UL 296

STANDARD FOR SAFETY

Oil Burners

UL Standard for Safety for Oil Burners, UL 296

Eleventh Edition, Dated February 24, 2017

Summary of Topics

This revision of ANSI/UL 296 dated November 16, 2022 includes the following changes in requirements:

– Addition of B100 biodiesel requirements for oil burners; 1.3, 5.20, Supplement SA, Supplement SB

– Metallic material requirements harmonization; SA6.8.1

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated September 30, 2022.

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Standard for Oil Burners

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The most recent designation of ANSI/UL 296 as an American National Standard (ANSI) occurred on November 16, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 296 on January 27, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover oil burners intended for firing appliances and devices such as boilers; central, floor, wall, and special furnaces; storage tank water, air, and direct-fired air heater units; and ovens. These burners are required to be equipped with automatic primary safety controls to restrict abnormal discharge of oil at the burner in case of ignition failure or flame failure.

1.2 The use of oil-burning equipment covered by these requirements are intended for installation in accordance with the National Fire Protection Association Standard for the Installation of Oil-Burning Equipment, NFPA 31, the International Mechanical Code, and the Uniform Mechanical Code.

1.3 Oil Burners covered by this standard are intended for use with one or more of the following grades of fuel oil/biodiesel blends as defined in the Standard Specification for Fuel Oils, ASTM D396:

a) No. 1 S15, No. 1 S500, No. 1 S5000, No. 2 S15, No. 2 S500, No. 2 S5000, No. 2, which may contain up to 5% biodiesel.

b) B6-B20 S15, B6-B20 S500, B6-B20 S5000 which are biodiesel blends that may contain up to 20% biodiesel.

c) B21-B100 which are biodiesel blends that may contain up to 100% biodiesel.

d) No. 4, No. 4 (Light), No. 5 (Light), No. 5 (Heavy), No. 6.

Note: Unless stated otherwise it is implied that all sulfur grades are included for the fuel oil grade listed

2 Components

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

2.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3 Units of Measurement

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

4 Undated References

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

5 Glossary

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

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

5.3 ANTIFLOODING DEVICE – A primary safety control that causes the fuel flow to be shut off upon a rise in fuel level or upon receiving excess fuel, and that operates before the hazardous discharge of fuel can occur.

5.4 BURNER, AUTOMATICALLY-LIGHTED – One where fuel to the main burner is turned on and ignited automatically.

5.5 BURNER, MANUALLY-LIGHTED – One where fuel to the main burner is turned on only by hand and ignited under supervision.

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

5.7 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.

5.8 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.

5.9 BURNER, VAPORIZING TYPE – A burner consisting of an oil-vaporizing bowl or other receptacle to which liquid fuel may be fed in controllable quantities; the heat of combustion being used to vaporize the fuel, with provision for admitting air and mixing it with the oil vapor in combustible proportions.

5.10 CENTRAL HEATING APPLIANCE – A stationary indirect-fired vented appliance comprising the following classes: boilers, central furnaces, floor furnaces, and recessed heaters. A floor-mounted unit heater to be connected to a duct system is classified also as a central heating appliance.

5.11 CONSTANT-LEVEL VALVE – A device for maintaining within a reservoir a constant level of fuel for delivery to the burner.

5.12 CONTROL – A device that functions to regulate the fuel, air, water, or electrical supply to the controlled equipment. It may be automatic, semiautomatic, or manual.

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

5.14 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 on satisfaction of demand. Operating controls may also actuate auxiliary equipment.

5.15 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, or injury to persons.

5.16 CONTROL, PRIMARY SAFETY – An automatic control that monitors the operation of a gas-fired or an oil-fired burner. It normally consists of the following sections that may be integrated into a common unit or may be separate units, interconnected by wiring:

Programming Unit – A device that programs the burner through start-up and shut-down operations in response to signals from regulating, limiting, and monitoring devices. It also provides the timings, as required, in proper sequence, for purging, flame establishing periods, and in case of flame failure, for safety shutdown (lockout).

Combustion Detector – A device that is responsive to flame properties. It monitors the flame at the point of flame supervision and transmits a signal to the programming unit, indicating absence or presence of flame.

5.17 CONTROL, SAFETY COMBUSTION – See Control, Primary Safety – 5.16.

5.18 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.

5.19 ELECTRICAL CIRCUITS –

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

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts rms alternating current (42.4 volts peak) or direct current and supplied by:

1) A Class 2 transformer, or by a battery, by a battery and fixed impedance, or by a transformer and fixed impedance, each of which, as a unit is in compliance with what is required for a Class 2 transformer; or

2) Is 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 as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

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

5.20 FUEL OIL – Any hydrocarbon oil or biodiesel blend as defined by Standard Specification for Fuel Oils, ANSI/ASTM D396-2021.

5.21 IGNITION, CONTINUOUS – Ignition by an energy source that is continuously maintained throughout the time the burner is in service, whether the main burner is firing or not.

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

5.23 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 proven to be established.

5.24 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.

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

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

5.27 PILOT, EXPANDING – A pilot that burns at a low turndown throughout the entire time the burner is in service whether the main burner is firing or not. Upon a call for heat, the pilot is automatically expanded so as to ignite the main burner as intended. This pilot may be turned down at the end of the trial-for-ignition period for the main burner.

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

5.29 POST-PURGE PERIOD – The period of time after the fuel delivered to the burner is stopped and during which the burner motor or fan continues to run to supply air to the combustion chamber.

5.30 PREPURGE PERIOD – The period of time during the burner start-up in which air is introduced into the combustion chamber and the associated flue passages in such volume and manner as to completely replace the air or fuel-air mixture contained therein prior to initiating ignition.

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

5.32 PUMP, AUTOMATIC OIL – A pump, not an integral part of a burner, that automatically pumps oil from the supply tank and delivers the oil by gravity under a constant head to an oil-burning appliance. The pump is intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the appliance.

5.33 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 which is not intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the appliance.

5.34 RECYCLE – A characteristic in some programming primary safety controls for automatically lighted burners that, upon accidental flame failure during a normal firing cycle and the subsequent shutoff of main burner fuel, will provide, after a preestablished shutdown period and under a normal starting program, one attempt to automatically light the main burner.

5.35 SAFETY SHUTDOWN – The action of shutting off all fuel and ignition energy to the device by means of a safety control or controls such that restart cannot be accomplished without a recycle or manual reset (lockout).

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

5.37 SERVICING – The periodic tasks usually 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 is not considered to be servicing. Some examples of servicing are:

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

b) Setting ignition electrodes.

c) Cleaning strainers or replacing strainer or filter element.

d) Resetting safety control.

e) Replacing igniter cable.

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

5.39 STRAINER, PRIMARY – The strainer through which all oil first passes on way to burner, being upstream from any other strainer.

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

5.41 UNATTENDED – Lacking the presence of a person, not necessarily an electrician, capable of exercising responsible control of the motor under consideration. Such a person need not be in sight of the motor at all times but must be available for opening the motor circuit in the event of motor overheating. See 41.6.

5.42 TRIAL-FOR-IGNITION PERIOD – That 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.

5.43 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.

5.44 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.

CONSTRUCTION – MECHANICAL

6 General

6.1 Fuel-confining parts or operating parts shall not sag, distort, melt, oxidize, show leakage of fuel, or reduce the likelihood of a safety device from functioning during any of the tests specified herein.

6.2 To conform to 6.1, a material shall have a melting point, solidus temperature, of not less than 950°F (510°C) and a tensile strength not less than 10,000 pounds per square inch (psi) (69 MPa) at 400°F (204°C).

6.3 Fuel-confining parts not conforming to 6.1 and 6.2 may be employed if a fusible-link valve or the equivalent is included in the assembly of the burner so as to shut off the fuel supply in the event of excessive temperature or fire in the vicinity of such parts.

6.4 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.

6.5 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.

6.6 The burner shall function so as to reduce to a minimum 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 such temperatures as may result in carbonization or clogging when the burner is tested in accordance with these requirements.

7 Servicing

7.1 The requirements of 37.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized.

7.2 Moving parts such as fan blades, blower wheels, pulleys, or belts which may cause injury shall be enclosed or guarded.

7.3 If the removal of doors or panels or shields will expose such moving parts:

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

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

c) A marking, preceded by the word "DANGER," shall be displayed which reads essentially as follows:

To Avoid Injury From Moving Parts, Shut Off The (Equipment) Before (Removing- Opening) This (Cover-Door).

7.4 The distance from an opening in a required guard or enclosure to the moving part mentioned in 7.1 shall be in accordance with Table 7.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76.2 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right-hand column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22 N).

7.5 A moving part is not to be considered when judging compliance with 7.2 and 7.4 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

Table 7.1
Dimensions of openings

Minor dimensions of openings[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
Over 2 inches	(over 50.8)	30	762

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

8 Assembly

8.1 Except as indicated in 8.2 – 8.6, a burner shall be factory-built and shipped as an unit assembly and shall include all the essential 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 burner need not be provided with the assembly if the burner is marked in accordance with 74.19.

8.2 The burner may incorporate individual assemblies which are installed remotely from the burner. Such individual assemblies shall be marked in accordance with 74.4.

8.3 A strainer needed to protect small orifices need not be provided with the burner. See 15.1.

8.4 In accordance with 8.1 the complete primary safety control shall be furnished with each burner by the burner manufacturer except that an oil burner having an input not in excess of 3 gallons per hour (gph) (11.4 liters per hour) and intended for use with separate interchangeable primary safety controls may be furnished less the control if the burner is marked to indicate the appropriate type to be used.

8.5 Parts of a safety control that are required to be burner-mounted shall be factory-attached. If the combustion detector is burner-mounted but the safety switch is not, the burner shall be marked to declare the safety switch with which it is to be used.

8.6 The burner equipment, if not assembled by the manufacturer as unit assemblies, shall be arranged 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 to permit them to 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.

8.7 If the abnormal discharge of oil is restricted by the establishment and maintenance of a definite maximum level of oil in the burner, the parts required to maintain that oil level shall be assembled and fixed upon a common base in the correct relationship with one another by the burner manufacturer. The minimum distance between the designed maximum normal oil level in the burner and the level of the lowest point at which overflow may occur shall be not less than 3/4 inch (19.1 mm).

8.8 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 arranged so that the adjustments may be fixed or restricted in a manner to prevent accidental changes in settings.

8.9 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 projecting sharp screw ends.

8.10 Accessibility shall be afforded to all burner parts, controls, and safety devices requiring servicing. 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 that may be required for servicing to be performed by the operator shall accompany the burner to the user.

8.11 A firing assembly, atomizer and nozzle assemblies, and the like, 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.

8.12 The burner and/or subassemblies shall incorporate provisions for support, adjustment, and attaching to the heating plant or to the foundation on which it rests in order that installation can be so made as to prevent its twisting, sliding, or dropping out of the intended position.

8.13 A burner intended to be installed with a special combustion chamber or hearth shall be constructed and arranged to facilitate its installation. Where necessary, such a burner shall be provided with means to support the combustion chamber or hearth in its intended position.

Table 8.1
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

8.14 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 restrain it from discharging fuel when in other than the firing position.

8.15 An adjusted or movable part shall be provided with a locking device to restrict accidental shifting.

8.16 Screws or bolts used to attach parts which are detached for servicing of the burner shall be capable of holding upon the application of the torques indicated in Table 8.1 after removal and replacement.

8.17 Burners equipped, or intended to be equipped in the field; with preheaters to heat the fuel oil before burner combustion shall be provided with an interlock to prevent fuel oil from being delivered to the burner for combustion until it has been heated to the intended temperature. An oil temperature in excess of the limit established by the burner manufacturer shall result in safety shutdown. If the oil temperature falls below the predetermined low limit, the interlock shall operate to stop fuel delivery to the burner and allow circulation of the oil until the temperature increases to permit firing. Preheaters shall comply with the Standard for Electric Oil Heaters, UL 574 and interlocks shall comply with the Standard for Limit Controls, UL 353.

8.18 Fuel oil pumps provided as part of the burner shall comply with the Standard for Pumps for Oil-Burning Appliances, UL 343.

9 Bases

9.1 The base or frame on which burner parts are mounted shall consist of noncombustible material.

9.2 Each base or frame shall incorporate provisions for installing the assembly, and shall include securing and adjusting means for leveling and alignment where such are necessary.

10 Fan Housings and Air Tubes

10.1 A fan housing and an air duct shall be made of noncombustible material having the strength and durability to not be damaged during test under these requirements.

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

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

10.4 The exterior portion of a firing head within 6 inches (152 mm) measured parallel to its axis, from the firing end and all parts which 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 conforming with 6.1 – 6.5.

10.5 An outer shell of a blast tube or firing head, if made of sheet metal, shall be such as to assure strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a thickness of not less than 0.053 inch (1.35 mm) or Type 309 stainless steel having a thickness of not less than 0.026 inch (0.66 mm).

11 Fire Pots and Vaporizers

11.1 A fire pot or vaporizer shall be constructed of ferrous materials and shall reduce the likelihood of splashing or seepage of fuel from it during tests under these requirements.

11.2 If sheet metal is used in the construction of a fire pot or vaporizer, the metal shall be such as to provide strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a thickness of not less than 0.042 inch (1.07 mm) for oil-retaining parts and having a thickness of not less than 0.032 inch (0.81 mm) for other parts. Drawn parts shall be made of steel possessing drawing qualities.

11.3 A vaporizing burner shall be constructed so that, when installed, the oil-inlet piping to the fire pot or vaporizers may be cleaned.

11.4 An air duct shall be so arranged with respect to a fire pot or vaporizer as to reduce the risk of the discharge of liquid fuel through it when the oil in the fire pot is at the maximum level permitted by the oil control.

12 Combustion Air Controls

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

12.2 The air inlet arrangement 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 in a manner so as to maintain thorough mixing of the fuel and air in order to complete the combustion within the combustion zone.

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

12.4 Sheet metal air shutters shall be of a thickness not less than 0.0254 inch (0.65 mm). If sheet metal air shutters are of a thickness less than 0.0508 inch (1.29 mm), they shall have the outer edge turned at right angles or be reinforced in an equivalent manner.

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

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

12.7 A burner arranged 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.

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

12.9 A burner having an input in excess of 20 gph (76 L/h) shall be provided with an interlock which shuts off the burner and causes safety shutdown upon loss of combustion air, so that a manual reset is required to restore the burner operation when the combustion air is reestablished. See 12.12.

12.10 For a burner having an input not in excess of 20 gph (76 L/h) for which combustion air is supplied by a forced or induced draft fan which is not integral with the burner motor shaft, the loss of combustion air shall result in shutting off the fuel. The burner operation may be resumed automatically when the combustion air is reestablished.

12.11 For requirements for mechanical draft burners not equipped with a combustion air interlock in regard to operation during the interruption and restoration of the combustion air supply see Section 52, Combustion Air Failure Test.

12.12 With respect to 12.9, loss of air during prepurge or any time at start-up prior to delivery of fuel, need not result in safety shutdown. However, no delivery of fuel shall be initiated before the combustion air flow has been reestablished and the required prepurge has been completed. See 13.1.

12.13 A burner having an input rating in excess of 20 gph (76 L/h) shall employ a low oil pressure interlock switch that shall cause safety shutdown when the oil pressure falls below the predetermined limit.

Exception No. 1: A low pressure interlock is not required for rotary cup type burners.

Exception No. 2: A low pressure interlock switch is not required if the oil pump is secured directly on the burner motor shaft.

12.14 A burner having an input rating in excess of 3 gph (11.4 L/h) shall be provided with a low pressure interlock switch for the atomizing media that shall cause safety shutdown when the pressure falls below the predetermined limit.

Exception: A low pressure interlock switch is not required provided the air pump is secured directly on the burner motor shaft and the input does not exceed 20 gph (76 L/h).

12.15 A control device provided as an interlock, as described in 12.13 – 12.14, shall be constructed and tested in accordance with the Standard for Limit Controls, UL 353.

13 Prepurge and Post-Purge

13.1 The following types of mechanical draft burners shall include a prepurge period in accordance with 13.2 and 13.3 before the ignition and fuel deliver are initiated:

a) A burner having an input in excess of 20 gph (76 L/h).

b) A burner having an input in excess of 7 gph (26.5 L/h) when the oil pump operates independently of the burner.

13.2 The prepurge shall be performed in accordance with one of the following. During the prepurge the air flow and the damper position shall be proven. See also 13.3.

a) A period of 30 seconds during which time the air flow is at a rate equivalent to that provided for combustion at the maximum rated high-fire input.

b) A period of 60 seconds during which time the air flow is at a rate at least equivalent to that provided for combustion at 60 percent of the maximum rated high-fire input.

13.3 A prepurge of a shorter time than specified in 13.2 is acceptable for a burner that is designated by a marking on the burner for use only on a specific appliance and it is determined that the shorter time provides at least four complete air changes for the combustion chamber, heat exchanger and the flue passages of the appliance. However, the purging shall be accomplished with the air flow at a rate not less than equivalent to that provided for combustion at 60 percent of the maximum rated high-fire input. During the purge the air flow and the damper position shall be proven.

13.4 A mechanical draft burner having an input in excess of 20 gph (76 L/h) shall provide a post-pruge period of not less than 15 seconds.

14 Draft Regulators

14.1 Regulation of draft within an oil-fired appliance over the ranges specified in Combustion Tests, Section 51, shall be anticipated in the construction of an oil burner.

15 Strainers

15.1 A small orifice or other opening in an oil-supply system shall be protected by a strainer in accordance with the requirements of 15.2 – 15.12. The strainer need not be provided with the burner if the marking on the burner or the installation instructions furnished with burner specify that a strainer suitable for the maximum fuel input and grade of oil marked on the burner shall be provided by the installer.

15.2 The largest opening of the strainer element shall be of such size that its larger dimension will not be greater than 90 percent of the smaller dimension of the smallest fixed opening protected by the screen.

15.3 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 0.03125 (1/32) inch (0.79 mm) when Nos. 1 and 2 oils are used, and 0.0625 (1/16) inch (1.59 mm) when Nos. 4, 5, and 6 oils are used.

15.4 A primary strainer shall be based on the maximum firing rate of the burner and the heaviest grade of fuel for which the burner is intended. The strainer shall comply with the requirements of the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331.

15.5 The effective area of a screen (total area of screen openings), shall not be less than as indicated in Figure 15.1 – Figure 15.3. A strainer shall be applied so that there will be no air trapped therein to affect rate of fuel flow to the burner or reduce the effective area of the straining element.

15.6 The effective area of a screen is not required to be greater than the maximum value shown in Figure 15.1 – Figure 15.3, regardless of the burner firing rate, but in any case the strainer is not to impair the flow of fuel supplied to fire the burner at maximum rated input.

15.7 A strainer employing an element other than a screen shall have a rated capacity not less than the maximum firing rate of the burner to which it is applied.

15.8 When two strainers installed in series are provided instead of a single primary strainer, each 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 equipped with a screen or element in which the size of the individual straining opening is not larger than 90 percent of the size of the straining opening in the element of the other strainer.

15.9 A secondary strainer, one supplementary to the main strainer, smaller in area than required in 15.5 may be used in the fuel line, downstream from the primary strainer.

15.10 A strainer shall be applied 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.

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

15.12 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.

Figure 15.1

Strainer area for* No. 1 Fuel oil

No. 1 Oil

Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1992

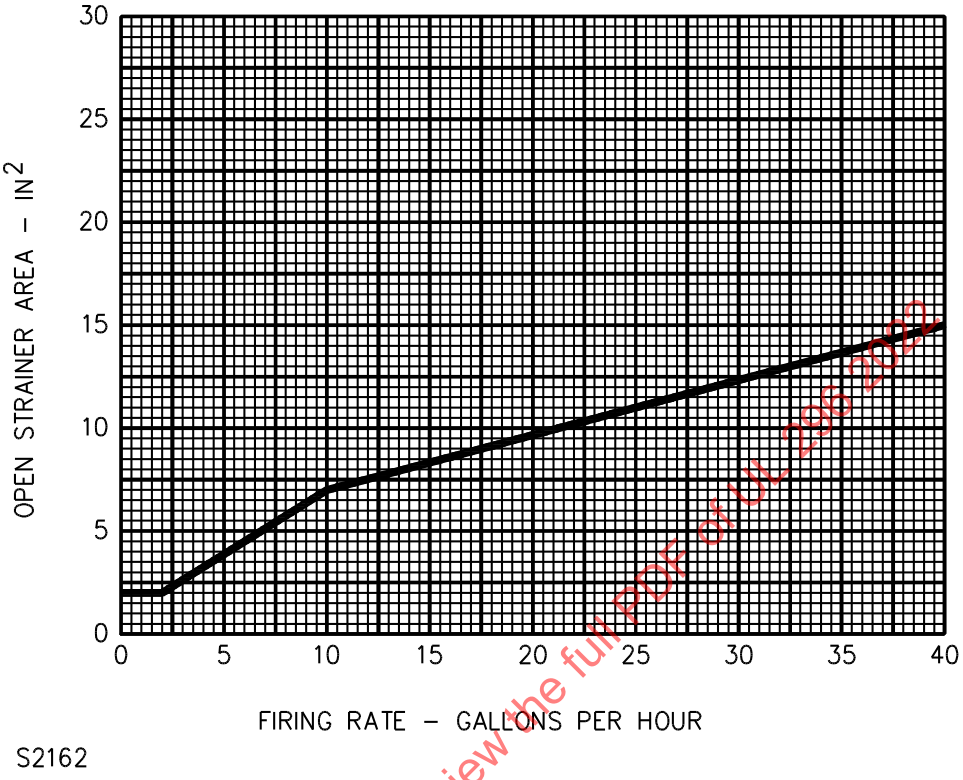
NOTES

1. 1 square inch = 6.45 cm^2

2. 1 gallon = 3.79 L

Figure 15.2

Strainer area for * No. 2 Fuel oil



No. 2 Oil

Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1992

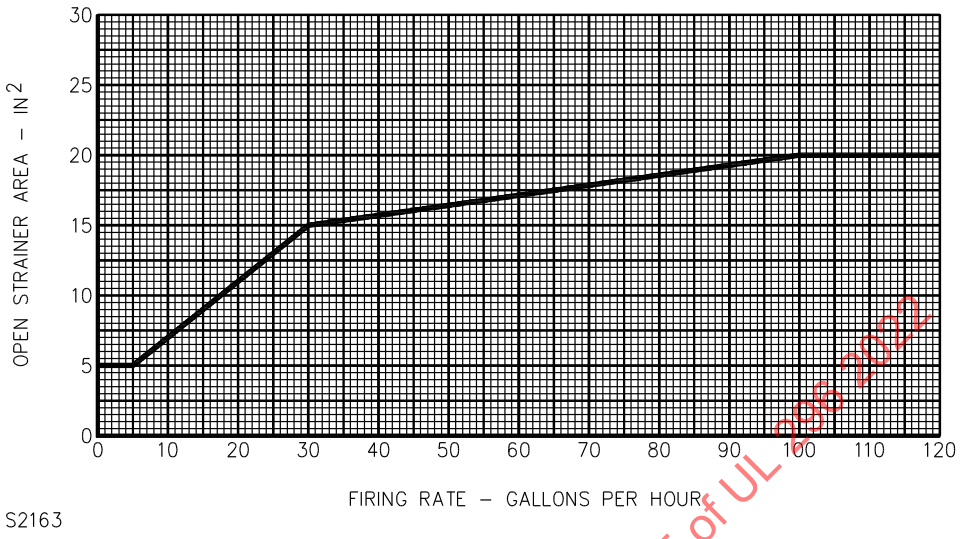
NOTES

1. 1 square inch = 6.45 cm^2

2. 1 gallon = 3.79 L

Figure 15.3

Strainer area for* Nos. 4, 5, 6 Fuel oil



Nos. 4, 5, 6 Oil Gallons Per Hour Firing Rate

*As designated by Standard Specification for Fuel Oils, ANSI/ASTM D396-1992

NOTES

1. 1 square inch = 6.45 cm^2

2. 1 gallon = 3.79 L

16 Constant-Level Devices

16.1 A constant-level valve included in the burner assembly shall be mounted and secured in place independently of the fuel piping and shall incorporate an antiflooding device.

16.2 A burner that requires the fuel oil to be supplied to it by gravity, and which is intended for installation with a constant-level device to be provided and installed in the oil supply line at the storage tank or with an automatic pump to maintain a uniform flow of fuel, may be furnished less such pump or device.

17 Floats

17.1 A float in a fuel-oil control or safety device shall conform to the requirements of 17.2 – 17.4.

17.2 The submerged part of a float in a float-actuated mechanism shall provide a buoyancy equivalent to 150 percent of that required to operate the mechanism with which it is related.

17.3 A float in fuel oil is to resist damage because of contact with the fuel and any impurities that may be contained therein, such as sulphur compounds and water. A metal, if used, is to have corrosion resistance equivalent to brass.

17.4 A float arranged to reduce the risk of the discharge of oil at the burner shall be used only when an acceptable auxiliary means is provided to guard against float or float valve failure, such as an automatic shutoff device.

18 Fittings, and Piping and Tubing

18.1 An opening threaded for pipe connection shall be threaded in accordance with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1.

18.2 An opening for field attachment to pipe larger than nominal 3 inch ANSI/ASME B1.20.1 pipe size shall be provided with a flanged pipe connection conforming to the Standard for Cast Iron Pipe Flanges and Flanged Fittings, ANSI/ASME B16.1.

18.3 A fitting, other than one conforming with the appropriate American National Standard, having openings threaded for pipe connections, shall be capable of withstanding, without damage or leakage, the turning effort (torque), see Table 18.1, exerted as if to screw the fitting onto a pipe or into a pipe fitting.

Exception: Fittings that comply with the Standard for Tube Fittings for Flammable and Combustible Fluids, Refrigeration Service, and Marine Use, UL 109 having appropriate ratings for the intended use are excluded from the requirements of 18.3.

Table 18.1
Torque requirements for pipe connections

Pipe Size ANSI/ASME B36.10M	Outside diameter		Torque	
Nominal Inches	Inch	(mm)	Pound-Inches	(N·m)
1/8	0.405	(10.3)	150	(17)
1/4	0.540	(13.7)	250	(28)
3/8	0.675	(17.1)	450	(51)

Table 18.1 Continued on Next Page

Table 18.1 Continued

Pipe Size ANSI/ASME B36.10M	Outside diameter		Torque	
Nominal Inches	Inch	(mm)	Pound-Inches	(N·m)
1/2	0.840	(21.3)	800	(90)
3/4	1.050	(26.7)	1000	(113)
1	1.315	(33.4)	1200	(137)
1-1/4	1.660	(42.2)	1450	(164)
1-1/2	1.900	(48.3)	1550	(175)
2	2.375	(60.3)	1650	(186)
2-1/2	2.875	(73.0)	1750	(198)
3	3.500	(88.9)	1800	(203)
4	4.500	(114.3)	1900	(215)

18.4 A tool which fits snugly about the fitting, or to a section of the shank shaped for a wrench, if such section is provided, is to be utilized to apply the turning force. The turning force 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 18.1 is to be applied to the fitting to screw it onto an extra-heavy pipe or into a pipe fitting of appropriate size. After the force has been applied, the fitting is not to leak when subjected to a hydrostatic pressure equivalent to one and one-half times the maximum working pressure.

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

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

18.7 Seamless drawn aluminum or copper tubing and steel tubing of the seamless, brazed, or welded type employed in the fabrication of factory-assembled equipment shall have a wall thickness of not less than that specified in Table 18.2.

Table 18.2
Wall thickness for aluminum, copper, and steel tubing

Outside Inches	Diameter, (mm)	Minimum wall thickness, Inches[a] (mm)			
		Aluminum and copper		Steel	
1/8	(3.2)	0.029	(0.74)	0.028	(0.71)
3/16	(4.8)	0.029	(0.74)	0.028	(0.71)
1/4	(6.3)	0.029	(0.74)	0.028	(0.71)
5/16	(7.9)	0.029	(0.74)	0.028	(0.71)
3/8	(9.5)	0.032	(0.81)	0.028	(0.71)
7/16	(11.1)	0.032	(0.81)	0.028	(0.71)
1/2	(12.7)	0.035	(0.89)	0.028	(0.71)
9/16	(14.2)	0.038	(0.96)	–	–

Table 18.2 Continued on Next Page

Table 18.2 Continued

Outside Inches	Diameter, (mm)	Minimum wall thickness, Inches[a] (mm)			
		Aluminum and copper		Steel	
5/8	(15.9)	0.038	(0.96)	0.035	(0.89)
3/4	(19.1)	0.045	(1.14)	0.035	(0.89)
7/8	(22.2)	0.045	(1.14)	0.049	(1.24)
1	(25.4)	0.049	(1.24)	0.049	(1.24)
1-1/8	(28.6)	0.049	(1.24)	0.049	(1.24)
1-1/4	(31.7)	0.055	(1.40)	0.049	(1.24)
1-3/8	(34.9)	0.055	(1.40)	–	–
1-1/2	(38.1)	–	–	0.065	(1.65)

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

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

18.9 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.

18.10 Cadmium plating shall have a thickness of not less than 0.0003 inch (0.008 mm), and zinc plating shall have a thickness of not less than 0.0005 inch (0.013 mm), except on parts where threads constitute the major portion of the area, in which case the thickness of the cadmium or zinc plating shall be not less than 0.00015 inch (0.0038 mm).

18.11 Flexible connector pipes shall not be used as a substitute for rigid piping or tubing as ordinarily employed. Its use shall be confined to applications where rigid piping or tubing is impractical and where flexible connections cannot be avoided. It shall not be subjected to torsional, tensile, or bending stresses or to abrasion. It shall not be used in conjunction with safety devices or where bending is caused by automatic operation. Flexible connector pipes shall comply with the Standard for Flexible Connector Piping for Fuels, UL 2039.

18.12 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 restrict the entrance of foreign material prior to installation.

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

19 Valves

19.1 The pressure rating of a valve shall be not less than the maximum operating pressure of the burner.

19.2 An oil burner having an input in excess of 3 gph (11.4 L/h) shall be provided with two oil safety shut-off valves or one safety shut-off valve and a nozzle cut-off valve. The closing times of the shut-off valves shall not exceed the timings as follows:

a) For inputs above 3 gph (11.4 L/h) but not exceeding 20 gph (75.7 L/h) – 5 seconds maximum.

b) For inputs exceeding 20 gph (75.7 L/h) – 1 second maximum.

19.3 An automatic safety valve shall be constructed so that it may not be restrained or blocked in the open position.

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

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

19.6 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.

19.7 A manually-operated fuel-metering valve shall be provided with a means that 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. This does not apply to a burner intended only for commercial or industrial installations not open to the public.

19.8 A plug or rotating-disc type valve, employing 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.

19.9 A petcock or valve which, when open, will permit the discharge of fuel oil into the room shall not be used.

19.10 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 will not exceed the intended maximum pressure for the burner.

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

19.12 A pressure-relief valve shall be connected into a fuel line in which pressure may build up in excess of that intended by the design, because of the closing of any valve in the assembly of the burner or when the oil is heated by a preheater.

19.13 Automatic safety shutoff valves shall be constructed and tested in accordance with the Standard for Electrically Operated Valves, UL 429 or equivalent nationally recognized automatic valve safety standard.

19.14 Manually operated valves shall be constructed and tested in accordance with the Standard for Valves for Flammable Fluids, UL 842, or equivalent nationally recognized manual valve safety standard.

20 Stuffing Boxes

20.1 If packing is used to restrict leakage of fuel oil around a shaft or stem, a stuffing box conforming to 20.2 – 20.11 shall be used if the construction is such that it is necessary to adjust or renew the packing to prevent leakage during usage or as wear occurs.

20.2 A stuffing box shall be provided with a removable, shouldered, unthreaded follower gland and with a nut, spring takeup, or equivalent means for adjusting the gland to maintain pressure on the packing as wear occurs.

20.3 A stuffing box for an automatically-operated stem shall be constructed to avoid binding of the stem.

20.4 If an adjustable stuffing box is used to seal an automatically-actuated stem of a safety device, it shall be such that any allowable adjustment of the packing take-up will not bind the stem sufficiently to prevent the device from functioning automatically. A gland shall be spring-loaded.

20.5 An automatic spring take-up for a gland shall employ a spring made of corrosion-resistant material or one coated to retard corrosion.

20.6 The physical characteristics of a take-up spring shall be such that it will advance the gland through not less than one-half its possible travel from its initial setting with the spring compressed.

20.7 At the advanced position of the gland, a take-up spring shall not require adjustment of the nut to prevent leakage from the stuffing box when tested under pressure of one and one-half times maximum rated pressure.

20.8 A stuffing-box gland shall be made of corrosion-resistant material. The assembly of parts shall be such as to result in compressing the packing against the stem when the stuffing box nut or yoke is tightened.

20.9 Before shipment, a stuffing box shall be fully packed with pliable packing material, the impregnation of which is not adversely affected by contact with fuel oil.

20.10 The structure shall be such as to permit repacking the stuffing box without requiring the assembly to be dismantled, and threads of a stem shall not enter the stuffing box recess.

20.11 A manually-operated stem shall not back out, nor shall threads of a stem enter a stuffing-box recess, when the stem is rotated or reciprocated in any allowable manner even though an adjustable packing nut or other take-up is disengaged.

21 Gauges

21.1 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.

21.2 A pressure gauge, when used, shall have a scale range of at least one and one-half 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.

22 Gas Pilots

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

22.2 A pilot burner not automatically lighted shall be accessible for manual lighting.

22.3 The pilot shall be independently controlled by means of a manually-operated pilot shutoff valve.

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

23 Manually-Lighted Burners

23.1 A manually-lighted burner shall be arranged to provide accessibility for ignition.

23.2 A burner provided with a preheating pan or similar arrangement for lighting shall be so constructed as to eliminate the need for waste and paper for ignition purposes. The pan shall be of sufficient depth and size to restrict the discharge of the oil supply into the ash pit of the heating plant prior to its discharge into the overflow provided for this purpose. An oil supply or overflow line leading to this type of burner shall not be exposed to the preheating flame.

23.3 The oil-regulating device of a burner intended for operation with an oil pilot shall be arranged to permit a pilot-fire setting within predetermined maximum and minimum firing rates only.

23.4 The maximum input to a continuous oil pilot shall be not more than 10 percent of the maximum input to the main burner.

24 Antiflooding Devices

24.1 An antiflooding device assembly not enclosed within the burner housing shall withstand, without permanent distortion or displacement, a 100 pound-force (445 N) applied to it uniformly in any direction after the subassembly is joined to the burner.

24.2 An antiflooding system intended to restrain the abnormal discharge of oil by restricting the oil level to a predetermined maximum in accordance with 8.7 shall include a constant-level device.

24.3 An antiflooding system, which functions to shut off the oil supply upon receiving oil delivered to it, shall conform to 24.4 – 24.13.

24.4 The mechanism shall be provided with a metallic enclosure to restrict accidental obstruction of moving parts by objects placed against or beneath the assembly. Any part of the enclosure which is intended to be moved during intended usage of the burner shall be nondetachable and shall automatically resume its initial position when released. The enclosure shall not be damaged or permanently displaced by a 25 pound-force (111 N) uniformly applied against the assembly from any direction.

24.5 The tripping point of an automatic shutoff device shall be set and tested at the factory so that, after the shutoff mechanism has operated, the amount of oil in the overflow receptacle will conform to the requirements of 24.6.

24.6 An overflow receptacle for an antiflooding device shall be constructed of seamless material, protected to retard corrosion. It shall be accessible for emptying and arranged so as not to be displaced or the support distorted. The construction and size shall be such that tripping of the receptacle will not cause the overflowing oil to be discharged into the room. An overflow receptacle shall be of such size that, after the shutoff mechanism has operated, sufficient excess capacity will remain to confine all oil discharged from the piping and overflowing chamber.

24.7 An oil receptacle of an antiflooding device shall not be drained by any method which, when left open by the operator, will result in an abnormal flow of oil or which will permit operation of the burner without the protection of the antiflooding device.

24.8 The antiflooding device shall be so arranged that either the oil shutoff valve will be closed or the electrical circuit opened in such a manner as to restrict operation of the burner until the antiflooding device has been restored to its normal position.

24.9 A drain plug or manually-operated valve which may be left open shall not be used for emptying an overflow receptacle.

24.10 The overflow pipe from a fire pot or vaporizing unit of an oil burner, or from a receptacle located in the combustion zone, to the antiflooding device shall be not less than nominal 1/2 inch ANSI/ASME

B1.20.1 pipe size. An overflow pipe from other receptacles which are normally closed shall be not less than 3/8 inch (9.5 mm) outside diameter tubing. The discharge end of the overflow pipe shall not be movable, as with a pipe elbow or similar fitting, but shall be mounted so as to ensure a positive discharge into the overflow receptacle.

24.11 An overflow line and its inlet shall be constructed and arranged to avoid clogging and shall be accessible for cleaning. If found necessary under test, provision shall be incorporated to restrict the discharge of vapors into the room. Where a trap is employed for this purpose, it shall be accessible for cleaning.

24.12 A combustion chamber constructed of fire brick or similar oil-absorbing material shall not be used to collect and direct unburned oil to actuate an antiflooding device.

24.13 The complete shutoff apparatus shall be assembled, set, and tested for reliability of operation by the burner manufacturer before shipment.

CONSTRUCTION – ELECTRICAL

25 Servicing and Adjustment

25.1 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 mechanism;

c) Operating manual switches; or

d) Adjusting air-flow dampers.

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

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

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

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

25.3 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized, excluding voltage measurements, shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting the service person to risk of electric shock from adjacent uninsulated live parts or to personal injury from adjacent moving parts.

25.4 Components in a low-voltage circuit are to comply with the requirements of 25.3 in their relation to uninsulated live parts in a high-voltage circuit and to hazardous moving parts.

26 Ignition Systems

26.1 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. See 5.42. 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 upon accidental extinguishment of the main burner flame.

26.2 With respect to 26.1, a burner that employs a primary safety control with return of ignition feature in conjunction with a combustion detector that may be susceptible to a delay in responding to flame failure when viewing hot refractory surfaces, shall be subjected to the return of ignition test in accordance with Section 67, Test No. 28. As an alternate the burner may be marked in accordance with 74.20. The information in this marking shall also be included in the installation instructions furnished with the burner. Examples of combustion detectors that may be susceptible to a delay in responding to flame failure when viewing a hot refractor are those employing a cadmium sulfide cell ("cad cell") or a cesium oxide cell ("photo cell").

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

26.4 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 these requirements.

26.5 The construction of an oil burner shall be such that the igniter assembly may be withdrawn 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.

27 Electric High-Tension Ignition

27.1 Assembly

27.1.1 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 accidental contact.

27.1.2 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 to each other between live parts of opposite polarity.

27.1.3 The tests to determine conformance to 27.1.2 shall be made with the ignition transformer 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.

27.1.4 If an adjustable air deflector or similar part is employed in the vicinity of high-tension parts, the construction shall be such that it cannot assume a position which can result in lack of conformance with the requirements of 27.1.2.

27.2 Electrode and bus bars

27.2.1 Bare high-tension conductors shall be self-sustaining when in place.

27.2.2 An electrode or bus bar supporting an electrode shall be so constructed that it may be fixed in its intended position and maintain the intended gap.

27.2.3 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.

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

27.2.5 An electrode tip shall be of such material that burning of its point will not be evident while the burner is being tested in accordance with these requirements. High-temperature alloy steel or equivalent material shall be used for the electrode tip.

27.2.6 An electrode slanting downward toward its insulator shall be provided with a drip loop, or the equivalent, to reduce the likelihood of oil running down the electrode from reaching the insulator.

27.3 Insulators

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

27.3.2 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.

27.3.3 The test to determine conformance with 27.3.2 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).

27.3.4 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 27.1.

27.3.5 An insulator included in a proved gas pilot assembly to be energized by a transformer having a secondary voltage of not more than 6,000 need not conform to 27.3.4 and Table 27.1 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 not less than 1/4 inch water column (62.3 Pa).

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

Table 27.1
Spacing over surface of insulators[a]

Secondary voltage of ignition transformer	Minimum surface distance over insulation inches (mm)	
Not more than 10,000	1-1/2	(38.1)
Not more than 15,000	2	(50.8)

[a] Except as indicated in 27.3.5, an insulator included in the assembly of a spark-ignited gas pilot shall have an over surface spacing of not less than 1 inch (25.4 mm) if the secondary voltage of the ignition transformer is 6000 or less.

27.4 Leads

27.4.1 Ignition cable shall have a voltage rating equal to or greater than 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 and ensure adequate connection to the terminal. A high-tension lead or cable shall be run individually in a manner to avoid sharp bends.

27.5 Transformers

27.5.1 A transformer shall be mounted as closely as possible to the spark gap to avoid long leads. Its location 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 unless that portion of the case within 1 inch (25.4 mm) of the floor is waterproof.

27.5.2 A spacing of at least 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.

27.5.3 The preceding requirements for electric high-tension ignition systems are based upon the use of ignition energy that is essentially sinusoidal. Other types of systems employing 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 and the peak voltage of the system, the average pulse power, time between pulses, duration of the pulses, and duty cycles.

28 Electric Hot-Wire Ignition

28.1 An igniter assembly shall withstand for 1 minute, without breakdown, the application of a 60 hertz potential of the following values between current-carrying parts and the enclosure and grounded metal parts, and between current-carrying parts of opposite polarity. The applied potential shall be 500 volts for an assembly operating at 30 volts or less and 6 amperes or less, and twice rated voltage plus 1000 volts for an assembly operating at more than 30 volts or more than 6 amperes.

28.2 The wiring between a transformer and the igniter shall be of sufficient capacity for the current involved and shall be provided with insulation having a temperature rating and thickness consistent with its use. Bare terminals shall be enclosed.

29 Control Applications

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

29.2 The control circuit shall be constructed so that a safety control or protective device cannot be rendered ineffective by short-circuit(s) to ground. Safety-control-circuit arrangements other than described in 29.1 shall provide equivalent protection.

29.3 The requirement of 29.1 does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

29.4 A control circuit shall be arranged so that it may be connected to a power-supply branch circuit that can be fused at not 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.

29.5 All safety controls shall be accessible.

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

29.7 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or allowing firing of the burner without the protection of each of the required safety controls.

29.8 A burner not equipped to provide automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and following restoration of an interrupted power supply.

29.9 A burner shall permit installation with a limit control(s) to restrict excessive pressure or temperature in the appliance being fired.

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

29.11 The purpose of the requirement in 29.10 is to restrict interposing in the limit-control circuit other controls, the failure of which may result in a condition the limit control is intended to restrict. For this purpose, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the desired circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls, or to interrupt a multiphase circuit.

29.12 An oil-burner circuit shall be arranged to restrict 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.

29.13 A vaporizing burner shall restrict pooling of the burner upon functioning of the limit control.

30 Primary Safety Controls

30.1 An oil burner shall be equipped by the burner manufacturer with a primary safety control, except as permitted by 8.4.

30.2 A primary safety control shall conform to the requirements of 30.3, 30.4, and Table 30.1.

30.3 A burner having a firing rate of not more than 4 gph (15.1 liters/hr), which upon ignition or flame failure collects or retains within a metal fire pot or receptacle furnished by the manufacturer as part of the burner assembly all of the oil delivered for combustion, may be equipped with an antiflooding device. See Antiflooding Devices, Section 24.

30.4 A primary safety control for a burner, except one equipped as permitted by 30.3, shall be a safety combustion control having nominal safety timings as indicated in Table 30.1.

Table 30.1
Required programming and timings for burners based on maximum fuel input rating

Operation	Maximum firing rate per combustion chamber		
	3 gph[a] (11.4 liters/hr) or less	Above 3 gph (11.4 liters/hr) to 20 gph[b] (76 liters/hr)	Above 20 gph[b] (76 liters/hr)
Prepurge	Not required	Up to 7 gph (26.5 L/h), not required. Greater than 7 gph, four air changes[c,d]	Four air changes[d]
Postpurge	Not required	Not required	15 seconds minimum
Pilot type and flame establishing period	N/A	Interrupted, 10 seconds maximum	Interrupted, 10 seconds maximum
Main burner flame establishing period			
Ignited by pilot	N/A	15 seconds maximum	10 seconds maximum firing distillate fuel, 15 maximum firing residual fuel[c]
Direct ignition	90 seconds maximum	15 seconds maximum[a]	10 seconds maximum firing distillate fuel, 15 maximum firing residual fuel[e] (Low-fire start required)
Flame failure reaction time[f]	90 seconds maximum	4 seconds maximum[g]	4 seconds maximum
Safety shutoff valve closing time after de-energization	Not specified	5 second maximum	1 second maximum
Action required on flame failure	One recycle permitted	One recycle permitted	Safety shutdown required
Proven low fire start	Not required	Not required	Required for direct ignition[h]
Combustion air proving	Not required	Required[i]	Required
Action required on loss of combustion air	Not required	Fuel shutoff with automatic restart when combustion air reestablished (See 12.10)	Safety shutdown (See 12.9)
Fuel pressure supervision	Not required	Not required	Required if oil pump operates independently of the burner. (See 12.13)
Low atomizing media supervision	Not required	Required unless atomization by air pump integral with burner. (See 12.14)	Required (See 12.14)
Oil temperature supervision	High and low temperature supervision required on preheated oil. (See 8.17)	High and low temperature supervision required on preheated oil. (See 8.17)	High and low temperature supervision required on preheated oil. (See 8.17)

[a] Approximately 400,000 Btu/hr (117 kW) firing distillate fuel

[b] Approximately 3,000,000 Btu/hr (879 kW) firing distillate fuel

[c] Prepurge is not required for a burner over 7 gph up to 20 gph if the oil pump is integral with the burner. See 13.1.

[d] Accomplished by 30 seconds prepurge at air flow equivalent to maximum high fire input; or 60 seconds prepurge at air flow equivalent to 60% of maximum high fire input, see 13.2; or alternate method described in 13.3.

[e] Where it can be demonstrated by tests that a burner equipped to burn a residual fuel needs a longer main flame establishing period so as to avoid nuisance shutdown, such MFEP may be more than 15 but not more than 30 seconds provided not more than 15 seconds of unburned fuel is discharged during an attempt to establish main flame.

[f] The flame-failure reaction time is to be considered, the interval between the actual flame extinguishment and the time the safety shutoff device (such as an oil valve) is de-energized.

[g] A flame-failure reaction time of more than 4 seconds, but not more than 15 seconds, is permitted if intermittent ignition is employed, or if the ignition system is reenergized in not more than 0.8 seconds after flame extinguishment occurs.

[h] Low fire start is ignition of the main flame at an input not greater than 20 gph.

[i] Applicable when the combustion air is supplied by a forced or induced draft fan which is not integral with the burner motor shaft. See 12.10

30.5 A primary safety control shall be constructed and tested in accordance with the Standard for Automatic Electrical Controls for Household and Similar Use - Part 2: Particular Requirements for Burner Ignition Systems and Components, UL 372.

31 General Components and Devices

31.1 Electrical equipment and wiring shall be arranged so that oil will not drip or run on them during intended usage or when a connection must be uncoupled for servicing.

31.2 Attachment plugs or separable connectors shall not be used in circuits when the breaking or making of the circuit by such devices may permit operation of the equipment without all required safety programming.

31.3 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

31.4 Thermoplastic wiring material shall comply with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

31.5 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62.

31.6 Fittings for conduit and/or metal clad cable shall comply with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

31.7 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9 for Class K).

31.8 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

31.9 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

31.10 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059.

31.11 Electrical (Junction) boxes shall comply with the Standard for Metallic Outlet Boxes, UL 514A or the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C, as applicable.

32 Field Wiring

32.1 General

32.1.1 A wiring terminal is considered to be a terminal to which power-supply or control-circuit connections will be made in the field when the burner is installed.

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

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

32.1.4 The connections are to be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made. For this purpose a cover-mounted component, such as a transformer, may serve as the cover. See 33.2.1.

32.1.5 The size of a junction box in which field-installed conductors are to be connected by splicing shall not be less than that specified in Table 32.1. A conductor passing through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. A field-furnished conductor for high-voltage circuits is considered to be not smaller than 14 AWG (2.1 mm^2).

Table 32.1
Size of junction boxes

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

32.1.6 The limitations in 32.1.5 do not apply to terminal housings supplied with motors nor to boxes or enclosures that contain terminals for electrical connections.

32.1.7 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 32.2.

32.1.8 Wiring exterior to the burner assembly and a limit control, a safety combustion control, or a motor controller, that can be readily done using the following wiring methods in accordance with these requirements, need not be furnished by the manufacturer as part of the oil burner if instructions for installing such wiring are furnished with each furnace. See 33.1.3.

a) Type T wire enclosed in conduit that complies with the Standard for Flexible Metal Conduit, UL 1 or the Standard for Electrical Rigid Metal Conduit – Steel, UL 6, as applicable, electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel, UL 797 or the Standard for Extruded Insulating Tubing, UL 224;

b) Metal-clad cable that complies with the Standard for Metal-Clad Cables, UL 1569; or

c) Exposed Run Tray Cable, Type TC-ER, that complies with the requirements for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members, UL 1277 or, for applications not exceeding 150 volts and/or 5 amps, Exposed Run Instrumentation Tray Cable, Type ITC-ER, that complies with the requirements of the Standard for Instrumentation Tray Cable, UL 2250. The cable utilized shall:

1) Comply with the crush and impact requirements of the Standard for Metal-Clad Cables, UL 1569;

2) Be secured and supported at intervals not exceeding 6 feet (1.8 m).

3) Have voltage and temperature ratings suitable for the intended application.

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

32.1.9 A box or enclosure included as part of the oil burner assembly and in which a branch circuit supplying power to the burner motor is to be connected shall not require that it be moved for servicing of the unit.

32.1.10 A box or enclosure in which field-installation conductors are to be connected as indicated in 32.1.8, 32.1.9, and 32.1.11 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 burner is tested in accordance with these requirements.

Table 32.2
Trade size of conduit in inches (mm od)[a,b]

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)

[a] This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

[b] Trade Size, ANSI C80.1, Nominal Inches.

32.1.11 Except as indicated in 33.1.3, wiring to be done in the field between the oil burner and devices not attached to the burner, or between separate devices that are field installed and located, shall comply with these requirements if done using the following wiring methods.

a) Type T wire enclosed in conduit that complies with the Standard for Flexible Metal Conduit, UL 1 or the Standard for Electrical Rigid Metal Conduit – Steel, UL 6, as applicable, electrical metallic tubing that complies with the Standard for Electrical Metallic Tubing – Steel, UL 797 or the Standard for Extruded Insulating Tubing, UL 224 or a metal raceway electrical enclosure;

b) Within metal-clad cable that complies with the Standard for Metal-Clad Cables, UL 1569; or

c) Exposed Run Tray Cable, Type TC-ER, that complies with the requirements for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members, UL 1277 or, for applications not exceeding 150 volts and/or 5 amps, Exposed Run Instrumentation Tray Cable, Type ITC-ER, that complies with the requirements of the Standard for Instrumentation Tray Cable, UL 2250. The cable utilized shall:

1) Comply with the crush and impact requirements of the Standard for Metal-Clad Cables, UL 1569;

2) Be secured and supported at intervals not exceeding 6 feet (1.8 m).

3) Have voltage and temperature ratings suitable for the intended application.

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

32.1.12 The wiring of the burner may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the burner to the wiring system specified in

32.1.2. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to reduce the likelihood of 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 burner is not more than 6 feet (1.83 m);

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

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

32.2 Leads and terminals

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

32.2.2 Leads may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead may result in damage to the lead insulation.

32.2.3 Leads intended for connection to an external circuit shall be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring that may cause the lead to separate from its termination or result in damage to the lead from sharp edges.

32.2.4 An identified (grounded) terminal or lead 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.

32.2.5 At terminals, stranded conductors shall be restricted 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 are intended to restrict disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by insulating tubing, or the equivalent, if the required spacings may be reduced as a result of loosening of the clamping means. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm).

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

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

32.2.8 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire-binding screws or pressure terminal connectors, located in the same compartment as the splice or

visible to the installer, unless the screws or connectors are rendered unusable for field-wiring connections or the leads are insulated at the unconnected ends.

32.2.9 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 32.2.6, except that for 10 AWG (5.3 mm^2) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to hold the wire in position.

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

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

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

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

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

32.2.13 A wire binding screw shall thread into metal.

33 Internal Wiring

33.1 General

33.1.1 The wiring of high-voltage and safety-control circuits shall conform to the requirements in this section.

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

33.1.3 If insulated conductors rated for use at temperatures in excess of 60°C (140°F) are required such wiring shall be furnished as part of the assembly. The devices to be connected by such wiring shall be factory-located on the equipment except as permitted by 74.14 for field-installed conductors.

33.2 Methods

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

33.2.2 Except as permitted by 33.2.15 and 33.2.16, conductors shall be:

a) Enclosed within conduit, electrical metallic tubing, metal raceway electrical enclosure;

b) Within a metal-clad cable; or

c) Exposed Run Tray Cable, Type TC-ER, that complies with the requirements for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members, UL 1277 or, for applications not exceeding 150 volts and/or 5 amps, Exposed Run Instrumentation Tray Cable, Type ITC-ER, that complies with the requirements of the Standard for Instrumentation Tray Cable, UL 2250. The cable utilized shall:

1) Comply with the crush and impact requirements of the Standard for Metal-Clad Cables, UL 1569;

2) Be secured and supported at intervals not exceeding 6 feet (1.8 m).

3) Have voltage and temperature ratings suitable for the intended application.

4) Be resistant to the effects of oil and be marked "oil-resistant I" or "oil resistant II" as applicable to the respective cable requirements.

33.2.3 Table 33.1 includes some wiring materials rated for use if enclosed as indicated in 33.2.2.

33.2.4 Flexible metal conduit shall be not smaller than 3/8 inch (9.5 mm) electrical trade size, ANSI C80.1-1990. This does not apply to parts of components, such as conduit protecting flame sensor leads.

33.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.37 m) and within 12 inches (305 mm) on each side of every junction box except for lengths not over 36 inches (0.9 m) where flexibility is necessary.

33.2.6 All splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered.

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

33.2.8 Splicing devices, such as fixture-type splicing connectors or pressure wire connectors may be employed if they have insulation rated for the voltage to which they are subjected. Thermoplastic tape wrapped over a sharp edge is not acceptable.

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

Table 33.1
Typical wiring materials

Type of wire, cord, or cable			
FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RUW, T, THW, XHHW, MTW, THW-MTW, THWN, TW, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFFH-3, or Thermoplastic appliance wiring material with insulation thicknesses shown below corresponding to wire sizes indicated.			
Wire size		**Insulation thickness**	
AWG	**(mm^2)**	**Inch**	**(mm)**
10 & Smaller	(5.3)	2/64	(0.8)
8	(8.3)	3/64	(1.2)
6	(13.3)	4/64	(1.6)
4	(21.2)	4/64	(1.6)
3	(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)

33.2.10 A splice is considered to be adequately enclosed when installed in a junction box, control box, or other enclosed compartment in which high-voltage wiring materials, as specified in Table 33.1 may be employed. Splices in enclosed machinery compartments are to be secured to a fixed member in the compartment so that they are not subject to movement or damage during servicing.

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

33.2.12 A wireway shall be such that the interconnection of sections and fittings will provide a rigid mechanical assembly and provide the required 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.

33.2.13 All wiring shall be supported and routed to reduce the risk of damage due to sharp edges or moving parts.

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

a) It is not practical to do the wiring in accordance with 33.2.3.

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

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

33.2.15 A length of Type SO or ST cord, as short as practicable, may be used for the wiring from the movable assembly to a disconnect on a stationary part of a swing-type burner for commercial and industrial installations only.

33.2.16 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 upon which the wires or cords may bear, to prevent abrasion of the insulation. Bushings if required, shall be ceramic, phenolic, cold-molded composition, fiber, or equivalent material.

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

33.2.18 To provide an acceptable unbushed opening in sheet metal usually requires rolling and/or extrusion of the metal around the opening, or the insertion of a grommet conforming to 33.2.16.

33.3 Short circuit protection

33.3.1 Except as indicated in 33.3.2, 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 a short circuit test without creating a risk of fire or electric shock. See Short-Circuit Test, Section 70.

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

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

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

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

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

34 Overcurrent Protection of High-Voltage Control-Circuit Conductors

34.1 General

34.1.1 For the purpose of these requirements, a control circuit is one that carries electric signals to operate a controller that, in turn, governs power delivered to a motor or other load in the burner. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the burner, see Overcurrent Protection of Transformers, Section 35, for additional requirements.

34.2 Direct-connected high-voltage control circuit

34.2.1 For the purpose of these requirements, a direct-connected high-voltage control circuit is one that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the burner. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the burner. See 74.12.

34.3 Tapped high-voltage control circuits

34.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the burner from the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 34.3.3 and 34.4.2.

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

34.3.3 A tapped high-voltage control-circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device shall not exceed the value specified in Table 34.1.

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

Exception No. 2: An overcurrent-protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in 70.14.

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

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

a) This protection is in accordance with requirements specified in Overcurrent Protection of Transformers, Section 35; and

b) The rating of the device does not exceed the applicable value specified in Table 34.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

34.4 Overcurrent-protective devices

34.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 34.3.3, shall be provided as part of the burner. If a fuse is used, the burner shall be marked in accordance with 74.10.

Exception: The overcurrent device, or devices, need not be provided as part of the burner if, based on the marked rating of the burner, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in Table 34.1.

Table 34.1
Overcurrent protective device ratings for control circuit conductors

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

[a] Includes copper-clad aluminum.

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

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

34.4.2 A control-circuit overcurrent-protective device shall:

a) Be provided for all ungrounded conductors;

b) Be of a size in accordance with the requirements in 34.3.3; and

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

The device shall be a circuit breaker, or a fuse, that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, R, 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 burner, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 70.1. If the supplementary device used is a fuse, the burner shall be marked in accordance with 74.11.

35 Overcurrent Protection of Transformers

35.1 High-voltage transformers

35.1.1 A transformer, other than as described in 35.4.1 and 35.4.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 35.2.1;

b) Be protected by an overcurrent device, or devices, in accordance with the requirements in 35.3.1; or

c) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 72.

Exception: This requirement is not applicable to an interchangeable ignition transformer that has been investigated in accordance with the requirements for ignition transformers in the Standard for Specialty Transformers, UL 506.

35.2 Thermal protection

35.2.1 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High-Voltage Transformers, Section 71.

Exception: If the thermal-overload-protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test, High-Voltage Transformers, Section 72.

35.2.2 A thermal cutoff shall comply with the requirements for the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manually or automatically reset thermal protector shall have an endurance rating of not 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.

35.3 Overcurrent protection

35.3.1 If a high-voltage transformer is protected by an overcurrent device or devices, such protection shall comply with the requirements specified in 35.3.2, 35.3.3, and 35.5.1 – 35.5.3.

35.3.2 A high-voltage transformer shall be protected by an overcurrent device, or devices, that is located in the primary circuit and that is rated or set as indicated in Table 35.1 for the primary. See 35.3.3 and 35.5.1.

35.3.3 If the circuit supplying a transformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected by a protective device rated or set as indicated in Table 35.1 for the secondary.

Table 35.1
Maximum rating of transformer overcurrent protective devices

Rated primary or secondary current, amperes	Maximum rating of overcurrent device, percent of transformer current rating when in:	
	Primary	Secondary
Less than 2	300[a]	167
2 or more, less than 9	167	167
9 or more	125[b]	125[b]

[a] Does not apply to an autotransformer; may be increased to 500 percent of transformer supplies a motor control circuit.

[b] If 125 percent of the current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating may be used. For the purpose of this requirement, standard ratings are 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60 amperes.

35.4 Low-voltage transformers

35.4.1 Except as specified in 35.4.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (Class 1, power-limited circuit) shall be protected by an overcurrent device, or devices, located in the primary circuit. The overcurrent device, or devices, shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 35.5.1.

35.4.2 A transformer that directly supplies a Class 2 circuit [see 5.19(b)] 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 equipped with an overcurrent device, or devices (noninherently-limiting transformer).

35.5 Overcurrent protective devices

35.5.1 Overcurrent protection in the primary circuit of a transformer, as described in 35.3.2 and 35.4.1, need not be provided as part of the burner if, based on the marked rating of the burner, the rating of the branch-circuit overcurrent-protective device, or devices, does not exceed the values specified in 35.3.2 or 35.4.1, as applicable.

35.5.2 Overcurrent protection in the secondary circuit of a transformer, as required by 35.3.3 shall be provided as part of the equipment. If a fuse is used the burner shall be marked in accordance with 74.10.

35.5.3 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 in accordance with the requirements in 35.3.2, 35.3.3 and 35.4.1, as applicable; and

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

The device shall be a circuit breaker, or a fuse, that is acceptable for branch-circuit protection. Examples of an acceptable fuse are a Class CC, G, H, J, K, L, R, 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 product, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 70.1. The product shall be marked in accordance with 74.11.

36 Separation of Circuits

36.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits (internal wiring) shall be separated by barriers or shall be segregated, and shall, in any case, be so separated or segregated from uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

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

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

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

b) Uninsulated live parts of any other circuit.

c) Any uninsulated live parts whose short-circuiting may affect the intended ignition, control, and operation of the appliance, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that Type T or equivalent conductors are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70.

36.4 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 respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits.

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 36.3, that the conductors entering each opening will be connected to the terminals opposite the opening.

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

36.5 To determine if a device complies with the requirements of 36.3, it is to be wired as it would be in service and in doing so a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

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

36.7 A metal barrier shall have a thickness equivalent to that required by Table 40.1 and Table 40.2, based on the size of the barrier. A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be accomplished so as to defeat its purpose. Any clearance at the edges of a barrier shall be not more than 1/16 inch (1.6 mm) wide.

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

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

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

37 Accessibility

37.1 An uninsulated high-voltage live part and moving parts likely to cause injury to persons shall be located, guarded, or enclosed so as to minimize the likelihood of unintentional contact by personnel performing service functions which may have to be performed with the equipment energized.

37.2 Accessibility and protection from electric shock and unintentional contact with moving parts may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 37.1.

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

b) Uninsulated live parts outside the control assembly projected clear space, except for live parts within a control panel, or unguarded moving parts are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

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

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

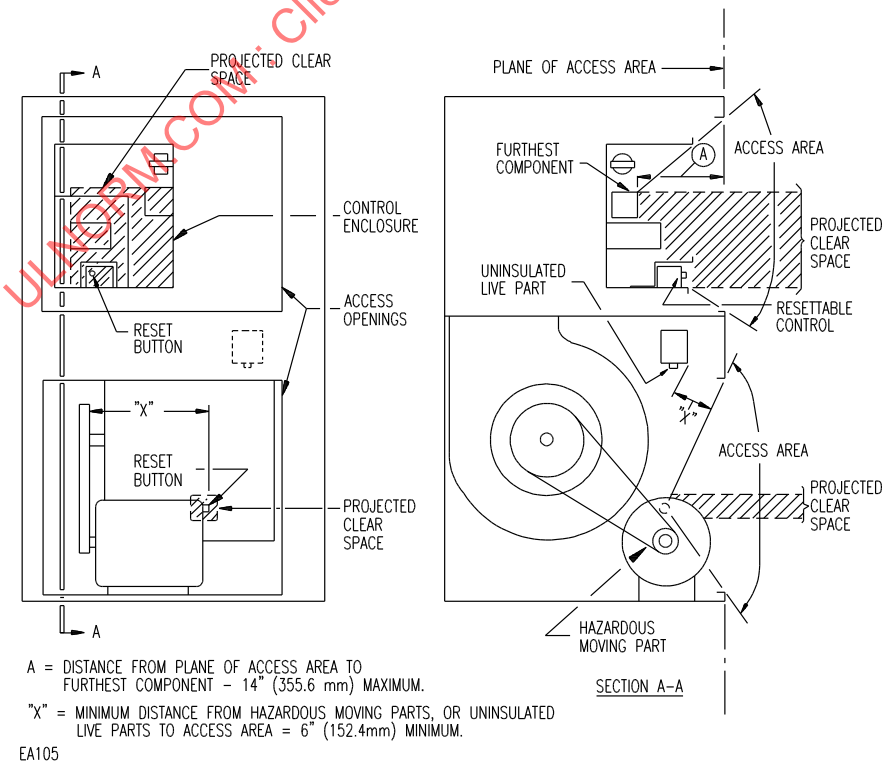
e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:

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

2) So that they are not immediately adjacent to uninsulated live parts outside the control assembly enclosure, unless guarded. See 25.2.

Figure 37.1

Accessibility and protection



37.3 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.

38 Bonding for Grounding

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

38.2 Except as indicated in 38.3, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping and valves shall be bonded for grounding if they may be contacted by the user or service personnel.

38.3 Metal parts, as described below, 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 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.

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 not less than 1/32 inch (0.8 mm) thick.

38.4 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, is to be provided with a grounding conductor not requiring removal for such service.

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

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

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

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

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

38.8 The bonding shall be by a positive means, such as by clamping, riveting, 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.

38.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 38.11 under any degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which are likely to occur in service. A clamping device shall be arranged for reassembly in its intended position following disassembly or removal for maintenance purposes.

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

38.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 38.12 – 38.18, it shall be acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 38.1, twice the current equal to the rating of the branch-circuit overcurrent device required to protect the equipment; and

b) During a short-circuit test in series with a fuse of proper rating. See Short-Circuit Test, Section 70.

Table 38.1
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

38.12 The size of a conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 38.11, the size of the conductor or strap shall be in accordance with Table 38.2.

Table 38.2
Bonding wire conductor size

Rating of overcurrent device amperes	Size of bonding conductor[a]			
	Copper AWG	Wire (mm^2)	Aluminum AWG	Wire (mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)

Table 38.2 Continued on Next Page

Table 38.2 Continued

Rating of overcurrent device amperes	Size of bonding conductor[a]			
	Copper AWG	Wire (mm^2)	Aluminum AWG	Wire (mm^2)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)

[a] Or equivalent cross-sectional area.

38.13 A bonding conductor to a component or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component or components within the enclosure.

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

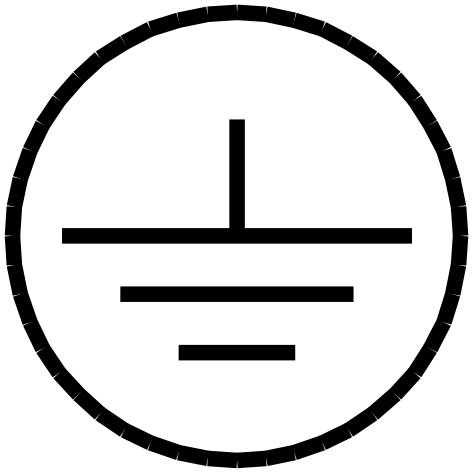
38.15 A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application, in accordance with the National Electrical Code, ANSI/NFPA 70.

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

38.17 The terminal for the connection of the equipment grounding conductor shall be a green not readily removable terminal screw with a hexagonal head, a green, hexagonal, not readily removable terminal nut, or a green pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the words "GREEN", "GROUND"; the letters "G", "GR"; a grounding symbol such as Figure 38.1; or otherwise identified by a distinctive green color. When the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be similarly marked.

Figure 38.1

Grounding symbol



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

38.19 Grounding and bonding equipment used to comply with this Section and other applicable requirements of this Standard shall comply with the Standard for Grounding and Bonding Equipment, UL 467.

39 Mounting of Electrical Components

39.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to restrict it from turning, except as noted in 39.2 and 39.3.

39.2 The requirement that a switch be restricted from turning away may be waived if all of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during 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) The spacings are not reduced below the required values if the switch rotates.

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

39.3 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 non-removable jewel, need not be restricted from turning if rotation cannot reduce spacings below the required values.

39.4 The means for restricting turning is to consist of more than friction between surfaces. A toothed lock washer that provides both spring takeup and an interference lock is acceptable as the means for restricting a small stem-mounted switch or other device having a single-hole mounting means from turning.

39.5 Uninsulated live parts shall be so secured to the base or mounting surface that they will be restricted from turning or shifting in position if such motion may result in a reduction of spacings below the acceptable values.

40 Electrical Enclosures

40.1 General

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

40.1.2 Among the factors taken into consideration when evaluating 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 part of an enclosure, all these factors are considered with respect to thermal and chemical aging.

40.1.3 The enclosure shall restrict 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.

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

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

40.1.6 Sheet metal complying with Table 40.1 and Table 40.2, whichever applies, is acceptable for the individual enclosure of electrical components.

40.1.7 Where the assembly and location of the component and the strength and rigidity of the outer cabinet warrant, an individual enclosure of thinner metal than specified in Table 40.1 or Table 40.2, whichever applies, may be employed.

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

40.1.9 All intended mounting positions of the unit are to be considered when determining compliance with the requirement in 40.1.3.

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

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

b) An opening between the box and motor frame having no dimension exceeding 1/2 inch (12.7 mm) shall restrict the entrance of a 13/64 inch (5.2 mm) diameter rod.

40.1.11 During the examination of a product to determine whether it complies with the requirements in 40.1.12 and 40.2.1 or 40.3.1 a part of the enclosure that may be opened or removed by the user without using a tool is to be opened or removed.

40.1.12 The probes mentioned in 40.3.1 and 40.3.2 and illustrated in Figure 40.1, Figure 40.2, Figure 40.4, and Figure 40.5 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 Figure 40.4 and Figure 40.5 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

40.1.13 The probes mentioned in 40.3.3 shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

Table 40.1
Minimum thickness of sheet metal for electrical enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Metal coated	
In inches	(cm)	In inches	(cm)	In inches	(cm)	In inches	(cm)	(MSG)		(GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.4)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.34)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	

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

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

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

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

Table 40.2
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
In inches	(cm)	In inches	(cm)	In inches	(cm)	In inches	(cm)	Inches (mm)	(AWG)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.2)	(0.74)	

Table 40.2 Continued on Next Page

Table 40.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
In inches	(cm)	In inches	(cm)	In inches	(cm)	In inches	(cm)	Inches (mm)	(AWG)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.4)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.4)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(1.91)	

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

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

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

3) An enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

40.2 Burners having a minimum input in excess of 3 gph (11.4 L/h)

40.2.1 For an oil burner having a minimum input in excess of 3 gph (11.4 L/h) the criteria for judging an opening in an electrical enclosure are given in the following items and the related figures:

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

1) A probe as illustrated in Figure 40.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

2) A probe as illustrated in Figure 40.2 cannot be made to touch film-coated wire when inserted through the opening.

b) An opening that will permit entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable under the conditions described in Figure 40.3.

Figure 40.1

Probe for uninsulated live parts

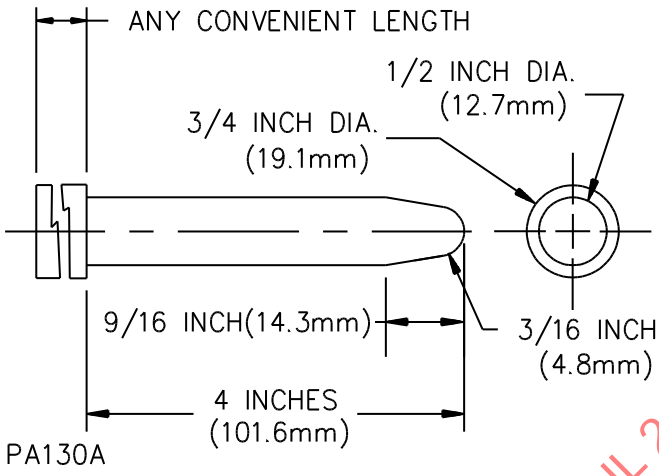


Figure 40.2

Probe for enamel-insulated wire

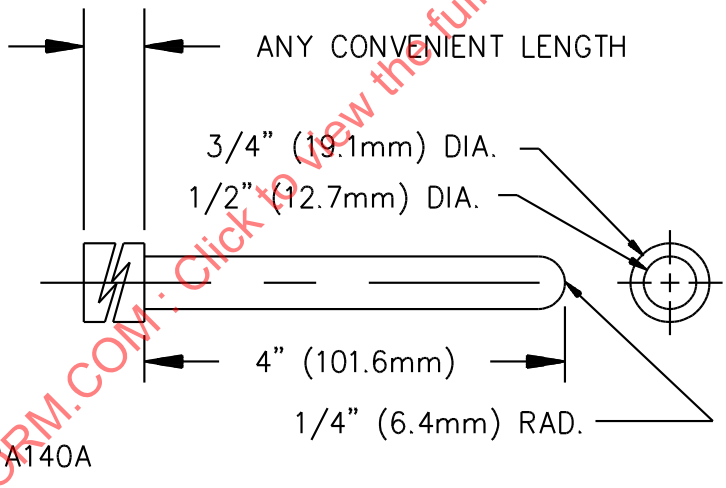
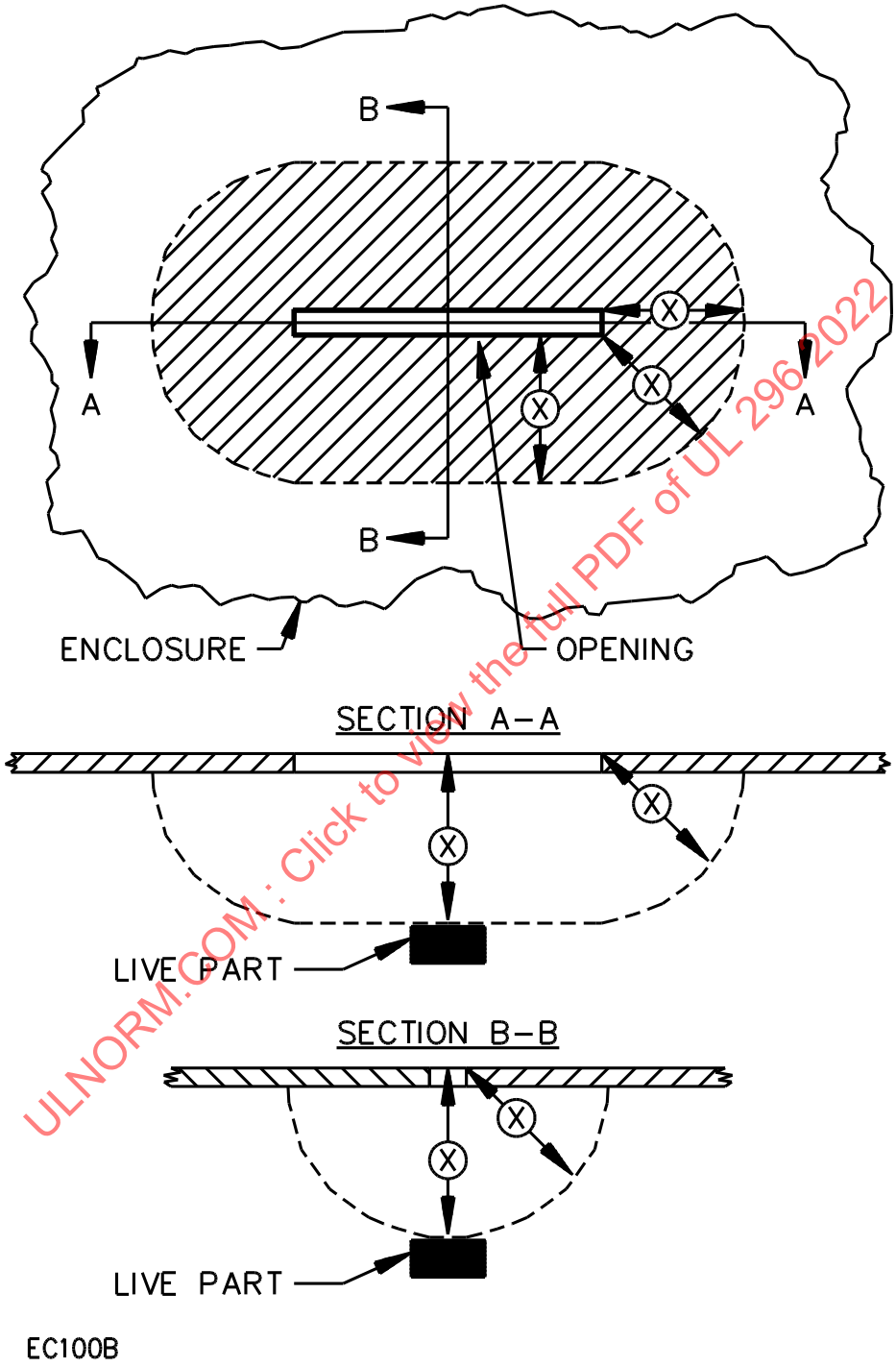


Figure 40.3

Opening in enclosure



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

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

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

40.3 Burners having a minimum input 3 gph (11.4 L/h) or less

40.3.1 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 either (a) or (b).

a) For an opening that has a minor dimension (see 40.3.3) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 40.4.

b) For an opening that has a minor dimension of 1 inch (25.4 mm) or more, such a part or wire shall be spaced from the opening as more, such a part or wire shall be spaced from the opening as specified in Table 40.3.

Exception: A motor need not comply with these requirements if it complies with the requirements in 40.3.2.

40.3.2 With respect to a part or wire as mentioned in 40.3.1, in an integral enclosure of a motor as mentioned in the exception to 40.3.1:

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

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 40.2.

2) In a directly accessible motor (see 40.3.4), an uninsulated live part cannot be contacted by the probe illustrated in Figure 40.5; and

3) In an indirectly accessible motor (see 40.3.4), an uninsulated live part cannot be contacted by the probe illustrated in Figure 40.1.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 40.3.

40.3.3 With reference to the requirements in 40.3.1 and 40.3.2, 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.

40.3.4 With reference to the requirements in 40.3.2, an indirectly accessible motor is a motor:

a) That 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) That is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

40.3.5 A directly accessible motor is a motor:

a) That can be contacted without opening or removing any part; or

b) That is located so as to be accessible to contact.

40.3.6 With reference to the requirements in 40.3.1 and 40.3.2, insulated brush caps are not required to be additionally enclosed.

Figure 40.4

Articulate probe with web stop

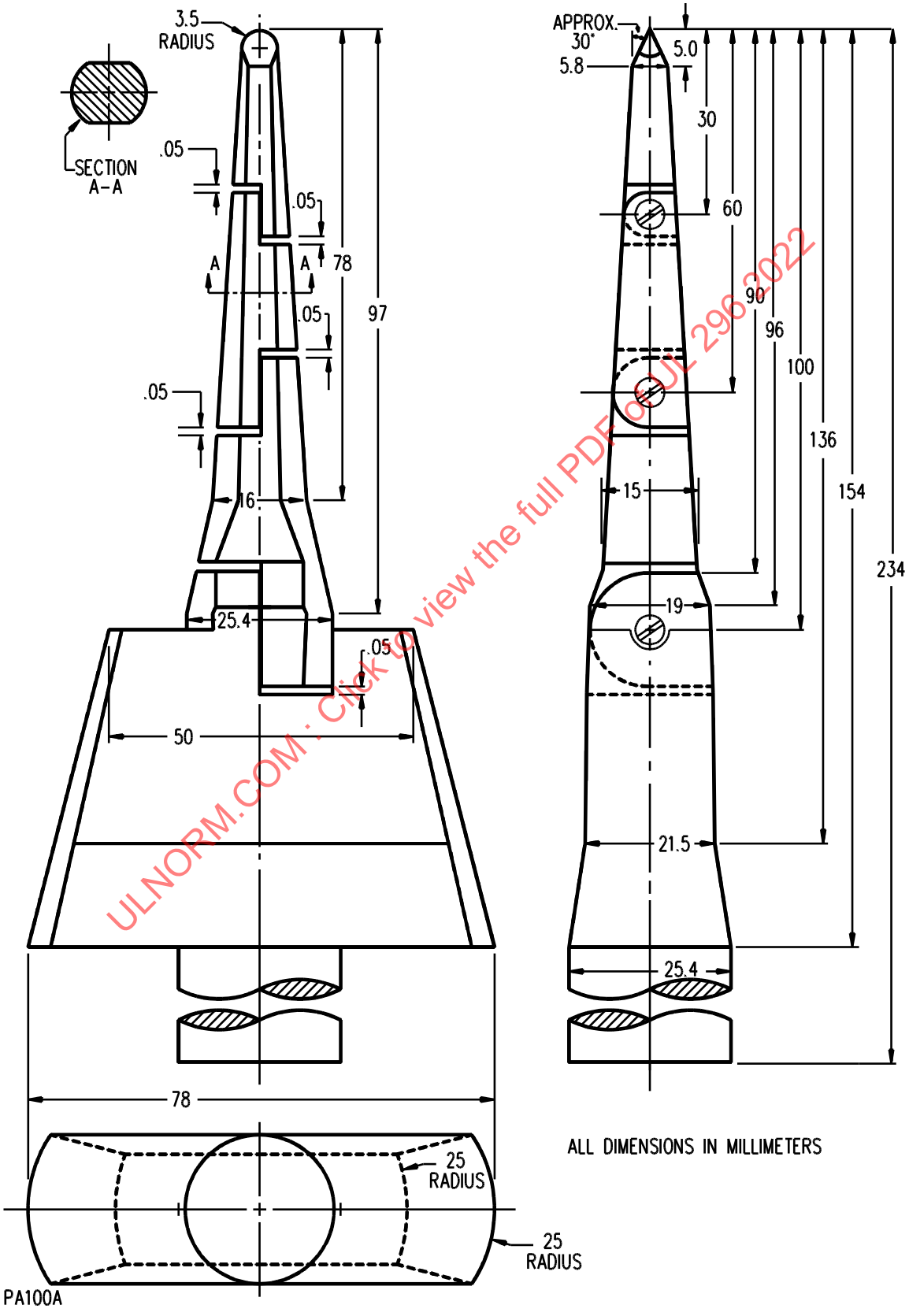


Table 40.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension[a] of opening		Minimum distance from opening to part,	
inches	(mm)	inches	(mm)[b]
3/4	(19.1)[c]	4-1/2	(114)
1	(25.4)[c]	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
d		30	(762)

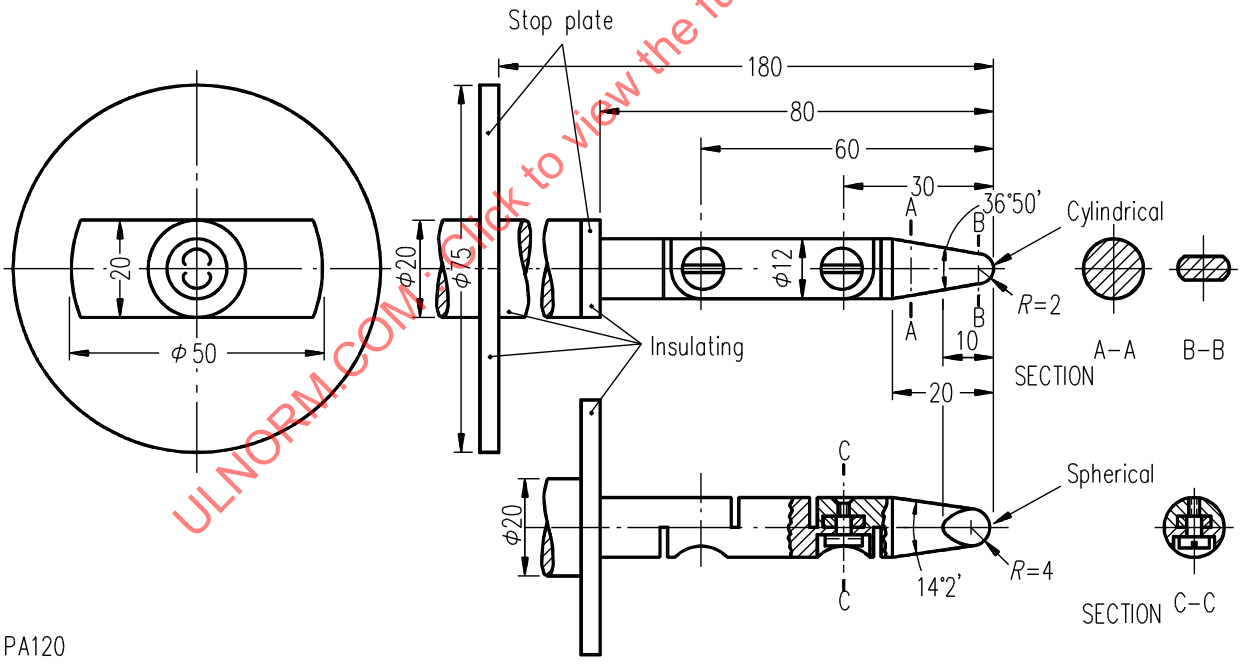
[a] See 40.3.3.

[b] Between 3/4 inch 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 (25.4 mm) applies to a motor only.

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

Figure 40.5
IEC articulate probe



40.4 Doors and covers

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

40.4.2 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.

40.4.3 The assembly shall be so arranged that an overcurrent protective device, such as a fuse, the protective functioning of which requires renewal, can be replaced and manual-reset devices can be reset without removing parts other than a service cover or panel, and a cover or door enclosing the device. See 40.4.7.

40.4.4 A required protective device shall be wholly inaccessible from outside the appliance without opening a door or cover, except that 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.

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

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

40.4.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the operation of the protective device such as resetting a manual reset overload protective device, except as indicated in 40.4.8.

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

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

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

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

d) Fuses in low-voltage circuits.

40.4.9 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.

40.4.10 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open it is considered to be an acceptable means for holding the door in place as required in 40.4.9.

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

40.4.12 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these and fastenings not more than 6 inches (152 mm) apart.

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

40.5 Field-wiring system connections

40.5.1 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) if uncoated steel, not less than 0.034 inch (0.86 mm) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

40.5.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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

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

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

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

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

b) 0.027 inch (0.69 mm) steel or 0.032 inch (0.81 mm) 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 securely mounted.

41 Motors and Motor Overload Protection

41.1 All motors shall be protected by an integral thermal protector or by an overcurrent protective device or combination thereof.

41.2 Overcurrent protective devices as referred to in 41.1 mean those which conform to the requirements of the National Electrical Code, ANSI/NFPA 70 as follows:

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

1) Motors with a marked service factor not less than 1.15 – 125 percent.

2) Motors with marked temperature rise not over 40°C (72°F) – 125 percent.

3) All other motors – 115 percent. For a multispeed motor, each winding connection shall be considered separately and the motor is to be protected at all speeds.

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

1) Motors with a marked service factor not less than 1.15 – 140 percent.

2) Motors with a marked temperature rise not over 40°C (72°F) – 140 percent.

3) All other motors – 130 percent.

41.3 An integral thermal protective device is to comply with the Standard for Thermally Protected Motors, UL 1004-3.

41.4 Separate overcurrent devices, except when included as part of a magnetic motor controller, are to be assembled as part of the equipment, and be identifiable as such after assembly to the equipment. Such protection is not to include means for manually interrupting the motor circuit if such interruption may affect the intended ignition, control and operation of the equipment.

41.5 Except as indicated in 41.6, 3-phase motors shall be provided with overload protection as follows:

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

b) Thermal protectors, combinations of thermal protectors and overcurrent devices, or equivalent methods of protection may be employed where the specific protective arrangement has been investigated and found to provide protection under primary single-phase failure conditions when supplied from transformers connected Wye-Delta or Delta-Wye. Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phasing conditions. This marking may be a paper sticker or decal, or may be on an attached wiring diagram.

41.6 If the assembly is such that it is not intended to be installed in isolated, inaccessible, or unattended locations, two properly rated overcurrent devices, or equivalent thermal protection, may be employed provided the assembly is marked to indicate it is for operation only in presence of a competent attendant.

41.7 Motors, such as direct-drive fan motors, 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 this requirement; provided it is determined that the motor will not overheat under actual conditions of use.

41.8 Impedance protection may be accepted for motors that are determined to be adequately protected against overheating due to locked-rotor current, provided it is determined that the motor will not overheat under the performance requirements of this standard.

41.9 Fuses shall not be used as motor overload protective devices unless the motor is adequately protected by the largest size fuse which can be inserted in the fuseholder.

41.10 Motors shall not exceed the temperature rises indicated in Table 58.1 when tested as described herein.

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

41.12 Interruption of the circuit to a motor by the overcurrent or overtemperature protective device shall not result in a risk of fire or explosion in the operation of the equipment or the 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. The device which interrupts the circuit to the valve may be independent of the motor circuit.

41.13 An automatic-reset type protective device shall not be used if the automatic reclosing of the circuit to the motor by the device may result in a risk of fire or explosion in the operation of the equipment.

41.14 The enclosure of a motor shall have no openings permitting a drop of liquid or a particle falling vertically onto the motor, to enter the motor as applied to the assembly.

41.15 Conformance to 41.14 may be provided by the motor frame or by other enclosure, structure, or shield, or by a combination of two or more such items, and is to be determined with the motor applied to the assembly.

41.16 Motors having openings in the enclosure or frame shall be installed or shielded to restrict particles from falling out of the motor on to flammable material within or under the assembly.

41.17 The requirement in 41.16 will necessitate the use of a barrier of nonflammable material 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, or

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

1) Open main winding,

2) Open starting winding,

3) Starting switch short-circuited, and

4) Capacitor shorted (permanent split capacitor type), or

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will reduce the likelihood that the temperature of the motor windings will become more than 125°C (257°F) under the maximum load below which the motor will run without causing the protector to cycle and from becoming more than 150°C (302°F) with the rotor of the motor locked.

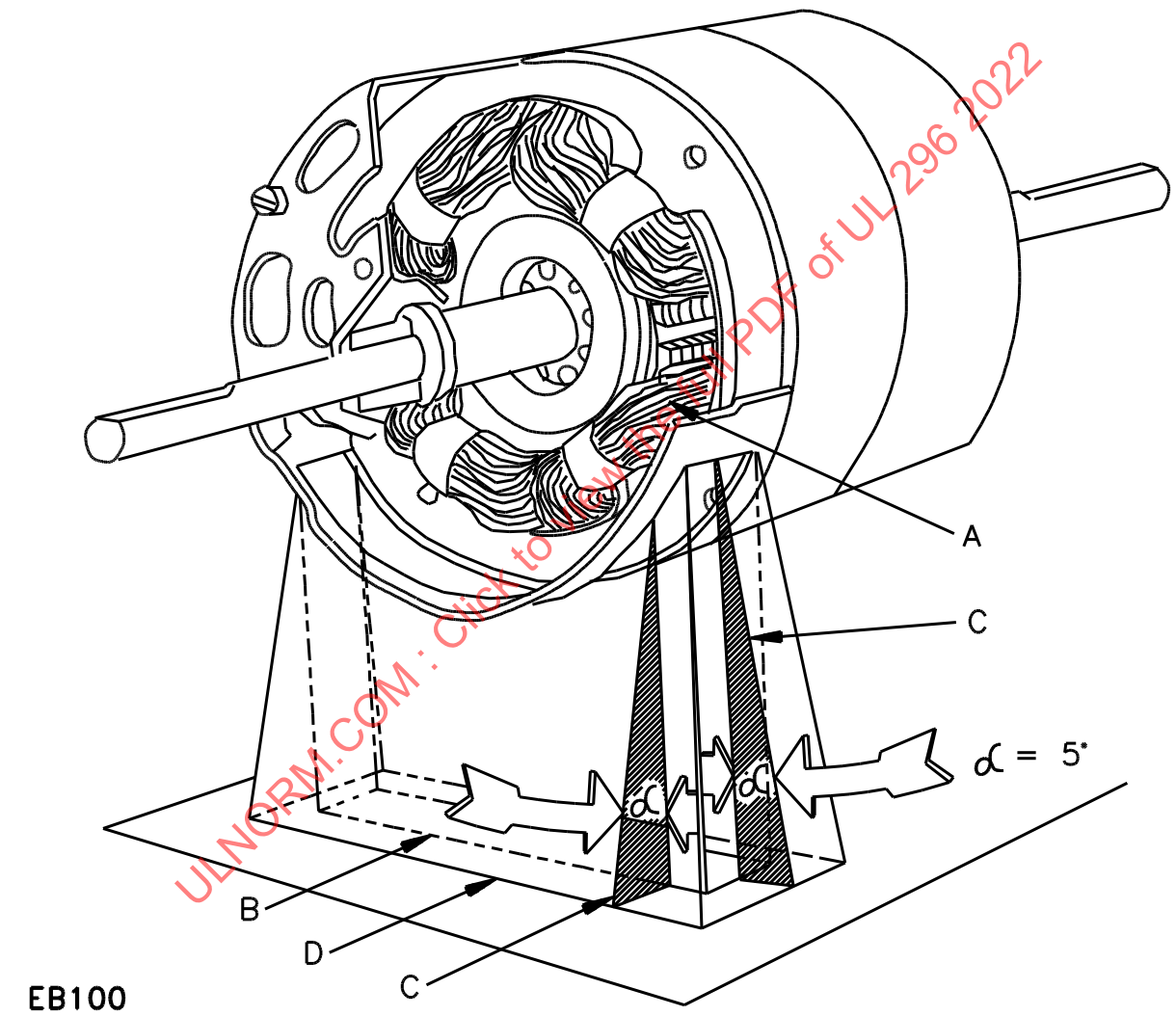
d) The motor complies with the requirements for impedance-protected motors and the motor winding will not exceed a temperature greater than 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

41.18 The barrier mentioned in 41.17 shall be horizontal, shall be located as indicated in Figure 41.1 and shall have an area not less than that described in that illustration. Openings for drainage and ventilation may be employed in the barrier, provided that such openings would not permit molten metal, burning insulation, or the like to fall on flammable material.

41.19 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short Circuit Test, Section 70.

Figure 41.1

Location and extent of barrier



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

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

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always

1) Tangent to the motor winding,

2) Five degrees from the vertical, and

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

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

41.20 Motors shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

42 Switches and Controllers

42.1 Except as indicated in 42.2 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.

42.2 A controller is not required for an assembly with more than one motor if the marked maximum fuse size does not exceed 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, and with not more than 6 amperes full-load current for any one of the motors.

42.3 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 in accordance with 74.15 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

42.4 A controller or switch shall be rated for the load which it controls.

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

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

42.7 If the controller is cycled by the operation of an automatic-reset overload device, it is to withstand an endurance test under locked-rotor conditions. The endurance test is to be of a duration equivalent to that required for the automatic-reset overload device and at an equivalent rate.

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

42.9 If the marked maximum fuse size of the oil burner 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 more severe intended conditions of service that might be encountered.

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

42.11 As applicable, switches shall comply with the Standard for Enclosed and Dead-Front Switches, UL 98, the Standard for General-Use Snap Switches, UL 20 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

42.12 Controllers shall comply with the following, as applicable:

a) The Standard for Industrial Control Equipment, UL 508;

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1;

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1; or

d) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2.

43 Capacitors

43.1 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 reduce the likelihood of the emission of flame or molten material resulting from failure of the capacitor. Except as noted in 43.2 and 43.3, the container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

43.2 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 burner and provided that such box, case, and the like, is acceptable for the enclosure of current-carrying parts.

43.3 If the container of an electrolytic capacitor is constructed of metal, it shall be insulated from dead metal parts in accordance with Table 45.1.

43.4 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 70.

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 in Table 70.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

43.5 Capacitors shall comply with the Standard for Capacitors, UL 810.

44 Electrical Insulating Material

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

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

45 Spacings – High-Voltage Circuits

45.1 Except as noted in 45.2 – 46.5, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than the values indicated in Table 45.1.

45.2 The through air and over surface spacings at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load or loads which 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 through air and over surface spacings at a component which controls only a motor is judged on the basis of the volt-amperes of the motor. A component which controls loads in addition to the motor is 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 is judged on the basis of the volt-amperes of the larger load. The volt-ampere values for the load referred to above are to be determined by the measured input.

45.3 The spacing requirements in Table 45.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component that is judged on the basis of the requirements for the component. However, the electrical clearance resulting from the installation of a component, including clearances to dead metal or enclosures, are to be those indicated in the table.

Table 45.1
Minimum spacings

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

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

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

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

[d] 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.

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

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

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

45.7 The spacings "To Enclosure" are not to be applied to an individual enclosure of a component part within an outer enclosure or cabinet.

46 Spacings – Low-Voltage Circuits

46.1 The spacings for low-voltage electrical components that are installed in a circuit which includes a motor overload protective device, or other protective device, where a short or grounded circuit may affect the intended ignition, control, and operation of the burner, shall comply with 46.2 – 46.5.

46.2 The spacing between an uninsulated live part and the wall of a metal enclosure including fittings for the connection of conduit or metal-clad cable shall be not less than 1/8 inch (3.2 mm). See 45.3.

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

46.4 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 not less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be definitely maintained.

46.5 The spacings in low-voltage circuits that do not contain devices such as those indicated in 46.1 are not specified.

47 Combination Gas-Oil Burners

47.1 A combination burner intended to burn only one fuel at a time shall be arranged 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.

47.2 A combination burner intended to burn only one fuel at a time, equipped to change automatically from one fuel to the other, shall be arranged 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.

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

47.4 An automatically or remotely lighted combination burner shall be equipped 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 assured (proved pilot).

PERFORMANCE

48 General

48.1 The performance of a burner is to be judged upon the basis of operation tests conducted on the burner using any grade of fuel recommended 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 prescribed herein. If optional features affecting performance are furnished, the burner may be tested with each such optional equipment.

48.2 A burner, when tested in accordance with these requirements, shall be uniform and reliable in operation and free from excessive carbonization or other phenomena that may adversely affect the intended operation of the burner.

48.3 Burners equipped, or intended to be equipped 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 arranged so that no oil can be delivered to the burner for combustion until it has been heated to the intended temperature.

49 Measurements

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

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

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

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

49.5 Temperatures shall be measured by thermocouples except that the change-of-resistance method may be used to measure the temperature of motor windings or of coils. The thermocouples shall consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouple wire shall conform to 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.

49.6 Where thermocouples are used in the determination of temperatures in connection with the heating of electrical equipment, it is a standard practice to employ 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.

49.7 Thermocouples are to be attached to pertinent materials and parts, such as those mentioned in Table 58.1.

49.8 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.

50 Test Voltage

50.1 Unless otherwise specified, burners are to be tested at the potentials indicated in Table 50.1 for each test as detailed in the paragraphs describing the test.

Table 50.1
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

Table 50.1 Continued on Next Page

Table 50.1 Continued

Rated voltage	Normal test voltage	Overvoltage	Undervoltage[a]
440 – 480	480	528	408
550 – 600	600	660	510
Other	Rated	110 percent	85 percent
		Rated	Rated

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

51 Combustion Tests

51.1 General

51.1.1 Combustion shall be stable and complete at all firing rates over the operating range of the burner without excessive smoke and without causing the formation of excessive carbonization.

51.1.2 The performance of a burner during the prescribed Test No. 1 (51.2.1 – 51.2.13) and Test No. 2 (51.3.1 – 51.3.16) shall be deemed to be in accordance with 51.1.1 when:

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. Burner flames do not flash outside the heating appliance being fired.

d) The observed smoke at all firing rates during the prescribed tests does not exceed the following on the Shell-Bacharach scale with the Model RDC smokemeter:

1) Number 1 spot for all mechanical draft burners having a maximum capacity not exceeding 7 gph (26.5 L/h) firing a distillate type fuel.

2) Number 2 spot for all vaporizing type burners firing a distillate type fuel and for mechanical draft burners having a maximum capacity in excess of 7 gph (26.5 L/h) firing a distillate type fuel.

3) Number 4 spot for all burners firing a residual type fuel.

e) Combustion at all firing rates is complete and consistent during the test.

f) No excess amount of soot is deposited on surfaces of the heat exchanger, flue passages, or the flue pipe of the heating appliance fired for the test. Any tar or flocculent soot accumulation is deemed excessive.

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

h) No excess amount of carbon, soot, and tar has been deposition on surfaces or accumulated on or in vaporizing burners and ignition rings of wall-flame burners. Any accumulation likely to be deleterious to the performance of the burner that continually increases as the test progresses, or that reduces the area of air openings in the burner or restricts fuel input, is to be deemed excessive.

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

j) An escapement or bleed pilot flame is freely ignited by the constant-burning pilot.

51.2 Mechanical-atomizing burners– test no. 1

51.2.1 The burner is to be installed for test in a boiler of a size commensurate with the firing rate of the burner to be tested, except that a burner intended for application to a specific appliance may be tested as applied to that appliance or an appliance representative of the appliance for which the burner is designed.

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

51.2.3 The burner is to be arranged for operation in accordance with the instructions furnished by the manufacturer. The burner is to be fired at a rate within the rating of the burner. A fire box, hearth, or the like, as recommended or furnished by the manufacturer, is to be provided.

51.2.4 The burner is to be fired with the heaviest grade of fuel for which the burner is rated and the air-fuel ratio adjusted in accordance with the manufacturer's instructions. The draft over fire is to be the value recommended by the manufacturer, but is not to exceed 0.03 inch (0.76 mm) water column for burners fired at 5 gph (18.9 liter/hr) or less; and shall not exceed 0.05 inch (1.27 mm) water column for burners fired at more than 5 gph (18.9 liter/hr), but not more than 16 gph (60.6 liters/hr); except that for a burner intended only for application to a specific appliance equipped with forced or induced draft fan or both, the draft is to be as specified by the manufacturer. Voltage is to be adjusted to the normal test voltage specified in Table 50.1.

51.2.5 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 is to be not more than that indicated on the Shell-Bacharach smoke scale with the Model RDC smokemeter as specified in 51.1.2(d).

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

51.2.7 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.

51.2.8 A manually-lighted automatically-regulated burner is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire if the burner is designed to be so fired, and 10 minutes on minimum fire.

51.2.9 A manually-lighted manually-regulated burner is to be fired in successive cycles, each cycle consisting of 2 hours on high fire, 2 hours on intermediate fire, and 4 hours on minimum fire.

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

51.2.11 The fuel-burning rate, draft over fire, smoke, and CO_2 on each operating fire are to be observed and recorded at the beginning of the test, after each 50 hours of operation thereafter, and at the end of the test.

51.2.12 The duration of these tests is to be that required to obtain conclusive performance data, and is expected to be until the burner has been fired for 250 hours.

51.2.13 Following Test No. 1 the total electrical input and the electrical input of each component, except those having a pilot duty rating, are to be measured.

51.3 Vaporizing burners – test no. 2

51.3.1 The burner is to be installed for test in a boiler of a size commensurate with the firing rate of the burner to be tested, except that a burner intended for application to specific appliances may be tested as applied to that appliance or an appliance representative of the appliances for which the burner is designed.

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

51.3.3 The burner is to be arranged for operation in accordance with the instructions furnished by the manufacturer and installed in a boiler or appliance capable of being fired at the maximum rating of the burner.

51.3.4 The burner is to be fired with the heaviest grade of fuel for which the burner is rated and the air-fuel ratio adjusted in accordance with the manufacturer's instructions. The draft regulator is to be adjusted to maintain the manufacturer's recommended high-fire draft which is not to exceed 0.06 inch (1.52 mm) water column. Draft settings are to be made normally on high fire. No change in draft or combustion air adjustment is to be made for other firing rates unless changed automatically, except for a manually regulated burner when the instructions on the burner so state, in which case correlation of the calibrations of the fuel and draft or air adjustment shall be included with those instructions. Voltage is to be adjusted to the normal test voltage specified in Table 50.1.

51.3.5 The burner is to be fired at each operating fire rate until steady-state combustion conditions exist. Smoke observations are then made in accordance with 51.3.6 – 51.3.8. The observed smoke is to be not more than that indicated by number 2 on the Shell-Bacharach smoke scale with the Model RDC smokemeter.

51.3.6 Observations are to be made of the smoke produced by a pilot fire over the allowable range of pilot firing rates in 1 cc increments from the minimum rate to and including a rate of 10 cc per minute or the maximum pilot rate allowed by the fuel metering device, whichever is smaller.

51.3.7 A manually-regulated burner and a modulating burner are to be fired successively at rates beginning with a firing rate of 10 cc per minute or the minimum rate allowed by the fuel-metering device and then at rates progressively increasing in increments equivalent to approximately 10 percent of the maximum high-fire rate as allowed by the metering device. The smoke is to be observed at all those firing rates.

51.3.8 An automatically-regulated burner intended to fire at one or more predetermined firing rates is to be fired at the minimum and maximum firing rates allowed by the fuel-metering device and at allowable intermediate rates in steps equivalent to approximately 10 percent of the maximum firing rate. Smoke observations are to be made at all those firing rates.

51.3.9 The burner is to be fired in accordance with the appropriate schedule described in 51.3.10 – 51.3.12. The firing rate selected for these tests is to be the allowable rate in each range which produced more smoke as determined in accordance with 51.3.5 – 51.3.8. The air-fuel ratio for the test is to be adjusted as recommended by the manufacturer's instructions.

51.3.10 A manually-regulated burner is to be fired each week of the test in accordance with the following schedule:

a) Five successive days per week –

1) Four hours at high fire

2) Four hours at intermediate rate

3) Sixteen hours at low or pilot rate

b) Two successive days per week at low or pilot rate.

The normal duration of the test is expected to be four weeks.

51.3.11 An automatically-regulated burner intended to operate with an oil pilot is to be fired 30 minutes on a high fire, 30 minutes on an intermediate fire if the burner is intended to be so fired, and 30 minutes on pilot fire, as a continual cycle for five successive days per week, then on pilot continuously for two successive days per week, each week of the test. The duration of the test is expected to be that required to obtain 250 hours of operation on high fire.

51.3.12 An automatically-regulated burner equipped with electric or gas ignition is to be fired 30 minutes on high fire, or on each fire stage if the burner is intended to operate with multiple stage fires, and then be off for 30 minutes as a continual cycle throughout the test. The duration of the test is expected to be that required to obtain 250 hours of operation on high fire.

51.3.13 During the test period, daily observations and recordings are to be made of the draft on all operating fires, ignition and combustion characteristics, combustion chamber conditions, and any abnormal performance.

51.3.14 The fuel-burning rate and draft over fire are to be determined and smoke observation and flue-gas analyses are to be made on each operating fire and recorded at the beginning of the test, after each period of 50 hours of operation on high fire, and at the end of the test.

51.3.15 At the end of the tests described in 51.3.10 and 51.3.11, smoke observations as described in 51.3.7 and 51.3.8 are to be made.

51.3.16 Following the above test the voltage is to be adjusted to rated voltage and the total electrical input and the electrical input of each component, except those having a pilot duty rating, are to be measured.

52 Combustion Air Failure Test – Test No. 3

52.1 A mechanical draft burner not provided with a combustion air interlock shall operate in accordance with the requirements specified in 52.3 and 52.4 during interruption and upon restoration of the combustion-air supply.

52.2 The initial conditions for the test are to be as for Test No. 1 (51.2.1 – 51.2.4), or Test No. 2 (51.3.1 – 51.3.4). The test may be conducted during the course of the Combustion Tests, Section 51. While the burner is being fired at any operating fire, the fan supplying air for combustion is to be stopped, that is, 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 in accordance with 52.3 or combustion, if continued, is to be in accordance with 52.4.

52.3 If the main burner flame is extinguished following interruption of the air supply, the fuel is to be shut off due to the inherent design of the burner or by action of a safety control within the safety control timing period specified in Table 30.1. 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 provided the intended automatic re-ignition is obtained.

52.4 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 ignited 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 indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 51.1.2(d).

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test.

c) Combustion is stable at all times during the test.

d) The reignition of the main burner flame is effected completely and without backfire, flash or "puff."

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

53 Interruption of Atomization Test – Test No. 4

53.1 A mechanical atomizing burner employing air, steam, or a mechanical device for atomizing fuel shall be arranged to shut off the delivery of fuel for combustion upon interruption of the atomizing media or the operation of the mechanical device.

53.2 The initial conditions for the test are to be as for Test No. 1 (51.2.1 – 51.2.4). The test may be conducted during the course of the Combustion Tests, Section 51. While the burner is being fired at any operating fire, the atomizing media or operation of the mechanical device is to be interrupted, that is, 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 an atomizing media furnished by a source other than the burner. Fuel to the main burner flame is to be shut off due to the inherent design of the burner or by action of the safety control timing period specified in Table 30.1. The burner is to require manual restart upon restoration of the atomizing means, or an automatically lighted burner may restart upon restoration of the atomizing means provided the intended automatic reignition is obtained.

54 Undervoltage Test – Test No. 5

54.1 A burner shall operate in accordance with the requirements specified in 54.2 when tested at an undervoltage as specified in Table 50.1.

54.2 The initial conditions for test are to be as for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4), except that the test voltage shall be regulated to maintain the appropriate undervoltage, as specified in Table 50.1. The test may be conducted during the course of the Combustion Tests, Section 51. The performance of the burner 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.

d) Flames at all allowable firing rates do not produce smoke in excess of that indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 51.1.2(d).

e) The burner is capable of operation without interruption.

55 Power Interruption Test – Test No. 6

55.1 A power-operated burner shall operate in accordance with the requirements of 55.3 or 55.4, during interruption and upon restoration of the power supply.

55.2 The initial conditions for test are to be as for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4). The test may be conducted during the course of the Combustion Tests, Section 51. 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 in accordance with 55.3, or combustion, if continued, is to be in accordance with 55.4.

55.3 If the main burner flame is extinguished immediately following interruption of the power supply, the oil shall be automatically shut off due to the inherent design of the burner or by action of a safety control. The burner shall 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 provided the intended automatic reignition is obtained.

55.4 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 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 indicated on the Shell-Bacharach scale with the Model RDC smokemeter, as specified in 51.1.2(d).

b) Flames are not expelled at any time from the burner or the heating appliance being fired for the test.

c) Combustion is stable at all times during the test.

d) The reignition of the main burner flame is effected without backfire, flash, or "puff."

e) Soot does not accumulate in the appliance being fired for the test and in the flue pipe to such an extent that stable combustion cannot be obtained.

56 Temperature Test – Test No. 7

56.1 The maximum temperature rise attained by burner parts shall not be more than the temperature rise indicated for such parts in Column 1, Table 58.1, while the burner is fired continuously at any rate of firing specified for Test No. 1 or Test No. 2 of the Combustion Tests, Section 51, or during the period immediately following termination of such firing. Also, the maximum temperature on any handle which the operator may need to touch to regulate or shut off the burner shall not exceed room temperature by more than 60°F (33°C) for metallic parts, nor more than 80°F (44°C) for nonmetallic parts.

56.2 The burner, as arranged and installed for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4), is to be fired at any test rate specified until equilibrium temperatures are attained. Room temperature is to be taken from 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.

57 Ignition Tests, Multiple Igniters

57.1 A burner equipped with multiple igniters, each of which is capable of functioning independently of the others, shall be so designed that when the burner is tested in accordance with the requirements of Sections 58 – 63, any one igniter will effect ignition while the others are inactive.

58 Ignition Tests, Electric High-Tension

58.1 Reduced voltage – cold oil – test no. 8

58.1.1 A high-tension ignition system for an automatically- or remotely-lighted burner shall effect the intended ignition of the fuel as introduced into the ignition zone when a voltage equivalent to 70 percent of normal test voltage is impressed on the primary circuit of the ignition system, the combustion air supply and burner are at room temperature and the temperature of the oil supplied to the burner is reduced to the value specified in 58.1.2.

58.1.2 The burner, arranged and installed as for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4), is to be tested after it has been subjected to the combustion Tests, Section 51, except that the test voltages are as indicated in 58.1.3. 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 oil fuel being used for the test. The spark gap or gaps are to be adjusted to the maximum recommended by the manufacturer, but not less than 1/8 inch (3.2 mm), if the burner is to employ an "Interchangeable transformer. The temperature of the oil as 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 equipped with a preheater, the temperature of the oil at the inlet to the preheater is to be not less than 20°F (11°C) above the pour point of the test fuel.

58.1.3 Except as indicated in 58.1.4, 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.

58.1.4 If the burner is equipped 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.

58.1.5 The burner and ignition circuits are to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. If the burner is to employ 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. During each trial, ignition is to be effected so that no flame is to be expelled from the burner or the heating appliance being fired for the test.

58.1.6 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes, during which period stable combustion is to be maintained.

Table 58.1
Maximum temperature rises for some items

Items	Maximum rise above room temperature			
	Column 1		Column 2	
	Degrees C	Degrees F	Degrees C	Degrees F
A. MOTORS				
1. Class A insulation on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors)[a,b]				
a. In open motors;				
Thermocouple or resistance method	75	135	115	208
b. In totally enclosed motors;				
Thermocouple or resistance method	80	144	115	208
2. Class A insulation on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors (not including universal motors)[a,b]				
a. In open motors;				
Thermocouple method	65	117	115	208
Resistance method	75	135	115	208
b. In totally enclosed motors;				
Thermocouple method	70	126	115	208
Resistance method	80	144	115	208
3. Class B insulation on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors)[a,b]				
a. In open motors;				
Thermocouple or resistance method	95	171	140	252
b. In totally enclosed motors;				
Thermocouple or resistance method	100	180	140	252
4. Class B insulation on coil windings of alternating-current motors having a frame diameter of more than 7 inches, of direct-current motors, and of universal motors[a,b]				
a. In open motors;				
Thermocouple method	85	153	140	252
Resistance method	95	171	140	252
b. In totally enclosed motors;				
Thermocouple method	90	162	140	252
Resistance method	100	180	140	252
B. COMPONENTS				
1. Capacitors				
a. Electrolytic type[c]	40	72	Not specified	
b. Other types[d]	65	117	Not specified	
2. Class 130 insulation (except motor coil windings)				
a. Thermocouple method	85	153	140	252
b. Resistance method	95	171	140	252
3. Phenolic composition used as electrical insulation or as parts where malfunction will result in a risk of fire or electric shock	125	225	150	270
4. Relay, solenoid, and other coils with Class 105 insulated winding				

Table 58.1 Continued on Next Page

Table 58.1 Continued

Items	Maximum rise above room temperature			
	Column 1		Column 2	
	Degrees C	Degrees F	Degrees C	Degrees F
a. Thermocouple method	65	117	115	208
b. Resistance method	85	153	115	208
5. Transformer enclosures				
a. Class 2 transformers	60	108	85	153
b. Power transformers	65	117	90	162
6. Sealing compounds	Maximum Temperature 15°C (27°F) less than melting point			
7. Fuses[h]	65	117	Not specified	
C. CONDUCTORS				
1. Conductors of field-wired circuits to be connected to burner and surface on which they may bear unless marked in accordance with 74.6	35	63	60	108
2. Wire Code[e]	25°C (45°F) less than temperature rating in National Electrical Code, ANSI/NFPA 70		Temperature rating in National Electrical Code, ANSI/NFPA 70	
3. Appliance wiring material[e]				
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
4. GTO cable	35	63	60	108
5. Flexible cord				
Types SO, ST, SJO, SJT	35	63	60	108
D. ELECTRICAL INSULATION – General				
1. Fiber used as electrical insulation or cord bushings	65	117	90	162
E. GENERAL				
1. Oil in constant-level valve	14	25	22	40
2. Carbon steel sheet, cast iron	517	930	683	1230
3. Aluminum alloys				
1100	183	330	239	430
3003	239	430	294	530
2014, 2017, 2024, 5052	294	530	350	630
4. Aluminum-coated steel[f]	656	1180	767	1380
5. Stainless steel				
Types 302, 303, 304, 316, 321, 347	767	1380	878	1580
Type 309	961	1730	1072	1930
Type 310	1017	1830	1128	2030
Type 405	683	1230	795	1430
Types 403, 409, 410, 416	572	1030	683	1230

Table 58.1 Continued on Next Page

Table 58.1 Continued

Items	Maximum rise above room temperature			
	Column 1		Column 2	
	Degrees C	Degrees F	Degrees C	Degrees F
Type 430	711	1280	822	1480
Type 442	877	1580	933	1680
Type 446	961	1730	1072	1930
6. Galvanized steel[g]	267	480	350	630
7. Carbon steel – coated with Type A19 ceramic	572	1030	683	1230

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

[b] 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 maximum, of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating-current motor, having a diameter of 7 inches or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be 5°C (9°F) for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type, 10°C (18°F) for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type, 15°C (27°F) for a Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type, and 20°C (36°F) for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type, more than the indicated maximum, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

[c] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F).

[d] These limitations do not apply to capacitors which are rated for service at higher temperatures.

[e] The limitations on rubber and thermoplastic insulation and on phenolic composition do not apply to compounds which have been investigated and found to be acceptable for higher temperatures than those specified in Table 58.1. Thermoplastics shall in no case attain temperature at which the material begins to flow. Rubber-insulated conductors within a Class A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), provided that an acceptable braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[f] When the reflectivity of aluminum-coated steel is utilized to reduce risk of fire, the maximum allowable temperature rise is 830°F (461°C).

[g] 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 risk of fire.

[h] Includes both casing and ferrule. However, a temperature not more than 20°C (36°F) higher than the values indicated in the table is acceptable on the casing (not ferrule) of a Class G, J, T, or L fuse.

58.2 Combustion detectors – test no. 9

58.2.1 The combustion detector of a primary safety control that is capable of detecting the presence of ignition spark shall be so positioned that the combustion detector shall sense only the presence or absence of flame.

58.2.2 The test is to be made in conjunction with Test No. 1 (51.2.1 – 51.2.13). 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 50.1. 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.

59 Ignition Test, Electric Hot-Wire

59.1 Reduced voltage – test no. 10

59.1.1 When a burner equipped with an electric hot-wire ignition system is energized at a reduced voltage not less than specified herein, with the combustion air supplied at room temperature and the oil at a normal temperature, the intended ignition, if obtained, shall conform with the requirements of 59.1.4. The voltage shall be not less than 70 percent of the normal test voltage or not less than the minimum voltage below which the burner is prevented positively from attempting a trial for ignition, whichever is higher. This requirement does not apply to a burner equipped with a positive means to prevent the burner from attempting a trial for ignition at voltages less than 85 percent of normal test voltage for alternating current or 80 percent of rated voltage for direct current shipment. See also 59.2.1.

59.1.2 A positive means for preventing a burner from attempting a trial for ignition below a given voltage is one that will always prevent an attempt to start when the voltage is below a specific value and will disconnect the burner from the power source if the voltage drops below the specific value after an attempt to start has begun.

59.1.3 The burner, arranged and installed as for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4), is to be tested after it has been subjected to the Combustion Tests, Section 51, except that the total voltage is to be as indicated in 59.1.4. The oil-temperature control for a burner intended to burn preheated oil is to be set for the maximum temperature recommended in the manufacturer's instructions. The oil supplied to any parts of the burner, except those located downstream from the preheater, is to be at room temperature. If a burner is equipped with a preheater, the temperature 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.

59.1.4 The voltage of the power supply to the primary of the ignition system is to be reduced to a voltage not less than specified in 59.1.1. The burner is to be energized and allowed to remain energized for the design trial-for-ignition period. Five trials are to be made at each test voltage. If ignition is effected, such ignition shall be effected so that no flame is expelled from the burner or the heating appliance being fired for the test.

59.2 Reduced voltage – test no. 11

59.2.1 A hot-wire ignition system for an automatically- or remotely-lighted burner shall effect the intended ignition of the fuel as introduced into the ignition zone when a voltage equivalent to 85 percent of normal test voltage for alternating-current systems or 80 percent of rated voltage for direct-current systems is impressed on the burner, the combustion air is supplied at room temperature, and the temperature of the oil supplied to the burner is reduced to a value as specified in 59.2.2.

59.2.2 The burner, arranged and installed as for Test No. 1 (51.2.1 – 51.2.4) or Test No. 2 (51.3.1 – 51.3.4), is to be tested after it has been subjected to the Combustion Tests, Section 51, except that the total voltage is to be as indicated in 59.2.3. 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 oil fuel being used for the test. 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 equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at room temperature.

59.2.3 The voltage of the power supply to the burner is to be reduced to 85 percent of normal test voltage for alternating current or to 80 percent of rated voltage for direct current.

59.2.4 The burner is to be energized and allowed to remain energized for the designed 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 the heating appliance being fired for the test.

59.2.5 Following the last trial for ignition described in 59.2.4, and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes, during which period stable combustion is to be maintained.

59.3 Endurance – test no. 12

59.3.1 The igniter of a hot-wire ignition system for an automatically- or remotely-lighted burner shall be capable of functioning as intended for at least 6000 ignition cycles.

59.3.2 Three samples of the igniter are to be tested. The burner is to be connected to a power source having the appropriate overvoltage as specified in Table 50.1. The system is to be energized and then de-energized successively as repeating cycles. The duration of the on period is to be the trial-for-ignition period for automatically-lighted burners and the average time required to establish ignition as determined during Test No. 1 or Test No. 2 (see Section 51, for manually-lighted burners). The duration of the off period is to be twice the on period unless the control system requires a longer time to complete a cycle of operation, in which case the off period is to be the minimum allowed by the control system. There shall be no electrical or mechanical failure of the igniters during the tests.

59.4 Component temperatures – test no. 13

59.4.1 Parts of a hot-wire ignition system shall not attain temperature rises in excess of those indicated for such parts in Column 1, Table 58.1, when the system is energized as follows:

a) A system intended to automatically recycle on ignition or flame failure shall be allowed to cycle until equilibrium temperatures are attained by the parts.

b) A system intended to require manual reset upon ignition or flame failure shall be energized and then reset as quickly as the system will allow after lockout until five attempts for ignition have been made.

c) A system that remains energized upon ignition failure shall be energized continuously until equilibrium temperatures are attained by the parts.

d) A system manually energized by means of a momentary contact switch that cannot be left in the on position shall be energized for 5 minutes.

e) A system manually energized by means of a switch that can be left in the on position shall be energized continuously until equilibrium temperatures are attained by the parts.

59.4.2 This test is to be made with the burner installed as for Test No. 1 or Test No. 2, but with the fuel supply to the burner shut off during attempted trials for ignition. Temperatures are to be measured as described in Section 56.

60 Ignition Tests, Gas

60.1 Reduced voltage – test no. 14

60.1.1 A pilot flame for an automatically- or remotely-lighted burner shall effect ignition of the fuel as introduced into the ignition zone in accordance with the requirements of 60.1.4, when the voltage of the power supply to the burner is 85 percent of rated voltage for alternating current and 80 percent of rated