



Underwriters Laboratories Inc.®

A not-for-profit organization dedicated to public safety
and committed to quality service

January 29, 1996

Revision pages for

Standard for

Waste Oil-Burning Air-Heating Appliances

UL 296A, Second Edition

Attached to this transmittal notice is a revision of the Second edition of UL 296A.

A CHANGE ON A PAGE DATED JANUARY 29, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THIS REVISION IS CONSIDERED NON-SUBSTANTIVE AND IS BEING ISSUED TO ELIMINATE THE OXYGEN BOMB TEST. THE OXYGEN BOMB TEST IS NO LONGER APPROPRIATE IN MOST CASES DUE TO THE ADDITION OF ANTIOXIDANTS TO RUBBER AND POLYMERIC COMPOUNDS. THEREFORE, UL IS ELIMINATING THE OXYGEN BOMB TEST AND REPLACING IT WITH AN AIR OVEN AGING TEST WHICH IS USED FOR THERMOPLASTIC COMPOUNDS. THE REQUIREMENTS ARE NOW IN EFFECT.

Revised and/or additional pages may be issued from time to time.

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

Page	Date
1	October 31, 1995(Reprinted January 29, 1996)
2 – 144	October 31, 1995
145	January 29, 1996
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1

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Table 117.2
Accelerated aging test criteria

Measured temperature rise degrees		Material	Test Program
C	F		
35	63	Rubber or neoprene	Air oven aging for 70 hours at 100°C (212°F)
35	63	Thermoplastic	7 days in an air-circulating oven at 87°C (189°F)
50	90	Rubber or neoprene	Air oven aging for 168 hours at 100°C (212°F)
50	90	Thermoplastic	10 days in an air-circulating oven at 100°C (212°F)
65	117	Rubber, neoprene or thermoplastic	7 days in an air-circulating oven at 113°C (235°F)
65	117	Rubber or neoprene	10 days in an air-circulating oven at 121°C (250°F)
65	117	Thermoplastic	7 days at 121°C or 60 days at 97°C (207°F) in an air-circulating oven
80	144	Rubber, neoprene or thermoplastic	7 days in an air-circulating oven at 136°C (277°F)

Table 117.2 revised January 29, 1996

117.2 Foamed neoprene or rubber compounds forming gaskets to seal an electrical enclosure shall be subjected to accelerated aging under the conditions indicated in Table 117.2. The compounds shall not harden or otherwise deteriorate to a degree that will affect their sealing properties.

117.3 Thermoplastic materials forming gaskets to seal an electrical enclosure shall be subjected to accelerated aging under the conditions indicated in Table 117.1. Thermoplastic material shall not deform, melt, or otherwise deteriorate to a degree that will affect its sealing properties. Solid polyvinyl-chloride gasket material shall have physical properties as indicated in Table 117.1 before and after the accelerated aging.

117.4 Gaskets of materials other than those specified in 117.1 – 117.3 shall be nonabsorptive and shall provide equivalent resistance to aging and temperature.

118 Metallic Coating Thickness Test

118.1 The solution to be used for this test is to be made from distilled water and is to contain 200 grams per liter of chemically pure chromic acid (CrO_3); and 50 grams per liter of chemically pure concentrated sulfuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of chemically pure concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4 .

118.2 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet provided with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5-1/2 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are more than 0.025 milliliter each. To preserve an effectively constant level, a small glass tube is to be inserted to the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ± 5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

118.3 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which should be noted and recorded. The test is to be conducted at an ambient temperature of 70 – 90°F (21.1 – 32.2°C).

118.4 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Samples are then to be thoroughly rinsed in water and dried. Care should be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

118.5 The sample to be tested is to be supported from 0.7 – 1 inch (18 – 25.4 mm) below the orifice so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested should be inclined approximately 45 degrees from horizontal.

118.6 The stopcock is to be opened and the time in seconds is to be measured until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

118.7 Each sample of a test lot is to be subjected to test at three or more points on the inside surface (excluding cut, stenciled, and threaded surfaces) and at an equal number of points on the outside surface, at places where the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

118.8 To calculate the thickness of the coating being tested, select from Table 118.1 the thickness factor appropriate from the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as noted in 118.6.

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UL Standards for Safety are developed under a procedure which provides for participation and comment from the affected public as well as industry. The procedure takes into consideration a survey of known existing standards and the needs and opinions of a wide variety of interests concerned with the subject matter of the standard. Thus manufacturers, consumers, individuals associated with consumer-oriented organizations, academicians, government officials, industrial and commercial users, inspection authorities, insurance interests and others provide input to UL in the formulating of UL Standards for Safety, to keep them consonant with social and technological advances.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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

INTRODUCTION

1 Scope

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

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

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

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

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

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

1.7 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this Standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Standard cannot be judged to comply with this Standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

2 General

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

2.2 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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

3 Glossary

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

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

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

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

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

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

- a) All air supplied for combustion;
- b) The combustion system of the appliance; and
- c) All products of combustion

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

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

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

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

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

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

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

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

3.14 **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 upon satisfaction of demand. An operating control may also actuate auxiliary equipment.

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

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

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

3.18 ELECTRICAL CIRCUITS:

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

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

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

1) Supplied by a Class 2 transformer, or by a battery, by a battery and fixed impedance, by a transformer and fixed impedance each of which complies with the requirements for a Class 2 transformer as specified in the Standard for Class 2 and Class 3 Transformers, UL 1585; or

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

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

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

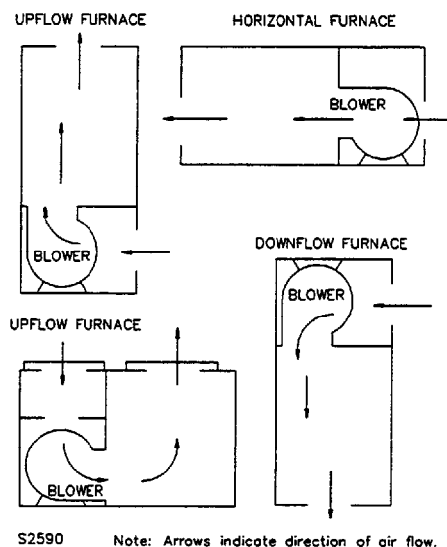
3.20 FLUE, APPLIANCE – The flue passages within the appliance.

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

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

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

Figure 3.1
Types of forced-air
central furnaces



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- a) Cleaning or replacing nozzles, atomizers, and pilots;
- b) Setting ignition electrodes;
- c) Cleaning strainers or replacing strainer or filter element;
- d) Resetting a safety control; and
- e) Replacing an igniter cable.

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

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

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

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

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

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

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

- a) **Metering (Regulating) Valve** – An oil control valve for regulating burner input;
- b) **Safety Valve** – A normally closed valve of the "on" and "off" type, without any bypass to the burner, that is actuated by a safety control or by an emergency device.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard; or
- b) Is superseded by a requirement in this standard.

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

4.4 Specific components are recognized as being 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 for which they have been recognized.

CONSTRUCTION

5 Protection of Users and Service Personnel

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

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

- a) Adjusting the setting of temperature controls with or without marked dial settings;
- b) Resetting control trip mechanisms;
- c) Operating manual switches; or
- d) Adjusting air-flow dampers.

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

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

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

- a) In front of the mechanism in the direction of access; and
- b) Within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

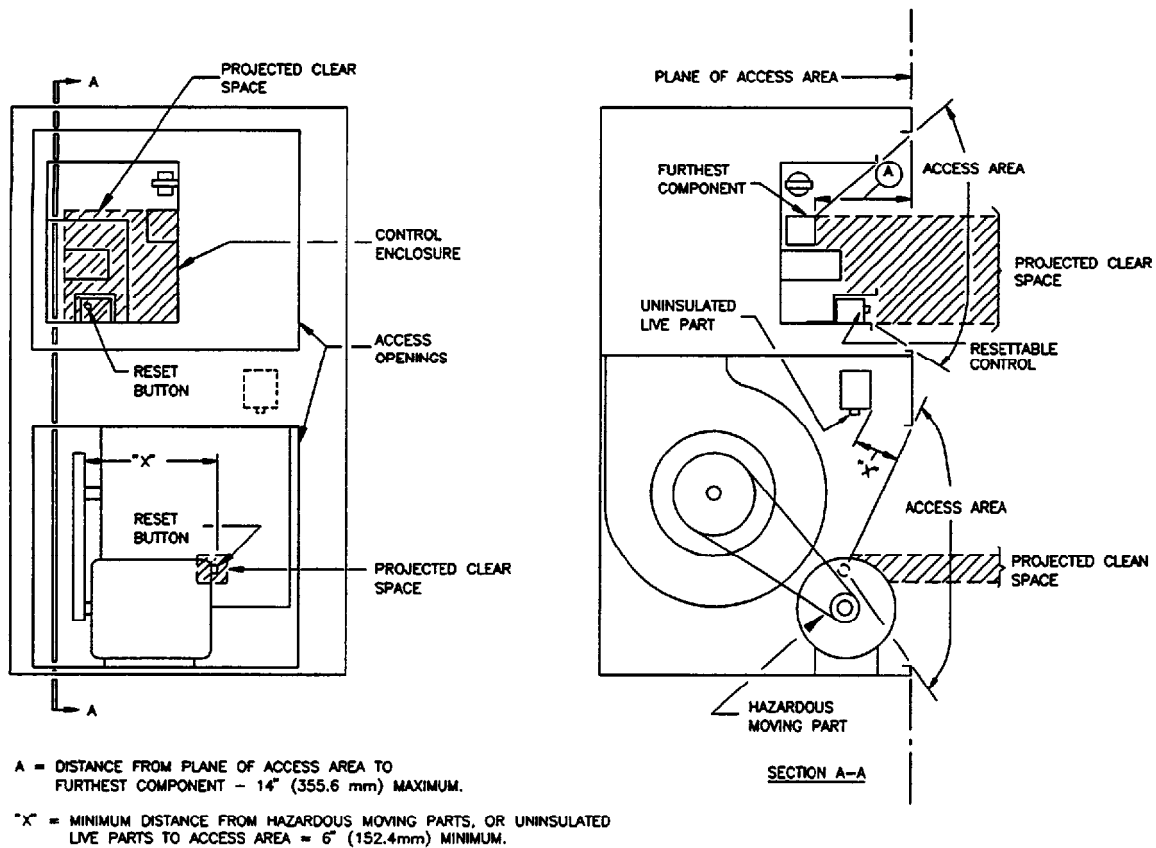
5.5 An electrical control component that may require examination, adjustment, servicing, or maintenance while energized (excluding voltage measurements other than for jacks or terminals specifically intended for that purpose) shall be located and mounted with regard to other components and with regard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

- a) The risk of electric shock from adjacent uninsulated live parts; or
- b) Injury from adjacent moving parts.

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

- a) The components are located with regard to the access opening in the outer cabinet so that the component in the control assembly that is located farthest from the access opening is no more than 14 inches (356 mm) from the plane of the access opening;
- b) Uninsulated high-voltage live parts outside the control assembly projected clear space (except for live parts within a control panel) or unguarded moving parts are located at least 6 inches (152 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure;
- c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet (within the access area) is completely free of obstructions, including wiring;
- d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in the assembly; and
- e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are to be located so that:
 - 1) There is unimpeded access to these components through the access opening in the outer cabinet: and
 - 2) They are not immediately adjacent to uninsulated live parts outside the control assembly enclosure as specified in 5.4, unless guarded.

Figure 5.1
Accessibility and protection



EA105

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

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

- a) Coils of controllers;
- b) Relays and solenoids;
- c) Transformer windings, if the coils and windings are provided with insulating overwraps;
- d) Enclosed motor windings;
- e) Insulated terminals and splices; and
- f) Insulated wire.

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

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

- a) The opening or removal of the door, panel, or shield interlocking device shall require the use of tools;
- b) An interlocking device shall shut off the mechanism; or
- c) A warning marking as specified in 34.6 shall be provided where readily visible after installation to warn the user to shut off the equipment before removing or opening the cover or door.

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

Table 5.1
Dimensions of openings in enclosure

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

^aOpenings less than 1/4 inch (6.4 mm) are not to be considered.

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

6 Enclosures

6.1 General

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

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

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

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

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

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

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

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

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

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

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

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

- a) An opening between the box and motor frame having a dimension greater than 1/2 inch (12.7 mm) does not permit the entrance of a flat feeler gauge that is 5/64 inch (2.0 mm) thick by 1/2 inch (12.7 mm) wide; and
- b) An opening between the box and motor frame having no dimension greater than 1/2 inch does not permit the entrance of a 13/64-inch (5.2-mm) diameter rod.

Table 6.1
Minimum thickness of sheet metal for electrical enclosures
carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width, ^b in	Maximum length ^c in	Maximum width ^b in	Maximum length in	Uncoated	Zinc coated
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)	Inch (mm)	Inch (mm)
4.0 (10.2)	Not limited	6.25 (15.9)	Not Limited	0.020 ^d (0.51)	0.023 ^d (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)		
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 ^d (0.66)	0.029 ^d (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)		
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)		
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)		
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)		
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)		
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)		
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)		
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)		
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)		
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)		

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

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

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

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

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

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

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

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

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

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

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

- a) For an opening that has a minor dimension, as defined in 6.1.15, less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 6.1.; and
- b) For an opening that has a minor dimension of 1 inch or greater, such a part or wire shall be spaced from the opening as specified in Table 6.3.

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

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

Minor dimension ^a of opening		Minimum distance from opening to part	
Inches ^b	(mm) ^b	Inches	(mm)
3/4	(19.1) ^c	4-1/2	(114.0)
1 ^c	(25.4) ^c	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(191.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(445.0)
d		30	(762.0)
^a See 6.15. ^b Between 3/4 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table. ^c Any dimension less than 1 inch applies to a motor only. ^d More than 2-1/8 inches, but no more than 6 inches (152 mm).			

Technical drawing of a mechanical part, likely a lamp base, showing front, side, and cross-sectional views with dimensions in millimeters.

Front View (Left):

- Top section: 3.5 RADIUS
- Section A-A: Circular cross-section with hatching.
- Dimensions: .05, .06, .06, .06, .05, 78, 97, 25.4, 50, 78.

Side View (Right):

- Top section: APPROX 30°, 5.0, 5.8
- Dimensions: 30, 60, 90, 96, 100, 138, 154, 234, 15, 19, 21.5, 25.4.

Bottom View (Bottom):

- Dimensions: 25 RADIUS, 25 RADIUS.

ALL DIMENSIONS IN MILLIMETERS

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

- a) An opening that has a minor dimension, as defined in 6.1.15, less than 3/4 inch (19.1 mm) is acceptable if:
 - 1) Film-coated wire cannot be contacted by the probe illustrated in Figure 6.2;
 - 2) In a directly accessible motor as specified in 6.1.16, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.3; or
 - 3) In an indirectly accessible motor as specified in 6.1.16, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.4;
- b) An opening that has a minor dimension of 3/4 inch or greater is acceptable if a part or wire is spaced from the opening as specified in Table 6.3.

Figure 6.2
Probe for film-coated wire

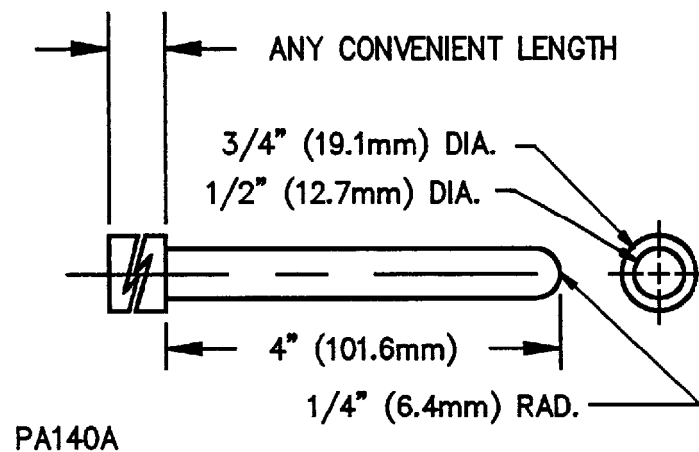


Figure 6.3
Articulate probe

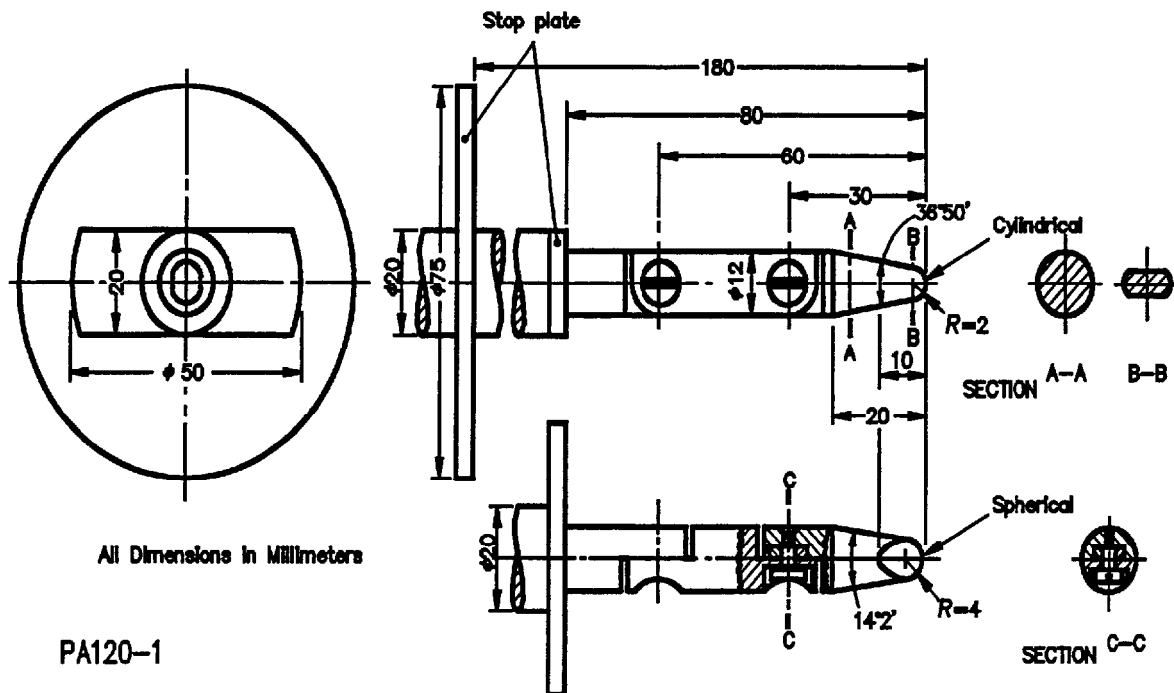
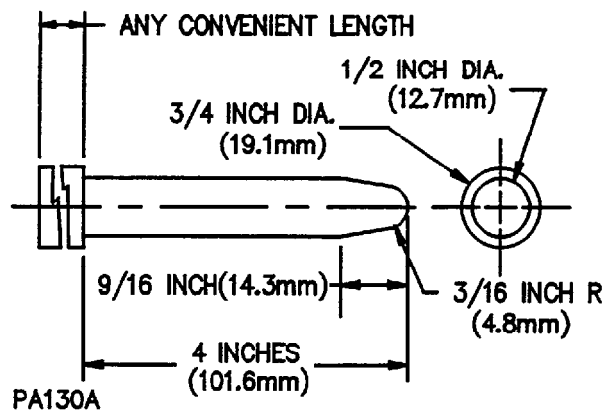


Figure 6.4
Probe for uninsulated live parts



6.1.13 The probes specified in 6.1.11 and 6.1.12 and illustrated in Figures 6.1 – 6.4 shall be applied to any depth that the opening will permit and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figures 6.1 and 6.3 shall be applied in any possible configuration and, if necessary, the configuration shall be changed after insertion through the opening.

6.1.14 The probes specified in 6.1.13 and 6.1.15 shall be used as measuring instruments to judge the accessibility provided by an opening and not as instruments to judge the strength of a material; the probes are to be applied with the minimum force necessary to determine accessibility.

6.1.15 With regard to the requirements specified in 6.1.11 and 6.1.12, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

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

- a) Is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool; or
- b) Is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted. A directly accessible motor is a motor that:
 - 1) Can be contacted without opening or removing any part; or
 - 2) Is located so as to be accessible to contact.

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

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

6.2 Doors and covers

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

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

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

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

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

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

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

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

- a) The door or cover gives access to fuses or any motor overload protective device, the intended protective functioning of which requires renewal; or
- b) It is necessary to open the cover in connection with the intended operation of the protective device such as resetting a manual reset overload protective device.

6.2.8 A hinged cover is not required for an enclosure in which the only fuses enclosed are:

- a) Control-circuit fuses, provided the fuses and control-circuit loads (other than a fixed control-circuit load, such as a pilot lamp) are within the same enclosure;
- b) Supplementary-type fuses of 2 amperes or less for small auxiliary resistance heaters with a maximum rating of 100 watts;
- c) An extractor-type fuse provided with its own enclosure; or
- d) Fuses in low-voltage circuits.

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

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

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

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

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

6.3 Field wiring system connections

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

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

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

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

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

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

- a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4-inch (6.4-mm) maximum dimension; and
- b) 0.027 inch (0.69 mm) for steel or 0.032 inch (0.81 mm) for nonferrous metal for a hole having a 1-3/8-inch (34.9-mm) maximum dimension. A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be mechanically secured.

7 Field Wiring

7.1 General

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

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

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

7.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be no less than that indicated in Table 7.1. A conductor passing through the box is counted as one conductor and each conductor terminating in the box is also counted as one conductor. A field-provided conductor for high-voltage circuits is considered to be no smaller than No. 14 AWG (2.1 mm²).

Table 7.1
Size of junction boxes

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

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

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

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

NOTES

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

2 Trade size per Specification for Zinc Coated Rigid Steel Conduit, ANSI C80.1.

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

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

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

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

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

- a) The total length of flexible metal conduit of any ground return path in the product is no more than 6 feet (1.83 m);
- b) No circuit conductor protected by an overcurrent-protective device rated at more than 20 amperes is included; and
- c) The conduit is no larger than 3/4-inch trade size or the fittings for the conduit are identified as providing grounding.

7.2 Leads and terminals

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

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

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

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

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

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

- a) Two screws or rivets;
- b) Square shoulders or mortices;
- c) A dowel pin, lug, or offset;
- d) A connecting strap or clip fitted into an adjacent part; or
- e) Some other equivalent method.

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

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

7.2.8 Terminal parts by which field-wiring connections are made shall consist of soldering lugs or pressure terminal connectors secured in place in accordance with the requirements in 7.2.5, except that for No. 10 AWG (5.3 mm²) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to secure the wire in position.

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

Exception No. 1: A No. 8 (4.2 mm major diameter) screw may be used for the connection of a conductor no larger than No. 14 AWG (2.1 mm²).

Exception No. 2: A No. 6 (3.5 mm major diameter) screw may be used for the connection of a No. 16 or No. 18 AWG (1.3 or 0.82 mm²) control-circuit conductor.

7.2.10 A terminal plate for a wire-binding screw shall be of metal no less than 0.030 inch (0.76 mm) thick for a No. 14 AWG (2.1 mm²) or smaller wire and no less than 0.050 inch (1.27 mm) thick for a wire larger than No. 14 AWG; and in either case there shall be no less than two full threads in the metal.

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

7.2.12 A wire-binding screw shall thread into metal.

8 Internal Wiring

8.1 General

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

8.1.2 Wiring shall be made with insulated conductors having a current-carrying capacity and voltage and temperature ratings consistent with their use. A conductor, other than an integral part of a component, shall be no smaller than No. 18 AWG (0.82 mm²).

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

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

8.2 Methods

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

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

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

Table 8.1
Typical wiring materials

Group	Type of wire, cord, cable, or appliance wiring material with insulation thicknesses and corresponding wire sizes as indicated	Wire size		Insulation thickness	
		No. AWG	mm ²	Inch	mm
A	RF2, FF2, FFH2, TF, TFF, TFN, TFFN, SF2, SFF2, RH, RHH, RHW, RUH, T, THW, XHHW, MTW, THW-MTW, THWN, TW, or thermoplastic appliance wiring material.	10 and smaller	5.3	2/64	0.8
		8	8.4	3/64	1.2
		6	13.3	4/64	1.6
		4	21.2	4/64	1.6
		3	26.7	4/64	1.6
		2	33.6	4/64	1.6
		1	42.4	5/64	2.0
		1/0	53.5	5/64	2.0
		2/0	67.4	5/64	2.0
		3/0	85.0	5/64	2.0
		4/0	107.0	5/64	2.0
		18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
B	SO, ST, SJO, SJT, or appliance wiring material with thermoplastic or neoprene insulation	12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.4	6/64	2.4
		6	13.3	8/64	3.2

NOTE — Thermoplastic wiring materials, as referenced in Group A, with insulation thickness of 2/64 inch (0.8 mm) for No. 16 or 18 AWG (1.3 or 0.082 mm²) and 3/64 inch (1.2 mm) for No. 14, 12, 10, or 8 AWG (2.1, 3.3, 5.3, or 8.4 mm²) are considered equivalent to the wiring material referenced in Group B when the conductors are covered with 1/32 inch (0.8 mm) wall thickness thermoplastic insulating tubing of a type recognized for the purpose from the standpoint of dielectric properties, heat resistance, moisture resistance, and flammability.

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

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

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

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

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

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

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

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

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

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

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

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

- a) It is not practical to do the wiring in accordance with 8.2.3;
- b) The cord is not required to be bent, twisted, or otherwise displaced to conduct routine maintenance and service; and
- c) The length of cord exterior to the assembly is no more than 4 inches (102 mm) and strain relief is provided.

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

- a) There are no openings in the bottom, unless a U-shaped channel or trough is located under the wiring and the wires do not project through the plane of the top of the trough or channel;
- b) If the appliance is for installation on noncombustible flooring only, the bottom of such compartment may be open provided all sides of the compartment extend to the floor level;

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

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

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

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

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

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

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

8.2.20 A fiber bushing shall:

- a) Be no less than 3/64 inch (1.2 mm) thick;
- b) Be located so that it will not be exposed to moisture; and
- c) Not be used where it will be subjected to a temperature higher than 90°C (194°F) under intended operating conditions.

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

- a) Type SP2 cord having only neoprene insulation;
- b) Type SPT2 cord or appliance wiring material having neoprene, thermoplastic, or equally durable insulation of equivalent thickness; or
- c) Low-energy safety control wire, if such wiring is located in a cavity or compartment of an appliance and is shielded from damage.

8.3 Short circuit protection

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

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

- a) Conductors that have no less than one-third the ampacity of the required branch-circuit conductors;
- b) Conductors that are No. 18 AWG (0.82 mm²) or larger and that are no more than 4 feet (1.2 m) long, provided that the circuit will be protected by a fuse or HACR Type circuit breaker that is rated 60 amperes or less as specified on the product nameplate or provided as part of the product and that is acceptable for branch-circuit protection; or
- c) Conductors that serve as jumper leads between controls, provided the length of the leads does not exceed 3 inches (76.2 mm) or the conductors are located in a control panel.

9 Separation of Circuits

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

- a) From each other; and
- b) From uninsulated live parts connected to different circuits or opposite-polarity parts of the same circuit.

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

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

- a) Field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit;
- b) Uninsulated live parts of any other circuit; and
- c) Uninsulated live parts the short-circuiting of which may permit unintended operation of the appliance.

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

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

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

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

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

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

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

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

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

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

10 Grounding and Bonding

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

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

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

- a) Adhesive-attached metal-foil markings, screws, handles, or parts that are located on the outside of enclosures or cabinets and that are isolated from electrical components or wiring by grounded metal parts;
- b) Isolated metal parts, such as magnet frames and armatures, and small assembly screws that are separated from wiring and uninsulated live parts;
- c) Panels and covers that do not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover; and
- d) Panels and covers that are insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material no less than 1/32 inch (0.8 mm) thick.

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

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

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

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

- a) Be protected from mechanical damage, such as by being located within the confines of the outer enclosure or frame; and
- b) Not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor would not ordinarily be omitted after removal and replacement of the fastener.

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

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

- a) Under any degree of compression that may be applied by a variable clamping device; and
- b) Following exposure to the effects of oil, grease, moisture, and thermal degradation that are likely to occur in service.

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

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

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

- a) When carrying, for the time indicated in Table 10.1, twice the rated current of the branch circuit overcurrent device required to protect the equipment; and
- b) During the short-circuit test described in Section 28, Short-Circuit Test while in series with a fuse of proper rating.

Table 10.1
Duration of current flow, bonding-conductor test

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

10.12 The size of a conductor or strap used to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the equipment will be connected. Except as indicated in 10.11, the size of the conductor or strap shall be as specified in Table 10.2.

Table 10.2
Bonding wire conductor size

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

^aOr equivalent cross-sectional area.

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

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

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

- a) For equipment intended to be connected to a metal-enclosed wiring system, a knockout or equivalent opening in a metal enclosure intended to receive the power-supply system; or
- b) For equipment intended to be connected by a nonmetal-enclosed wiring system, such as metal-clad cable, an equipment grounding terminal or lead.

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

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

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

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

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

ELECTRICAL COMPONENTS

11 General

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

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

12 Mounting of Electrical Components

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

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

- a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during operation of the switch;
- b) The means for mounting the switch is not subject to loosening as the result of operation of the switch;
- c) Rotation of the switch does not result in a reduction of spacings below the values specified in Sections 19, High-Voltage Circuits, and Section 20, Low-Voltage Circuits; and
- d) Operation of the switch is by mechanical means rather than by direct contact by the user.

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

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

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

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

13 Motors and Motor Overload Protection

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

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

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

- 1) 125 percent for motors with a marked service factor no less than 1.15;
- 2) 125 percent for motors with a marked temperature rise no more than 40°C (72°F); and
- 3) 115 percent for all other motors;

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

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

- 1) 140 percent for motors with a marked service factor no less than 1.15;
- 2) 140 percent for motors with a marked temperature rise no more than 40°C; and
- 3) 130 percent for all other motors.