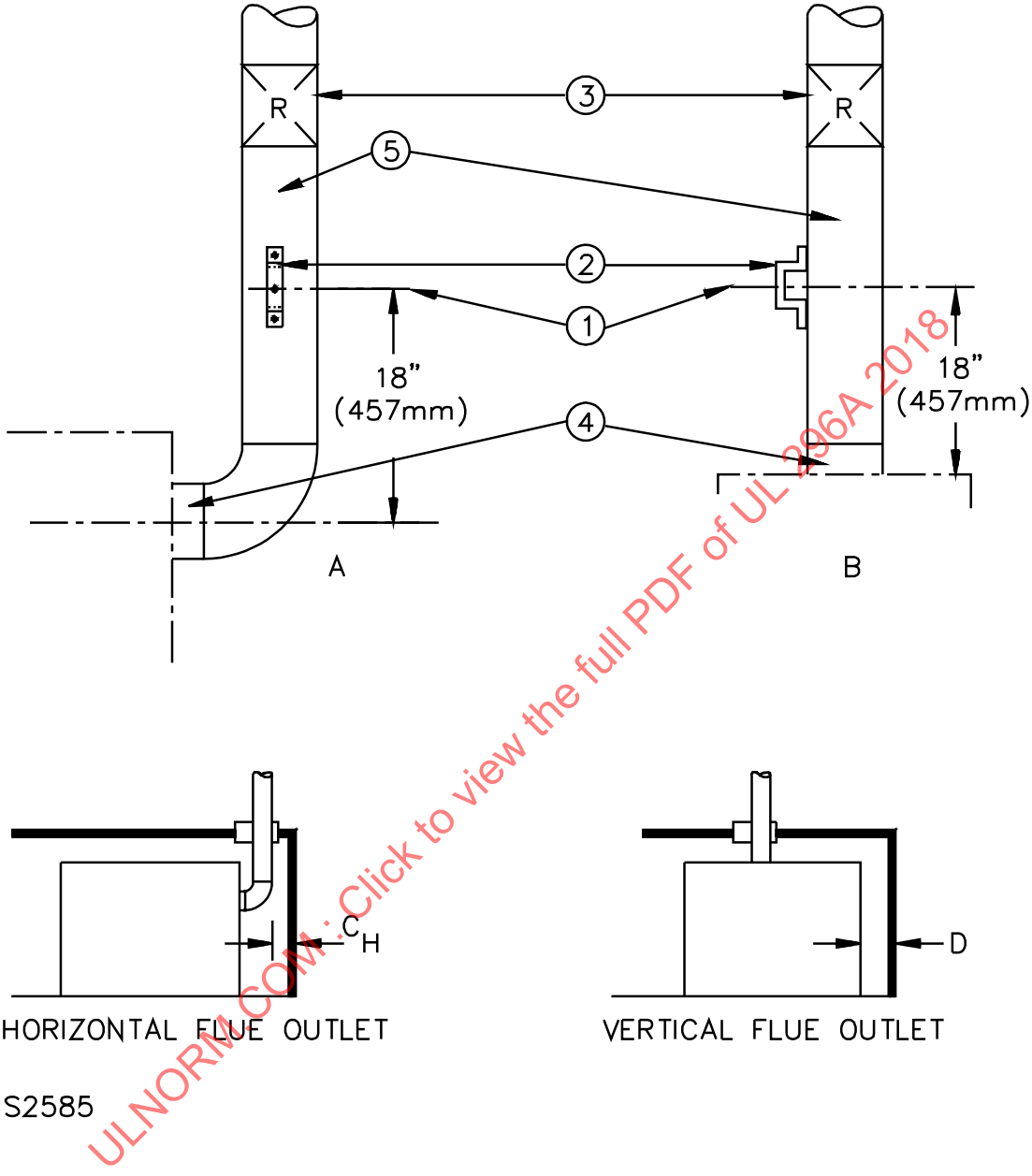
Figure 87.2
Chimney connectors – standard clearance test



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1. Centerline of thermocouple.

2. Support bracket.

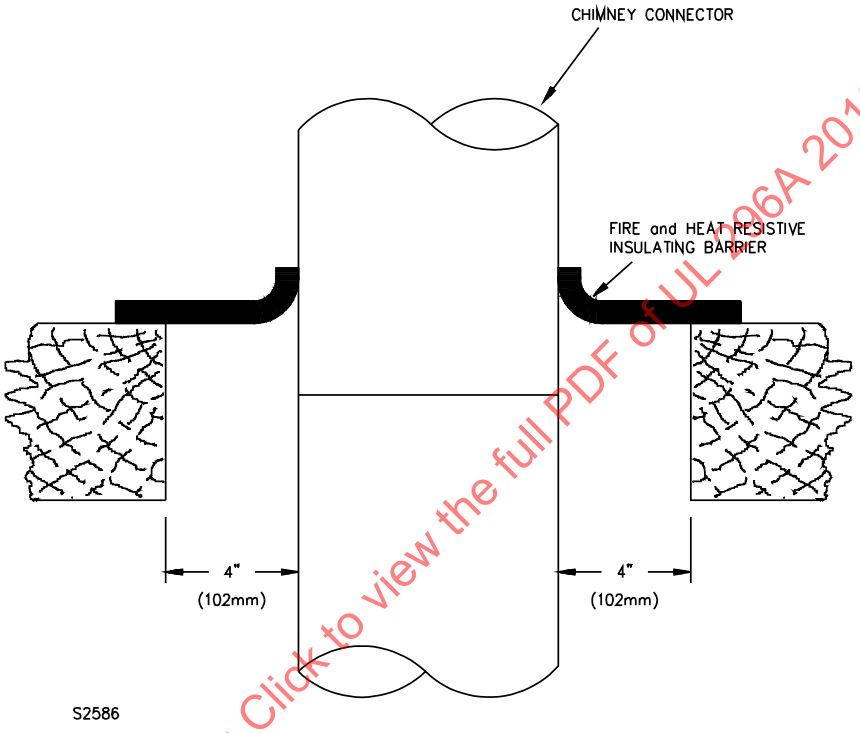
3. Draft regulator.

4. Flue collar.

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

87.2.2 Where the chimney connector pierces the enclosure, an opening having a diameter 8 inches (203 mm) larger than the diameter of the chimney connector is to be cut in the enclosure, and the resulting annulus is to be sealed on the exterior surface with a fire and heat resistive insulating barrier no less than 1/8 inch (3.2 mm) thick as shown in Figure 87.3. Temperatures on the surfaces surrounding the chimney connector are to be determined at points located no less than 2 inches (50.8 mm) from the outer edge of the annulus.

Figure 87.3
Sealing of annulus around chimney connector



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87.2.3 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown in item 2 of Figure 87.2.

87.2.4 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure as shown in item 3 of Figure 87.2.

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

87.2.6 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

87.3 Air outlet and inlet – forced air furnace

87.3.1 Unless the supply plenum is an integral part of the furnace, a metal plenum chamber or bonnet having the same dimensions as the warm-air outlet of the furnace is to be provided by the manufacturer for test purposes. For forced-air upflow furnaces, a separate plenum is to be at least 18 inches (457 mm) high but no less than that required to obtain 2 inches (50.8 mm) clearance to a ceiling located at least 7-1/2 feet (2.29 m) above the floor of the test enclosures shown in Figure 87.4. For downflow furnaces intended for installation on combustible flooring, the depth of the plenum is to provide the specified clearance between the top of the outlet duct and the lower surfaces (ceiling) of the floor structure, as shown in Figure 87.5.

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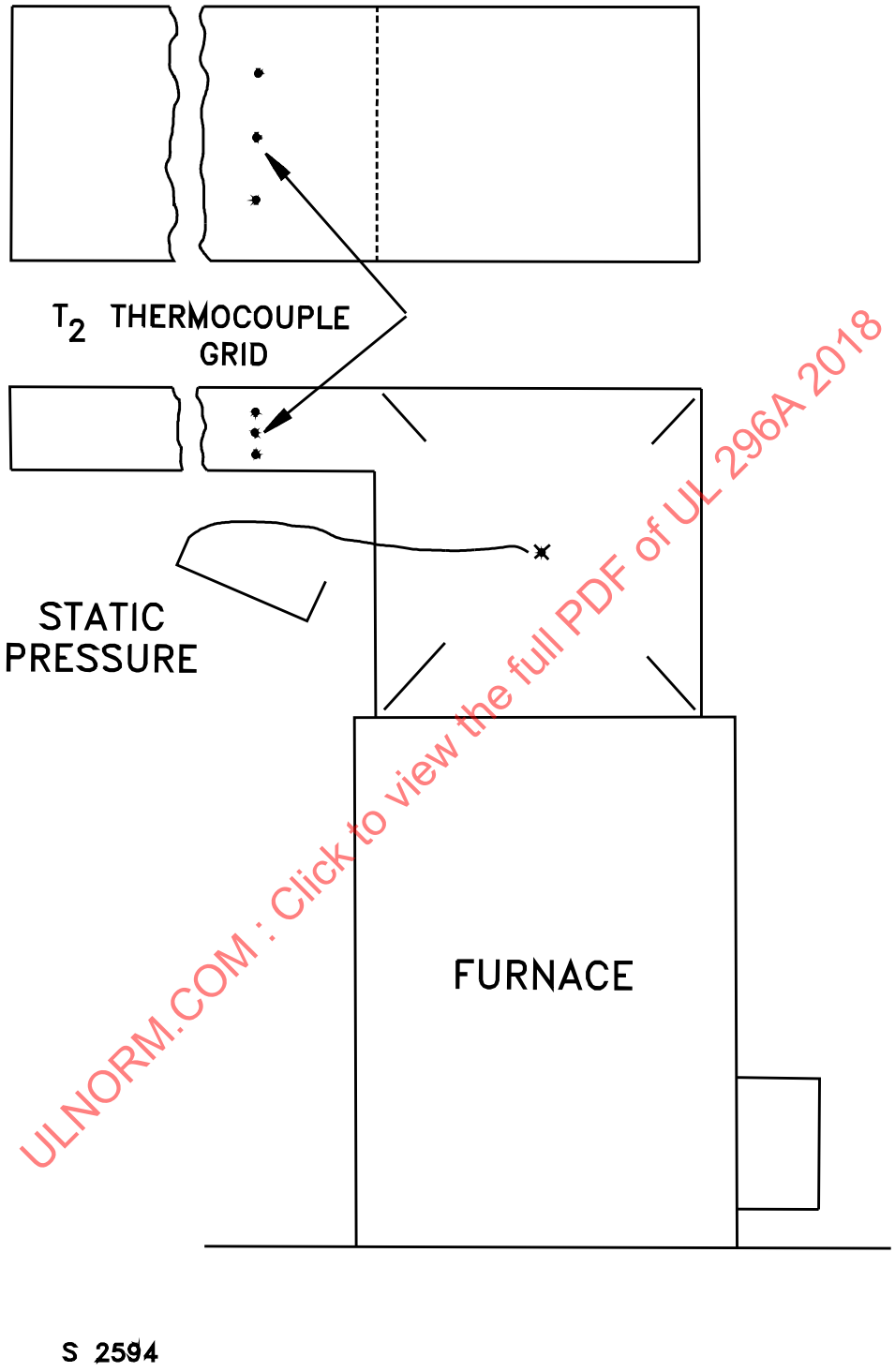
Figure 87.4
Plan of ducts for forced-air upflow furnaces



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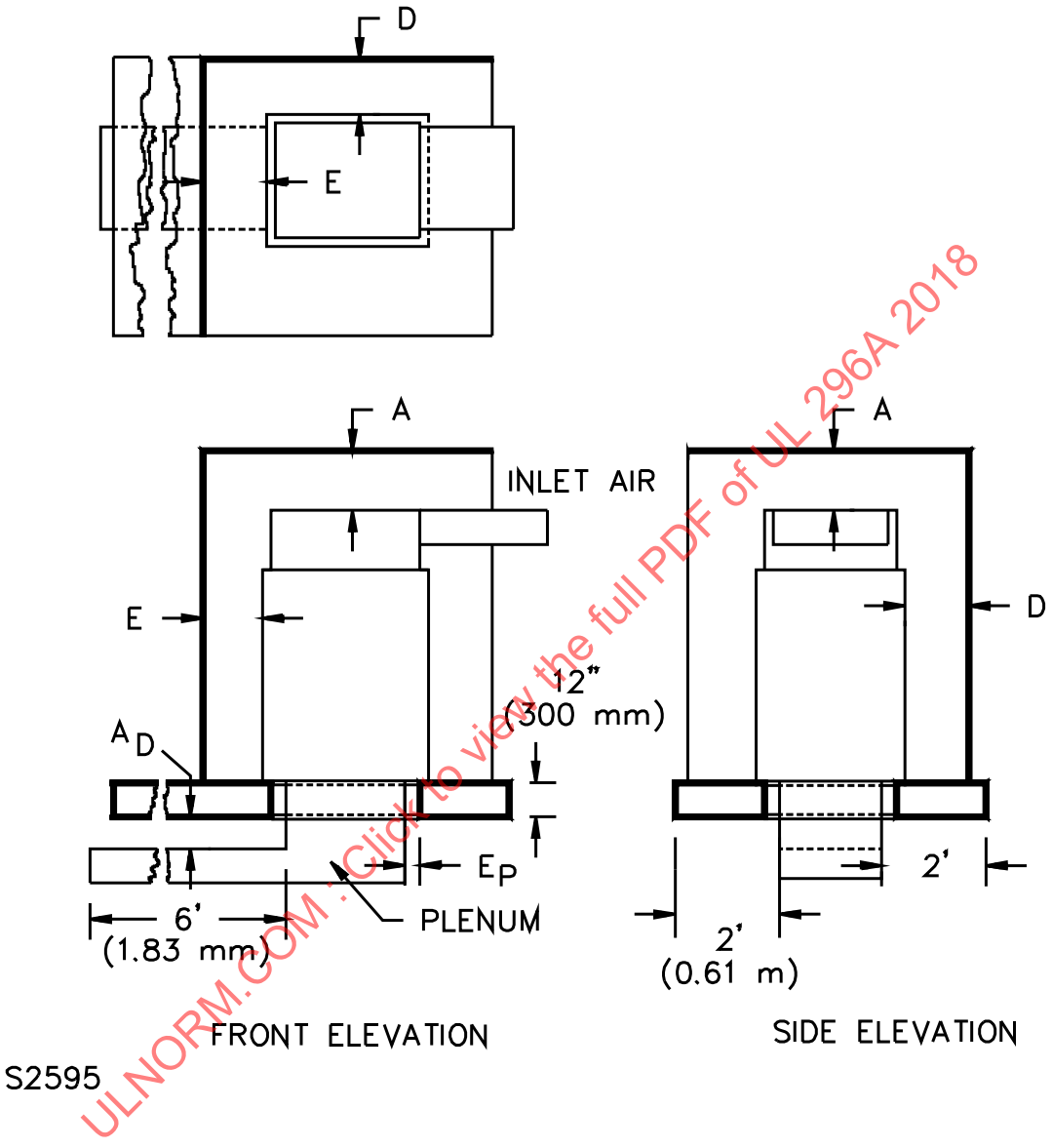
t^2 – Outlet-air temperature

Figure 87.5
Test enclosure – downflow furnace standard clearance – combustible floor



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A – From top of furnace casing.

A_D – From top of horizontal warm-air duct within 6 feet (1.83 m) of furnace.

D – From back of furnace.

E – From side of furnace.

E_P – From side of supply plenum.

87.3.2 The warm-air outlet opening is to be:

a) Extended by a duct or ducts beyond the test enclosure; and

b) Located to discharge in a direction away from the cold-air inlet of the furnace.

87.3.3 For a forced-air furnace, the size of the outlet duct is to be:

a) Calculated for a velocity of approximately 900 feet (274 m) per minute of standard air [0.075 pounds per cubic foot (1.2 kg/ with a 90°F (50°C) temperature rise through the furnace; and

b) Based on an output equivalent to 75 percent of the rated input [Btu per hour (W)] of the furnace. The specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

87.3.4 Formulas derived from the requirement specified in 87.3.3 based on the outlet duct area are as follows:

Area (in^2) = (Btu per hour input) × 0.00122

Area (cm^2) = Watts × 0.0000554

87.3.5 The test duct, as shown in Figure 87.4, is to be rectangular, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar, but the aspect ratio is not to exceed four to one.

87.3.6 A thermocouple grid, as shown in Figure 87.4, is to be located in each warm-air outlet duct in a plane within 6 inches (152 mm) downstream from the location closest to the plenum where any thermocouple will be in line of sight with any surface of the heat exchanger. The duct is to extend at least 6 inches beyond the thermocouple grid.

87.3.7 The cross-sectional area and shape of the air-inlet duct is to be equivalent to the cold-air inlet of the furnace. The inlet-air temperature is to be measured by a thermocouple, no heavier than 24 AWG (0.21 mm^2), shielded from direct radiation and centrally located 24 inches (610 mm) in front of the furnace and 24 inches above the floor of the test enclosure.

87.3.8 The limit control, if furnished separately for mounting in a field-installed plenum, is to be located as specified in the installation instructions provided with the furnace.

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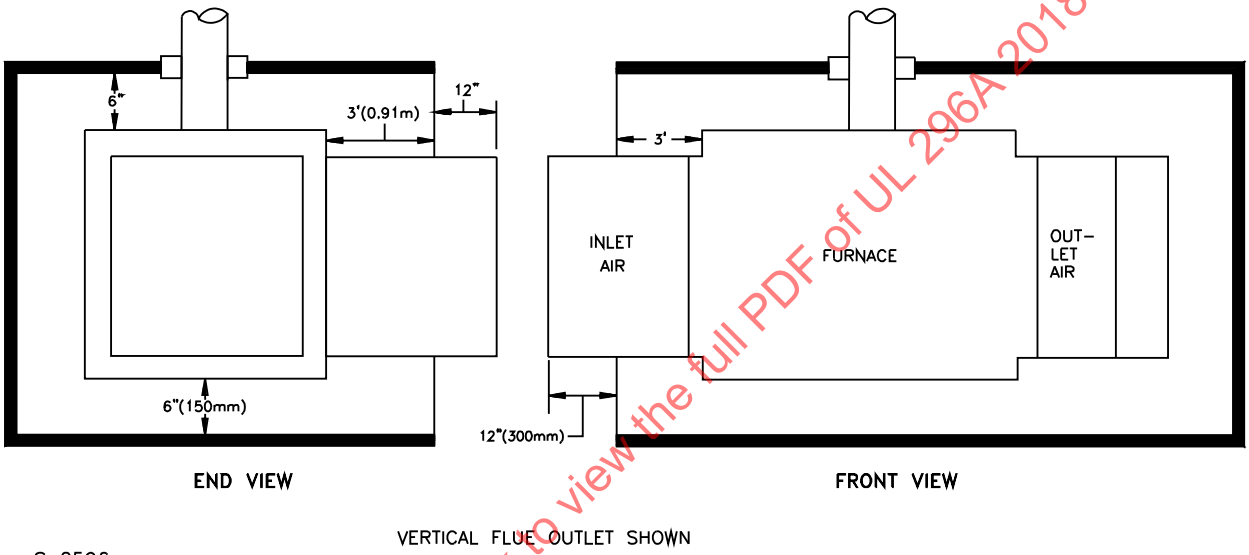
87.4 Horizontal furnace enclosure

87.4.1 A horizontal furnace is to be tested when installed in a partial enclosure constructed of nominal 1-inch (25.4-mm) thick wooden boards or 3/4-inch (19.1-mm) plywood finished in flat black, with all joints sealed, as shown in Figure 87.6. If the furnace is intended for installation on combustible flooring, the clearance beneath the furnace to the enclosure is to be zero. The walls are to be the minimum distance specified in Table 86.1 from the side and back of the furnace, except that when the flue outlet is horizontal, the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow as specified in 87.5.1.

Figure 87.6
Enclosure for horizontal furnace – standard clearances



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87.4.2 The furnace is to be level. Leveling means, if provided, are to be removed if detachable, or are to be adjusted if non-detachable, to place the base of the furnace the minimum possible distance above the floor.

87.5 Chimney connector

87.5.1 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe no heavier than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure and be directly connected to and extended vertically from a vertical flue collar or outlet and connected to a horizontal flue collar or outlet by using a 90-degree sheet-metal elbow at the bottom of the vertical section as shown in Figure 87.2.

87.5.2 Where the chimney connector pierces the ceiling, an opening having a diameter 8 inches (203 mm) larger than the diameter of the chimney connector is to be cut in the enclosure, and the resulting annulus is to be sealed on the upper surface with a fire and heat resistive insulating barrier no less than 1/8 inch (3.2 mm) thick as shown in Figure 87.3. Temperatures on surfaces surrounding the chimney connector are to be determined at points located no less than 2 inches (50.8 mm) from the outer edge of the annulus.

87.5.3 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by item 2 of Figure 87.2.

87.5.4 A draft regulator is to be provided for test purposes and located in the chimney connector outside the enclosure as shown by item 3 of Figure 87.2.

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

87.5.6 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

87.6 Air outlet and inlet

87.6.1 The cold-air inlet and warm-air outlet openings of the furnace are to be extended beyond the test enclosure by an appropriate duct or ducts. A metal plenum chamber having the same dimensions as the discharge opening of the furnace is to be provided by the manufacturer for test purposes. The plenum and the warm-air duct are to be constructed as indicated in Figure 87.7. The inlet-air duct is to have the same dimensions as the inlet opening of the furnace. The ducts are to extend at least 12 inches (305 mm) beyond the walls of the test enclosure.

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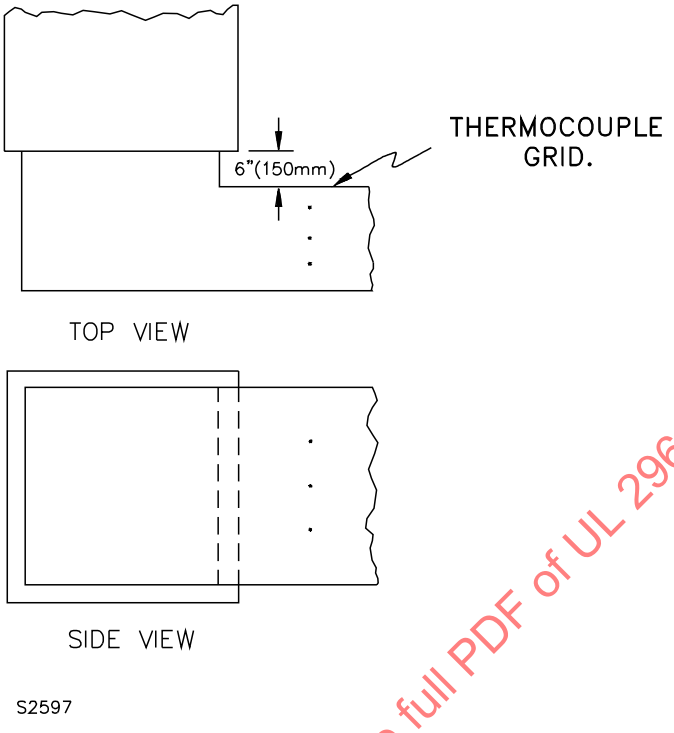
Figure 87.7
Plenum and outlet duct for horizontal furnace



87.6.2 A thermocouple grid, as shown in Figure 87.7, is to be located in the warm-air duct in a plane within 6 inches (152 mm) downstream from the position closest to the plenum where any thermocouple will be in line-of-sight of any surface of the heat exchanger. The duct is to extend at least 6 inches beyond the thermocouple grid.

87.6.3 The room temperature is to be measured by a thermocouple, no heavier than 24 AWG (0.21 mm^2), shielded from direct radiation and centrally located 24 inches (610 mm) in front of the furnace and at an elevation midway between the floor and ceiling of the test enclosure.

87.6.4 The clearance between the nearest surfaces of the chimney connector and the walls and ceiling is to be no less than 9 inches (229 mm) and no more than 18 inches (457 mm).

Exception: If the construction of the furnace is such that, when installed with the clearances selected by the manufacturer, the clearance between the chimney connector and the interior walls of the test enclosure is less than 9 inches, the test may be conducted with such lesser clearance from the walls if portions of the wall located within 9 inches of the chimney connector are protected. Directions that such surfaces shall be so protected are to be included in the instructions furnished with the furnace.

87.6.5 A furnace with vertical flue outlet is to be tested with two chimney connector constructions, Styles I and III, and a furnace with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III, as shown in Figure 87.8.

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Exception: If the manufacturer elects to specify the minimum clearance from the furnace as that obtained when tested with the chimney connector arranged in accordance with Style I or II only, the furnace need not comply with this requirement.

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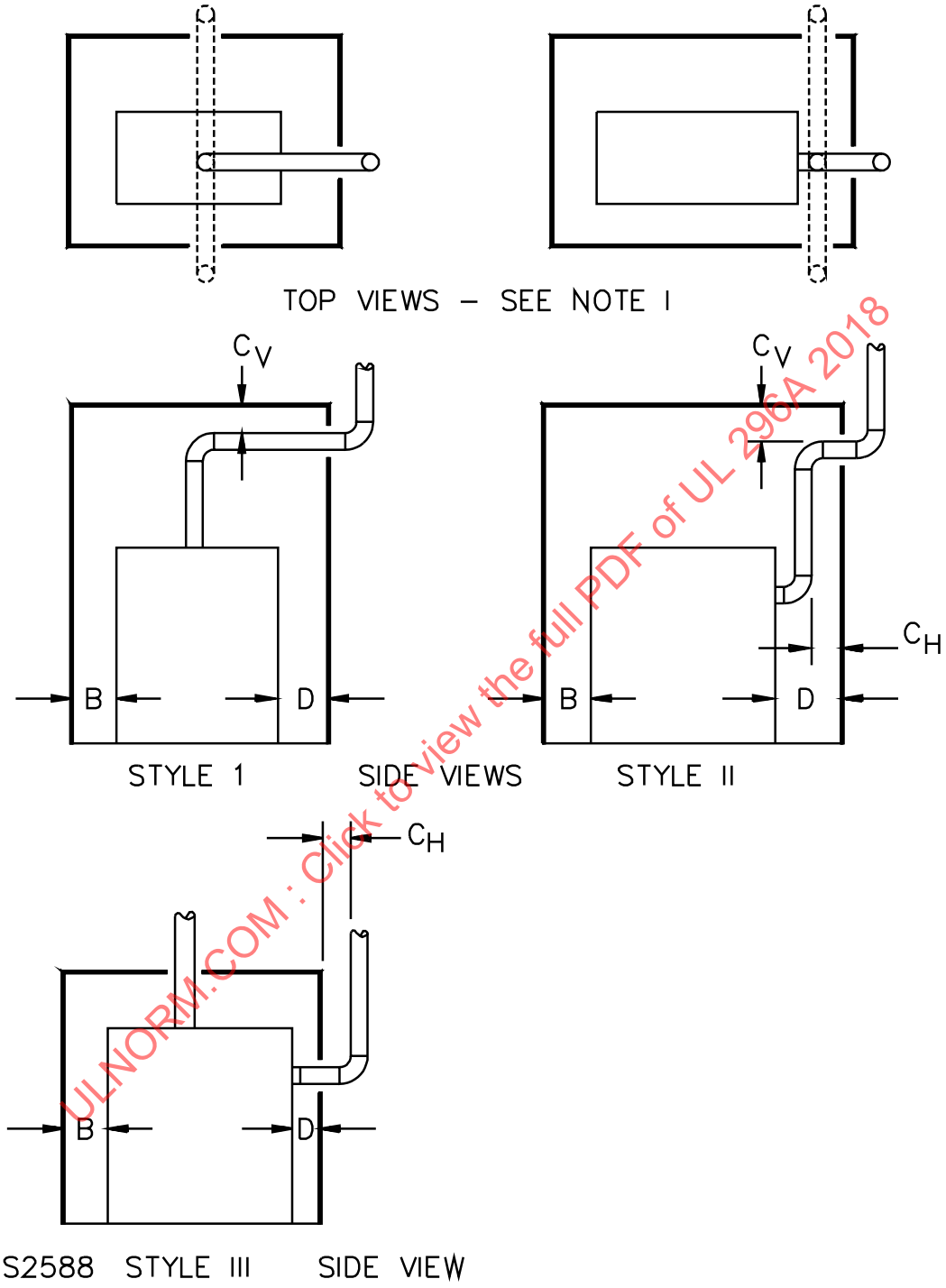
Figure 87.8
Chimney connector construction for alcove and closet installation



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Note: With connector arrangement Styles I and II, the horizontal run is to pierce the back or a side wall, whichever is farthest from the vertical run.