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Standard for Safety

UL 727

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Oil-Fired Central Furnaces

100 a century of public safety 1894-1994

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Standard

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August 1, 1994

Standard for

Oil-Fired Central Furnaces

UL 727, Eighth Edition

Accompanying this transmittal notice is a copy of the Eighth edition of UL 727.

THIS EDITION OF THE STANDARD IS NOW IN EFFECT.

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

UL 727

Standard for

Oil-Fired Central Furnaces

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Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest published set of revision pages.

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CONTENTS

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 1 – ALL PRODUCTS

INTRODUCTION

1 Scope

1.1 These requirements cover oil-fired central furnaces which include forced-air furnaces of the downflow, horizontal, and upflow types. Floor-mounted unit heaters designed to supply heated air through ducts are covered also by these requirements.

1.2 These requirements cover furnaces intended to burn standard grade fuel oils as specified in the Specifications for Fuel Oils, ASTM D396.

1.3 Requirements for the installation and use of oil-burning equipment are included in the Standard for Installation of Oil-Burning Equipment, NFPA 31, and in codes such as the BOCA National Mechanical Code, the SBCC Standard Mechanical Code, and the IAPMO Uniform Mechanical Code. The applicable requirements are to be utilized in conjunction with this standard.

1.4 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 may be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

2 Units of Measurement

2.1 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.

3 Glossary

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

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

3.3 ANTIFLOODING DEVICE – A primary safety control which 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.

3.4 APPLIANCE – Refers to any equipment covered by these requirements unless specifically noted otherwise.

3.5 APPLIANCE FLUE – The flue passages within the appliance.

3.6 AUTOMATICALLY LIGHTED APPLIANCE – An appliance in which fuel to the main burner is turned on and ignited automatically.

3.7 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.

3.8 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.

3.9 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.

3.10 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.

3.11 COMBUSTIBLE – Is defined in the Standard Glossary of Terms Relating to Chimneys, Vents, and Heat Producing Appliances, NFPA 97M.

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

3.13 CONTROL, LIMIT – As it pertains to this standard, a safety control responsive to changes in temperature normally set beyond the intended operating range of the furnace 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 on satisfaction of demand. Operating controls may also actuate auxiliary equipment.

3.15 CONTROL, SAFETY – Automatic controls, including relays, switches, and other auxiliary equipment used in conjunction therewith to form a safety control system, that are intended to reduce the risk of improper operation of the controlled equipment.

3.16 CONTROL, PRIMARY SAFETY – The automatic safety control intended to reduce the risk of abnormal discharge of oil at the burner in case of ignition failure or flame failure.

3.17 CONTROL, SAFETY COMBUSTION – See Control, Primary Safety.

3.18 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.

3.19 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) 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 open-circuit secondary voltage rating not exceeding 1000 volts.

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

3.20 FUEL OIL – Any hydrocarbon oil as defined by Specifications for Fuel Oils, ASTM D396-86.

3.21 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.

3.22 FURNACE, ATTIC CENTRAL – A forced-air type central furnace designed specifically for installation in an attic or in a space with low headroom, normally unoccupied.

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. See Figure 3.1.

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

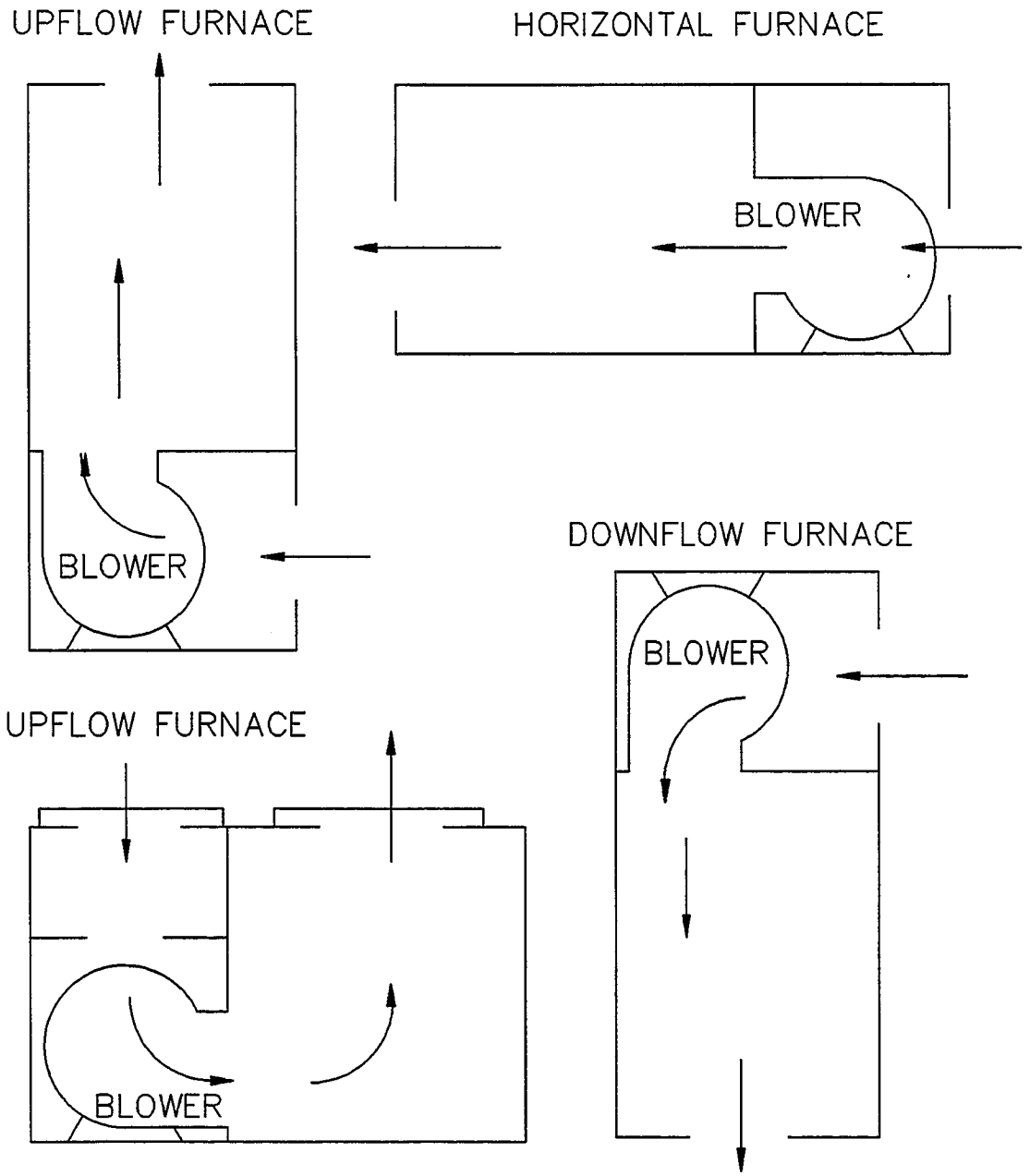
3.26 INDIRECT-FIRED APPLIANCE – An appliance constructed so that combustion products or flue gases are not mixed in the appliance with the medium, that is, to be heated; hence is provided with a flue collar.

3.27 NONCOMBUSTIBLE – Is defined in the standard Glossary of Terms Relating to Chimneys, Vents, and Heating Producing Appliances, NFPA 97M.

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

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

Figure 3.1
Types of forced-air central furnaces



Note: Arrows indicate direction of air flow

3.30 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.

3.31 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.

3.32 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.

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

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 – MECHANICAL

5 Assembly

5.1 A furnace shall be factory-built as a group assembly and shall include all the essential components necessary for its intended function when installed as intended. An oil-fired furnace may be shipped as two or more major subassemblies.

5.2 A furnace, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. Each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling (except to the extent indicated in 5.3), threading, welding, or similar tasks by the installer. Two or more subassemblies, that must bear a definite relationship to each other for the intended installation or operation of the furnace, shall be arranged and constructed to permit them to be incorporated into the complete assembly, only in the correct relationship with each other without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one element.

5.3 To be in accordance with 5.2, major subassemblies of a furnace are deemed to be:

a) The burner,

b) The heat exchanger, including its base, combustion chamber, casing, and safety controls,

c) The blower assembly, including the base, filters, and casing, and

d) The blower motor if not included as part of the blower assembly.

A wiring harness may be packaged with one of the major subassemblies.

5.4 Cutting or drilling which is required for the attachment of a return or supply plenum, an optional filter rack, or to cut a return air opening in the furnace casing is deemed to conform to 5.2. If a return air opening is to be cut in the casing panel by the installer, suitable instructions and a template shall be furnished with the furnace, or the corners of the opening shall be embossed in knock-out form.

5.5 A radiation shield or baffle employed to prevent temperatures in excess of those intended, shall be assembled as part of the furnace; or be part of a subassembly that must be attached to the furnace for its intended operation; or be constructed so that the furnace cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

5.6 The construction of a furnace shall be such that, for any intended installation, the alteration or removal of a baffle, insulation, or a radiation shield needed to reduce the risk of temperatures that may result in a risk of fire, electric shock, or injury to persons, is not required.

5.7 A horizontal furnace intended for suspended installation shall be provided with brackets or hangers to support the furnace from its basic frame or structure.

5.8 A furnace shall provide for convenient operation of those parts requiring attention or manipulation by the user during intended usage.

5.9 Adjustable or movable parts shall be provided with locking devices to reduce the risk of unintentional shifting.

5.10 Screws or bolts used to attach parts that are detached for care or servicing of the appliance shall be capable of holding upon the application of the torques indicated in Table 5.1 after removal and replacement.

Table 5.1
Maximum torque requirements for screw or bolts

American standard screw size		Torque		I.S.O. screw size	Torque	
No.	mm	Lb-In.	N • m	mm	N • m	Lb-In.
–	–	–	–	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
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

5.11 Any external door providing access into the combustion chamber of a furnace intended for installation with a clearance of less than 24 inches (610 mm) from the face of or 48 inches (1220 mm) above the door shall be self-closing.

5.12 A furnace intended for installation in the cooled-air path, downstream from a cooling coil, shall conform to the following:

a) All interior surfaces of the heat exchanger, combustion chamber including its bottom, radiators, and flues shall be resistant to corrosion by moisture.

b) The firebox liner shall resist deterioration from being wetted by condensation.

c) Condensation shall not drip on burner parts or other corrodible parts if corrosion of any such parts may cause operation that may result in a risk of fire, electric shock, or injury to persons.

d) The heat exchanger and appliance flue shall contain no traps or pockets in which condensation may collect.

5.13 A burner shall be secured so it will not twist, slide, or drop out of position.

5.14 A furnace equipped with an antiflooding device shall be constructed so that, when the furnace is level, the minimum distance between the designed maximum intended oil level maintained by the oil control device and the level of the lowest point at which overflow may occur is not less than 3/4 inch (19.1 mm).

6 Servicing

6.1 General

6.1.1 A furnace shall be provided with means of access for cleaning of parts such as interior surfaces of vaporizing burners, heating surfaces in contact with combustion products, oil inlet pipes, and oil strainers, without major dismantling of the furnace or removal of parts required to be factory-assembled.

6.1.2 The removal of access panels, burners, blowers, caps, plugs, and the like, permitting removal and replacement for servicing, and the detachment of the chimney connector are not considered major dismantling as defined by 6.1.1.

6.1.3 Accessibility shall be afforded for cleaning, inspection, repair, and replacement of all burners, controls, and safety devices when the furnace is installed as intended by the manufacturer. The disposition of parts in the assembly removed for servicing shall be such that their restoration, following removal, will not necessitate their realignment to secure their intended relationship with other parts of the assembly. Special facilities required for servicing to be performed by the operator shall accompany the furnace and be attached to or placed, per instructions, near the furnace at the time of installation.

6.1.4 The requirements of 36.1 are not applicable to mechanical service functions which are not normally performed with the equipment energized. Such functions include adjusting or replacing belts and cleaning and replacement of strainers and oil filters.

6.2 Moving parts

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

6.2.2 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, or

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

c) A warning marking shall be displayed which reads essentially as follows:

"DANGER – TO AVOID INJURY FROM MOVING PARTS, SHUT OFF THE (EQUIPMENT) BEFORE (REMOVING-OPENING) THIS (COVER DOOR)."

6.2.3 The distance from an opening in a required guard or enclosure to the moving part mentioned in 6.2.1 shall be in accordance with Table 6.1, but the minor dimension of the opening shall not in any case exceed 3 inches (76 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).

6.2.4 A moving part is not to be considered when judging compliance with 6.2.1 and 36.1 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

Table 6.1
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	114.0
1	25.4	6-1/2	165.0
1-1/2	38.1	10-1/2	267.0
2	50.8	14-1/2	368.0
Over 2 inch (over 50.8)		30	762.0

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

7 Disposal of Combustion Products

7.1 The construction of a furnace shall not allow the products of combustion to become mixed with the circulating air.

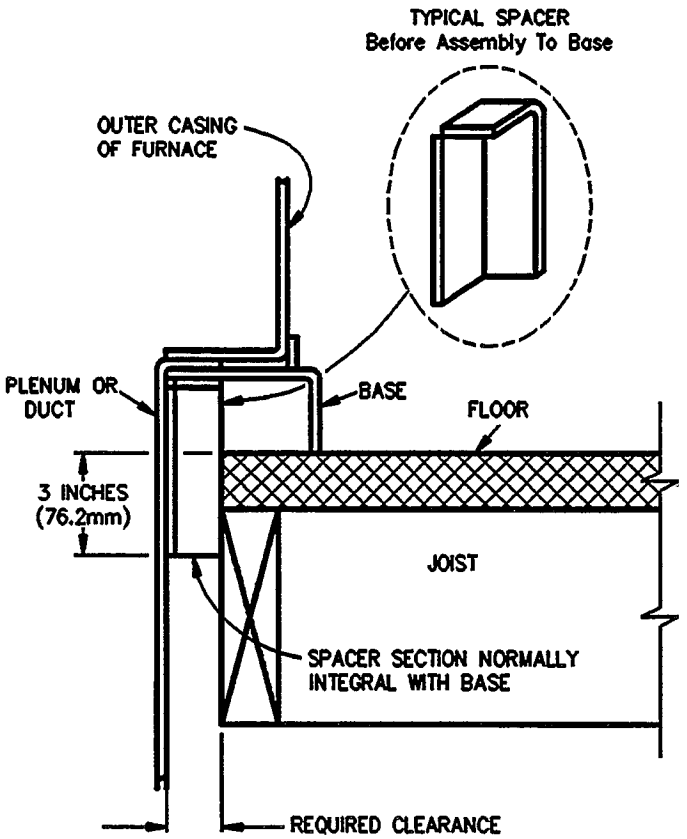
8 Base

8.1 The base of a furnace shall be constructed of metal or fabricated of other nonflammable material in a manner to provide equivalent strength and durability. The assembly shall be constructed so that there will be no open passages in the floor through which flame or hot gases from a fire originating in the space below the floor can travel to the room above when the furnace is installed as intended.

8.2 A subbase, if furnished as a separate assembly, shall be arranged for attachment to the furnace in the intended position only and in a manner that will establish and maintain correctly the position of the furnace with respect to the subbase.

8.3 The base and subbase of a downflow furnace intended for installation on flammable flooring material shall establish and maintain not less than the required clearance between vertical surfaces of the plenum or duct to be attached thereto and the floor construction. A spacer shall extend at least 3 inches (76 mm) below the upper surface of the floor on which the furnace is to be installed. An acceptable base design is shown in Figure 8.1.

Figure 8.1
Acceptable base construction for downflow furnace



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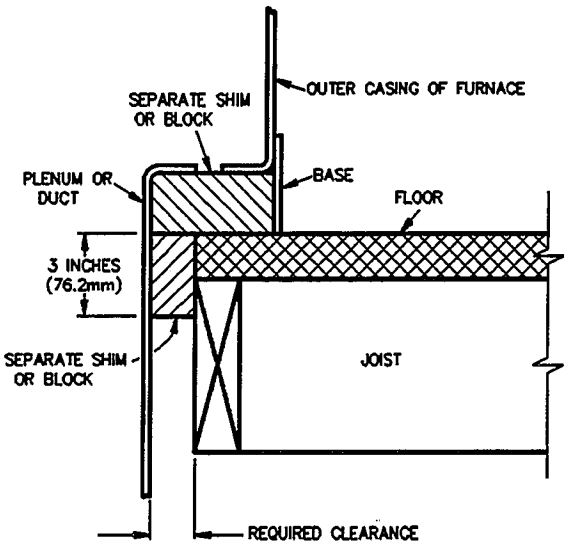
8.4 The use of spacers in the form of separate blocks or shims is not considered to be in accordance with 8.3. This latter type of construction is shown in Figure 8.2.

Figure 8.2
Unacceptable base construction for downflow furnace



9 Casings

9.1 An outer casing or jacket shall be made of steel or equivalent material, braced, reinforced or formed to avoid damage through handling in shipment, installation, and use. Sheet metal casings shall be made of steel having a minimum thickness of 0.020 inch (0.51 mm) if uncoated, or 0.023 inch (0.58 mm) if galvanized, or of nonferrous sheet metal having an average thickness of not less than 0.029 inch (0.74 mm).

9.2 Access panels which may be removed for servicing and accessibility shall be constructed to permit removal and replacement repeatedly without causing damage or impairing any required insulating value.

9.3 A removable panel through which air is drawn for combustion shall be so constructed as to prevent it from being attached in a manner that may affect the intended performance of the furnace.

9.4 A removable panel shall be so constructed that it will not be interchangeable with other panels on the same furnace if interchange may affect the intended operation of the furnace.

9.5 The casing of a furnace for installation on combustible flooring material shall completely close the bottom or be constructed to provide an effective radiation barrier between the heat exchanger and the floor; except an opening intended to be always connected to a circulating-air distribution duct may be permitted.

9.6 The casing of a forced-air type furnace shall have no uncovered openings communicating with the circulating air compartments unless such openings are intended to be always connected to a circulating air distribution duct.

9.7 The furnace shall be constructed so that a negative pressure created by an air-circulating fan cannot affect the combustion air supply or draw products of combustion into the circulating air.

9.8 A connection between the heat exchanger and the casing which encloses circulating air shall be constructed to prevent leakage of combustion products into the circulating air.

9.9 An access opening to a return-air compartment shall be completely covered.

9.10 A central furnace shall provide for the attachment of warm-air outlet and cold-air return ducts.

Exception: A furnace arranged for a specific kind of installation permitted to be made without outlet or return air ducts may be tested for such restricted use.

9.11 An integral plenum of a furnace for alcove or closet installation shall have not more than one outlet-air opening unless each additional opening is provided with means supplied at the factory to close the openings in the casing and any insulation or liner.

10 Radiation Shields or Liners

10.1 A radiation shield or liner shall be so constructed, formed, and supported so as to provide for the intended positioning and to prevent distortion or sagging in service. A shield or liner shall be protected against corrosion if its deterioration may cause excessive temperature when the furnace is tested in accordance with these requirements. Any finish to obtain the required resistance to corrosion shall not be damaged by heat when the furnace is tested under these requirements.

11 Materials in Air Handling Compartments

11.1 Materials in a compartment handling air for circulation through a duct system shall not have a flame spread rating over 25 nor a smoke developed rating over 50 when tested in accordance with the tests for Surface Burning Characteristics of Building Materials, UL 723. This requirement does not apply to the following:

a) Air filters, drive belts, wire insulation, and paint as applied for corrosion protection.

b) Gaskets forming air or water seals between metal parts.

c) Miscellaneous small parts such as resilient or vibration mounts, wire ties, clamps, labels, and the like.

d) An adhesive which, when tested in combination with the specific insulating material, complies with the requirement.

e) Molded or formed components made of polymeric materials, not liners, in such quantity that the total surface area of such materials in the compartment does not exceed 10 square feet (0.93 m^2). See 11.7.

11.2 The supporting surface to be used in the surface burning characteristics test of adhesives is to be of asbestos-cement board or metal. Other materials requiring support may be supported using metal rods or bars or 2-inch (51-mm) hexagonal mesh-wire with metal bars or rods.

11.3 Exposed unimpregnated asbestos material shall not be used in an air-handling compartment. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

11.4 Thermal or acoustic insulating material shall be secured in position if:

a) Loosening may reduce or block air flow to cause temperatures or pressures in excess of those acceptable in the temperature tests, or

b) Loosening will result in reduction of electrical spacings below the required values, short-circuiting, or grounding.

Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air.

11.5 Mechanical fasteners for securing the insulating liner in position shall be used for each square foot (0.09 m^2) unless the liner is retained in position under all test conditions by a lesser number of fasteners because of its inherent rigidity. Mechanical fasteners may be volts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads provides protection for leading edges against damage from effects of the velocity of moving air.

11.6 An adhesive required for securing insulation shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the performance requirements of this standard and at 0°F (minus 17.8°C) or minus 20°F (minus 29°C) for outdoor-use equipment.

11.7 Polymeric materials exempted by 11.1 (e) shall not have a flame spread rating exceeding 25 or shall conform to the Flammability Test requirements of Section 57.

12 Air Filters

12.1 An air filter, if supplied as a part of the furnace, shall be accessible for inspection or replacement without the use of special tools and without dismantling the furnace.

13 Combustion Chambers

13.1 A combustion chamber and flueway within the air handling compartment shall be constructed of cast iron, sheet steel, or equivalent material. Sheet steel, if used, shall be such as to provide the strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel having a minimum thickness of 0.042 inch (1.07 mm).

13.2 Combustion chamber (firebox) lining material, if used, shall be secured in place, and accessible for replacement with equivalent material.

14 Radiators

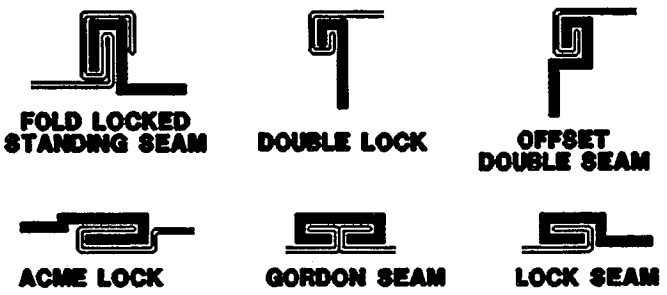
14.1 A radiator shall be made of material not lighter than that designated in 13.1 for a combustion chamber and shall be accessible for cleaning.

15 Heating Surface Joints

15.1 Joints in heating surfaces shall be welded, locked-seamed, machined and bolted or riveted. The tightness of a joint shall be equivalent to that afforded by lock-seaming and shall not depend primarily on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength.

15.2 Examples of some acceptable lock-seams are illustrated by Figure 15.1.

Figure 15.1
Types of acceptable lock-seams



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16 Baffles

16.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI 1010 hot-rolled sheet steel having a minimum thickness of 0.042 inch (1.07 mm) unless its deterioration will not cause excessive temperatures when the furnace is tested in accordance with these requirements.

16.2 A flue baffle shall be accessible for cleaning. A flue baffle that is removable for cleaning shall be such as to facilitate its removal and permit replacement only in its intended position.

17 Flue Collars

17.1 A flue collar shall be constructed and arranged to permit the attachment of the chimney connector.

17.2 A flue collar flue collector parts or extensions exterior to the air handling compartment shall have the rigidity, heat, and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.016 inches (0.41 mm).

17.3 A flue collar or flue collector parts within the air handling compartment shall have the rigidity, heat and corrosion resistance at least equivalent to that of sheet steel having a thickness of not less than 0.042 inches (1.07 mm).

18 Dampers and Draft Regulators

18.1 An adjustable damper shall be equipped with minimum and maximum operating stops. The minimum operating stop for such damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

18.2 An automatically operated damper shall maintain the intended damper opening at all times and be arranged to prevent starting of the burner unless the damper is in the intended position for starting.

18.3 A furnace to be equipped with a barometric draft regulator shall be designed so as not to require the regulator to be installed in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator and the combustion air supply.

CONSTRUCTION – ELECTRICAL

19 Controls

19.1 Application

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

19.1.2 It is the intent of the requirement in 19.1.1 that a short circuit or combination of short circuits to ground will not render a safety control or protective device inoperative. Safety control circuit arrangements other than described in 19.1.1 may be acceptable if they accomplish the intent of this requirement.

19.1.3 The requirement of 19.1.1 does not apply to a 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.

19.1.4 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.

19.1.5 All safety controls shall be accessible.

19.1.6 A safety control shall be supported so that it and its sensing element will remain in their intended positions. It shall be possible to determine by observation or test whether or not each control is in its intended location.

19.1.7 Nothing shall be provided for the purpose of permitting any safety control to be rendered ineffective or to allow firing of the furnace without the protection of each of the required safety controls.

19.1.8 A burner not equipped to provide for 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.

19.2 Limit control

19.2.1 A furnace shall be provided with a limit control to prevent excessive temperature.

19.2.2 The maximum setting of a limit control allowed by a fixed stop shall permit an outlet-air temperature of not more than that indicated in 43.1.

19.2.3 An automatically lighted furnace shall be provided with an automatic-reset type limit control. An auxiliary limit control may be of manual-reset type.

19.2.4 A downflow or a horizontal furnace shall be controlled to limit the air temperature build-up in the return air duct opening under conditions of reverse air flow. See the Continuous Operation Test, Section 48.

19.2.5 A limit control which functions to interrupt the delivery of fuel for combustion by opening an electrical circuit shall be so arranged as to effect the direct opening of that circuit, whether the switching mechanism is integral with the sensing element or remote from same.

19.2.6 The purpose of the requirement in 19.2.5 is to avoid interposing in the limit-control circuit other controls, the failure of which may result in a condition that the limit control is intended to prevent. However, a limit control may interrupt the pilot circuit of a magnetic-type motor controller which, in turn, directly opens the safety circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls, or to interrupt a multiphase circuit.

19.2.7 A furnace equipped with a vaporizing burner shall be constructed to avoid pooling of the burner upon functioning of the limit control.

19.2.8 The limit control or controls for an attic, downflow, or horizontal furnace, for a furnace intended to operate with an outlet-air temperature of not more than 200°F (93°C), or for a furnace for alcove or closet installation, shall be factory-located on the furnace or its location shall be factory-predetermined by a bracket or an equivalent means supplied as part of the furnace. Such bracket shall be marked to explain its purpose, and the arrangement shall be such that omission of the bracket is obvious.

19.2.9 An automatically or manually lighted furnace shall be equipped with a primary safety control. See 4.1.

19.3 Fan control

19.3.1 The furnace shall be provided with a fan control that controls the operation of the circulating air fan so that the operation of the furnace is continuous in accordance with 43.2 and 43.3 at all settings of the fan control. Such fan control shall comply with the requirements for a fan control as given in the Standard for Limit Controls, UL 353.

20 Field Wiring

20.1 General

20.1.1 Provision shall be made for connection of a power supply wiring system conforming with the National Electrical Code, ANSI/NFPA 70-1993.

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

20.1.3 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. A component intended for such use may serve as a cover.

20.1.4 The size of a junction box in which field-installed conductors are to be connected by splicing shall be not less than that indicated in Table 20.1. 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 No. 14 AWG (2.1 mm^2).

20.1.5 A knockout for connection of a field wiring system to a terminal box or compartment shall accommodate conduit of the trade size determined by applying Table 20.2.

20.1.6 Wiring exterior to a furnace between the burner assembly and a limit control, a safety combustion control, or a motor controller, that can be done readily with Type T wire enclosed in conduit or with metal-clad cable in accordance with these requirements, need not be furnished by the manufacturer as part of the furnace if adequate instructions for installing such are furnished with each furnace. See 21.1.4.

20.1.7 A box or enclosure included as part of the assembly and in which a branch circuit supplying power to the furnace 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 permitted, to which metal-clad cable or flexible metallic conduit is to be directly attached.

Table 20.1
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)

Table 20.2
Trade size of conduit in inches (mm OD)[a,b]

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

[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 term 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 per Specifications for Zinc-Coated Rigid Steel Conduit, ANSI C80.1.

20.1.8 A box or enclosure in which field-installation conductors are to be connected as indicated in 20.1.6, 20.1.7, and 20.1.9 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 furnace is tested in accordance with these requirements.

20.1.9 Except as otherwise indicated in 21.1.4, wiring to be done in the field between the furnace and devices that are attached to the furnace, or between separate devices that are field installed and located, shall comply with these requirements if done with Type T wire enclosed in conduit or with acceptable metal-clad cable.

20.1.10 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 20.1.1. If the conduit terminates in an outlet box larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not acceptable as a means to prevent loosening of the conduit fittings. A grounding conductor of the size specified in the National Electrical Code, ANSI/NFPA 70-1993, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product is not more than 6 feet (1.83 m);

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

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

Exception: The overcurrent devices mentioned in (b) may be rated up to 60 amperes if 3/4 to 1-1/4 inch trade size liquid-tight flexible metal conduit is used.

20.2 Leads and terminals

20.2.1 Wiring terminals or leads not 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 70-1993, and corresponding to the marked rating of the assembly.

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

20.2.3 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.

20.2.4 A terminal or lead 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.

20.2.5 At terminals, stranded conductors shall be prevented from contacting other uninsulated live parts and from contacting dead metal parts. This may be accomplished by use of pressure-terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means. 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 not less than 0.028 inch (0.71 mm).

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

20.2.7 Conductors intended for connection to a grounded neutral line shall be identified, that is, finished a white or natural gray color. All other current-carrying conductors visible to the installer shall be finished in colors other than white, natural 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.

20.2.8 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.

20.2.9 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 20.2.6, except that for No. 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.

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

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

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

20.2.11 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 No. 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 No. 14 AWG; and in either case there shall be not less than two full threads in the metal.

20.2.12 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.

20.2.13 A wire-binding screw shall thread into metal.

21 Internal Wiring

21.1 General

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

21.1.2 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 No. 18 AWG (0.82 mm^2).

21.1.3 Except as indicated in 20.1.6, the wiring for all furnace circuits shall be furnished by the manufacturer as part of the furnace. If the furnace is not assembled and wired at the factory, such wiring shall be furnished as harness with each furnace and be arranged to facilitate attachment when the furnace is assembled; in which case a pictorial diagram showing the exact arrangement of the wiring shall be included with each furnace.

21.1.4 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.

21.2 Methods

21.2.1 Electrical wiring to a part which 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 a part shall terminate in eyelets or connectors. If the wiring to a part which functions also as an access plate or cover, that is, a transformer closing the access to the nozzle assembly is not readily detachable, the assembly shall include provision for support of that part by means other than the wiring when the part is moved for servicing. Any allowable movement of such part shall not unduly twist, bend, or pull the wiring.

21.2.2 Conductors shall be enclosed within conduit, electrical metallic tubing, metal raceway, electrical enclosure, or metal-clad cable, except as permitted by 21.2.14 and 21.2.15.

21.2.3 Group A of Table 21.1 includes some wiring materials recognized for use if enclosed as indicated in 21.2.2.

21.2.4 Flexible metal conduit shall be not smaller than nominal 3/8-inch electrical trade size specified in the Standard for Flexible Metal Conduit, UL 1. This does not apply to parts of components, such as conduit protecting flame sensor leads.

21.2.5 Flexible metal conduit shall be mechanically secured at intervals not exceeding 4-1/2 feet (1.4 m) and within 12 inches (300 mm) on each side of every junction box except for lengths not over 36 inches (0.91 m) where flexibility is necessary.

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

21.2.7 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.

21.2.8 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.

21.2.9 Splices shall be located, enclosed, and supported so that they are not subject to damage as the result of flexing, motion, or vibration.

21.2.10 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 Group A of Table 21.1, 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.

Table 21.1
Typical wiring materials

Group	Type of wire, cord, cable or appliance wiring material with insulation thicknesses shown at the right corresponding to wire sizes indicated	Wire size		Insulation thickness	
		No. AWG	(mm^2)	Inch	(mm)
A	FFH-2, TF, TFF, TFFN, SF-2, SFF-2, RH, RHH, RHW, THW, XHHW, MTW, THW-MTW, THWN, TW, PF, PFF, PCF, PGFF, RFH-2, RFHH-2, RFHH-3 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	107.2	5/64	2.0
B	SO, ST, SJO, SJT, S, SE, SJ, SJTO, SJTOO, SOO, STO, STOO, or appliance wiring materials with thermoplastic or neoprene insulation	18	0.82	4/64	1.6
		16	1.3	4/64	1.6
		14	2.1	5/64	2.0
		12	3.3	5/64	2.0
		10	5.3	5/64	2.0
		8	8.4	6/64	2.4
		6	13.3	8/64	3.2

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

21.2.11 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 its 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.

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

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

21.2.14 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 21.2.3.

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 (100 mm) and strain relief is provided.

21.2.15 Cords or appliance wiring material as referenced in Group B, Table 21.1 may be employed if the wiring is enclosed by a furnace casing conforming to all of the following:

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

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

c) Openings in other than the bottom will not permit entrance of a rod having a diameter of 1/2 inch (12.7 mm), and openings for such items as pipe or conduit are not more than 1/2 inch in diameter larger than the object that will be installed through the opening.

d) Openings are not closer than 6 inches (150 mm) to the wiring unless metallic barriers or baffles are placed between the wiring and the openings. Louvered openings of a kind that serve to protect the wiring from mechanical damage from outside the compartment and that are so formed as to assist in confining an electrical disturbance to within the compartment are exempt from this requirement. To conform with these requirements the louvers should be of a drawn metal of a form to completely obscure viewing of the wiring within the compartment when viewed from the horizontal outside the compartment, and the openings shall be located so an object falling vertically cannot enter the compartment through the louvered opening.

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

21.2.16 With reference to 21.2.15(e), plastic materials shall be classified as Type 94V-0, 94V-1, 94V-2, 94-5V, 94HF-1, or 94HF-2 in accordance with the Standard for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and other nonmetallic materials shall have equivalent characteristics.

21.2.17 Cords and other wiring material acceptable in accordance with 21.2.15 and 21.2.21 shall be arranged to avoid being damaged, such as by closely following surfaces, and shall be supported. Strain relief, where required, shall be provided.

21.2.18 In applying the requirement of 21.2.15, an opening that is always intended to be connected to an air duct may be considered as closed.

21.2.19 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 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.

21.2.20 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.

21.2.21 To provide an acceptable unbushed opening in sheet metal usually requires rolling or extrusion of the metal around the opening, or the insertion of a grommet conforming to 21.2.19.

21.2.22 Factory wiring of a low-voltage safety circuit may be 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 damage.

21.3 Short circuit protection

21.3.1 Except as indicated in 21.3.2, 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 risk of fire or electric shock. See Short-Circuit Test, Section 53.

21.3.2 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 No. 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 which 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.

22 Separation of Circuits

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

22.2 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.

22.3 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 permit unintended operation of the appliance, except that a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that conductors having insulation at least equivalent to those referenced in Group A of Table 21.1 are or will be installed when wired in accordance with the National Electrical Code, ANSI/NFPA 70-1993.

22.4 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 22.3 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 live parts connected to a different circuit is to be investigated.

22.5 To determine if a device complies with the requirements of 22.3, it is to be wired as it would be in service and in doing so 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.

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

22.7 A metal barrier shall have a thickness at least as great as that required by Tables 27.1 and 27.2, 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.

22.8 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.

22.9 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.

22.10 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 compartment, and the output of each circuit shall be marked to warn that the separation shall be maintained.

23 Bonding for Grounding

23.1 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.

23.2 Except as indicated in 23.3, 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 serviceman.

23.3 Metal parts, as described below, need not be grounded:

a) Adhesive-attached metal-foil-markings, screws, handles, or parts which 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.

23.4 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.

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

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

23.7 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.

23.8 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.

23.9 A connection that depends upon the clamping action exerted by rubber or similar materials is acceptable if it complies with 23.11 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.

23.10 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.

23.11 If the adequacy of a bonding connection cannot be determined by examination, or if a bonding conductor is smaller than required by 23.12 – 23.20, it shall be acceptable if the connecting means does not open:

a) When carrying for the time indicated in Table 23.1, 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 53.

Table 23.1
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

23.12 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 23.11, the size of the conductor or strap shall be in accordance with Table 23.2.

Table 23.2
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire AWG (mm^2)		Aluminum wire AWG (mm^2)	
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.3)
40	10	(5.3)	8	(8.3)
60	10	(5.3)	8	(8.3)
100	8	(8.3)	6	(13.3)
200	6	(13.3)	4	(21.2)

[a] Or equivalent cross-sectional area.

23.13 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.

23.14 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.

23.15 The following are considered to constitute means for connection to a ground:

a) In 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.

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

23.16 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 70-1993.

23.17 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.

23.18 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 connection of such a conductor shall be identified by being marked, "G, GR, GROUND, 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 so located that it is not necessary to be removed during servicing. At a wire-binding screw, upturned lugs, or the equivalent, shall be provided to retain the conductor. If a pressure 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" and/or identifying the connector by a green color.

23.19 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.

23.20 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 15 millivolts after 10 cycles of attachment and removal of the part being bonded.

24 Servicing and Adjustment

24.1 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 intended direction of access if uninsulated high-voltage live parts or moving parts which may 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.

24.2 Service functions which may have to be performed with the equipment energized include:

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

b) Resetting control trip mechanism,

c) Operating manual switches, or

d) Adjusting air-flow dampers.

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

24.3 An electrical control component which may require examination, adjustment, servicing, or maintenance while energized, excluding voltage measurements except for jacks or terminals specifically intended for that purpose, 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 serviceman to the risk of electric shock from adjacent uninsulated live parts or to injury from adjacent moving parts.

24.4 Components in a low-voltage circuit are to comply with the requirements of 24.4 in their relation to uninsulated live parts in a high-voltage circuit and to moving parts.

25 Electrical Components

25.1 Electrical equipment and wiring shall be arranged so that during periods of intended use or when uncoupling of a connection is required for servicing, they will not be contacted by water or oil.

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

26 Mounting of Electrical Components

26.1 A switch, fuseholder, lampholder, or similar electrical component shall be mounted to prevent it from turning, except as noted in 26.2 and 26.3.

26.2 The requirement that a switch be prevented 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 is by mechanical means rather than by direct contact by persons.

26.3 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 cannot reduce spacings below the required values.

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

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

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

27 Electrical Enclosures

27.1 General

27.1.1 Uninsulated live high-voltage 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 such parts located in a compartment into which access is required for servicing of the equipment, such as resetting controls, replacing filters, lubrication and cleaning.

27.1.2 Among the factors taken into consideration when judging the acceptability of an enclosure are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) 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.

27.1.3 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.

27.1.4 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 70-1993.

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

27.1.6 Sheet metal complying with Tables 27.1 and 27.2, whichever applies, is acceptable for the individual enclosure of electrical components.

Table 27.1
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					
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Uncoated		Metal coated	
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)				
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)				
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)				

(Continued)

Table 27.1 (Cont'd)

[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 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 that 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 that 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 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 which 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 27.2
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

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

(Continued)

Table 27.2 (Cont'd)
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)
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	(63.4)	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 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 via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

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

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

3) An enclosure surface loosely attached to a frame, such as with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece 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 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.

27.1.7 Where the construction 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 27.1 or 27.2, whichever applies, may be employed.

27.1.8 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.

27.1.9 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement of 27.1.3.

27.1.10 A junction box which 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 does not permit the entrance of a 13/64 inch (5.2 mm) diameter rod.

27.1.11 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 either (a) or (b).

a) For an opening that has a minor dimension (see 27.1.15) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 27.1.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 27.3.

Exception: An opening in an integral enclosure of a motor need not comply with these requirements if it complies with the requirements in 27.1.12.

27.1.12 With respect to a part or wire as mentioned in 27.1.11, in an integral enclosure of a motor as mentioned in the exception to 27.1.11:

a) An opening that has a minor dimension (see 27.1.15) less than 3/4 inch (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 27.3;

2) In a directly accessible motor (see 27.1.16), an uninsulated live part cannot be contacted by the probe illustrated in Figure 27.4; or

3) In an indirectly accessible motor (see 27.1.16), an uninsulated live part cannot be contacted by the probe illustrated in Figure 27.2.

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 27.3.

27.1.13 The probes mentioned in 27.1.11 and 27.1.12 and illustrated in Figures 27.1, 27.1 – 27.4 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 27.2 and 27.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

27.1.14 The probes mentioned in 27.1.13 and 27.1.15 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; they are to be applied with the minimum force necessary to determine accessibility.

27.1.15 With reference to the requirements in 27.1.11 and 27.1.12, 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.

Figure 27.1
Articulate probe with web stop

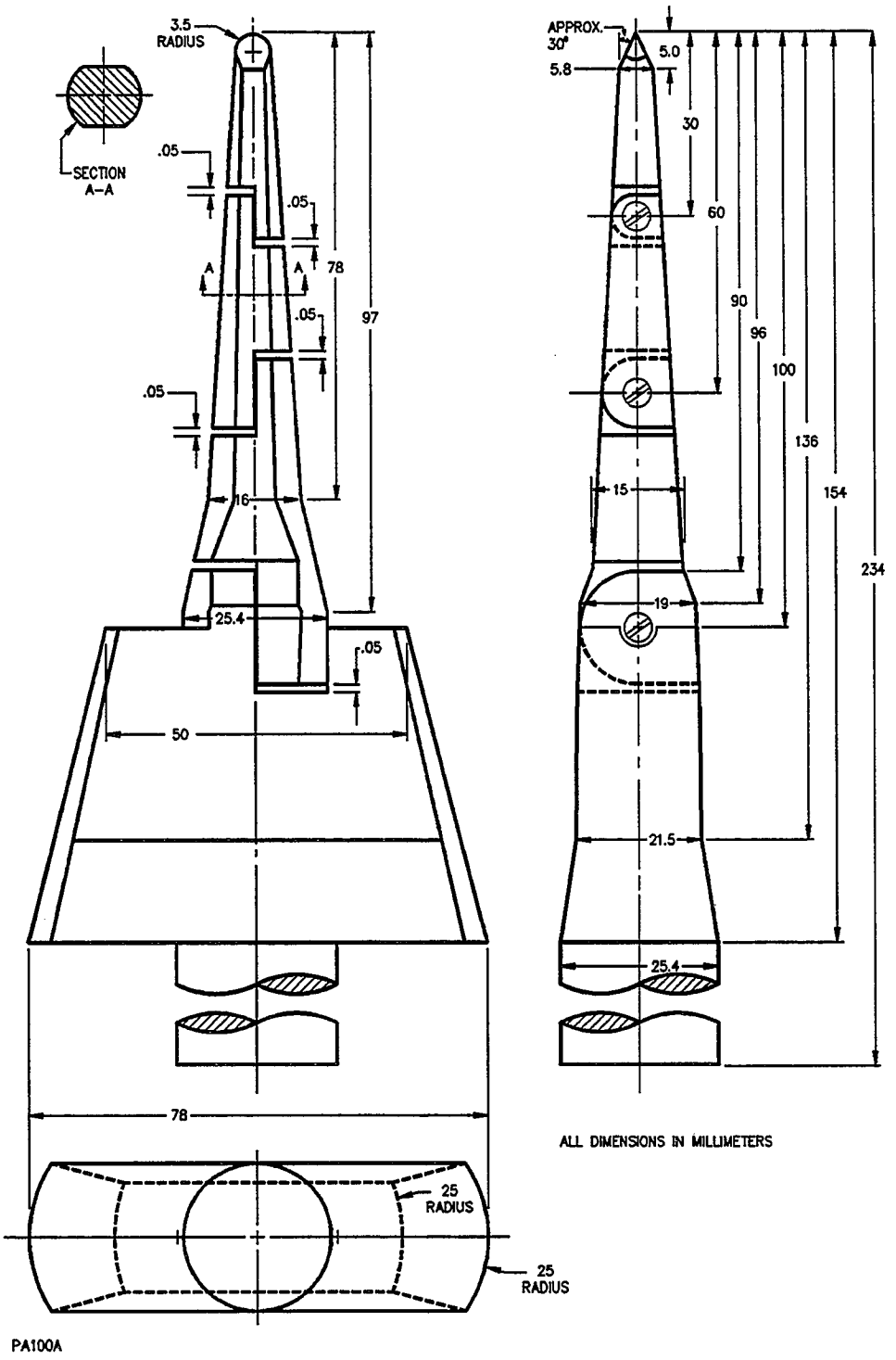


Figure 27.2
Probe for uninsulated live parts

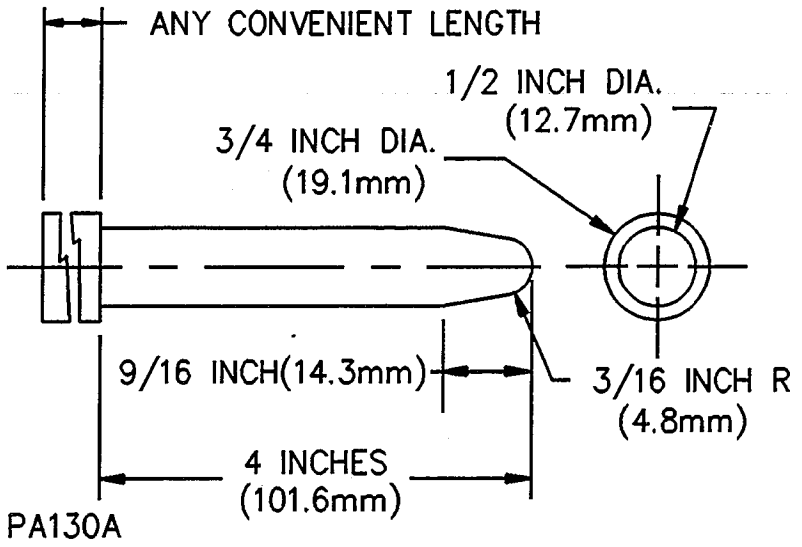


Figure 27.3
Probe for film-coated wire

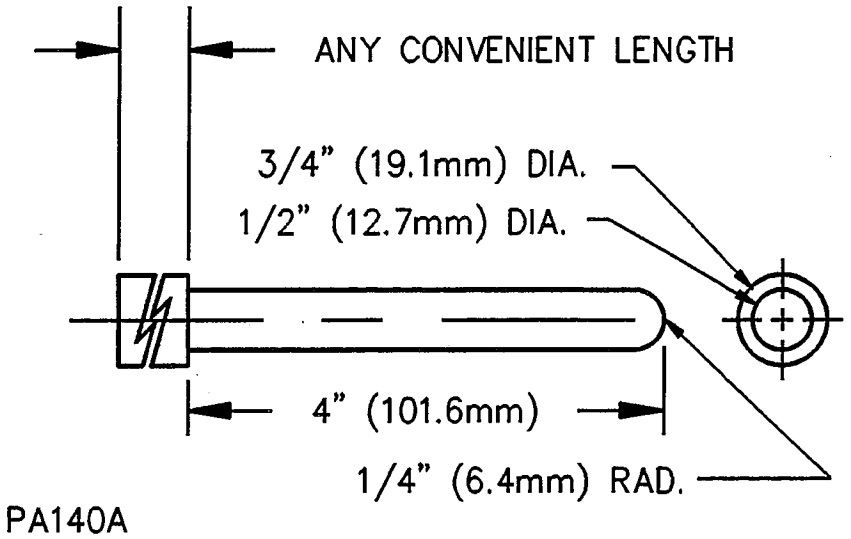


Figure 27.4
Articulate probe

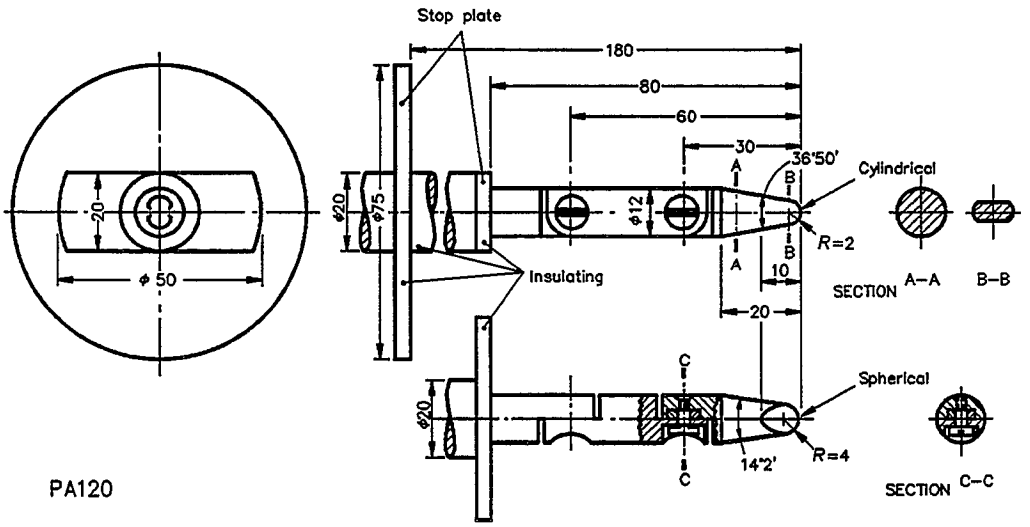


Table 27.3
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimensions of opening[a]		Minimum distance from opening to moving part	
Inches	mm[b]	Inches	mm[b]
3/4	(19.1)[c]	4-1/2	(114)
1[c]	(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 27.1.15.

[b] Between 3/4 (19.1 mm) and 2-1/8 inches (54.0 mm), interpolation is to be used to determine a value between values specified in the table.

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

[d] More than 2-1/8 inches (54.0 mm), but not more than 6 inches (152.0 mm)

27.1.16 With reference to the requirements in 27.1.12, 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. A directly accessible motor is a motor:

1) That can be contacted without opening or removing any part, or

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

27.1.17 During the examination of a product to determine whether it complies with the requirements in 27.1.11 or 27.1.12, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

27.1.18 With reference to the requirements in 27.1.11 and 27.1.12, insulated brush caps are not required to be additionally enclosed.

27.2 Doors and covers

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

27.2.2 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 likely to cause injury to persons.

27.2.3 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 27.2.7.

27.2.4 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.

27.2.5 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.

27.2.6 A fuseholder shall be so constructed, installed, or protected that adjacent uninsulated high-voltage live parts within 4 inches (100 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.

27.2.7 The door or cover of an enclosure shall be hinged if it gives access to fuses or any motor overload protective device, the intended protective functioning of which requires renewal, or if 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, except as indicated in 27.2.8.

27.2.8 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) An extractor-type fuse with its own enclosure, or

d) Fuses in low-voltage circuits.

27.2.9 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.

27.2.10 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 to open it is considered to be an acceptable means for holding the door in place as required in 27.2.9.

27.2.11 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.

27.2.12 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 mm) from each end of each strip, and at points between these end fastenings not more than 6 inches (150 mm) apart.

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

27.3 Field wiring system connections

27.3.1 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.

27.3.2 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 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.

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

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

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

27.3.6 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 dimension, 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 (35-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.

28 Motors and Motor Overload Protection

28.1 All motors shall be protected by an integral thermal protector or by overload protective devices, or combination thereof.

28.2 Overload protective devices as referred to in 28.1 mean those that conform to the requirements of the National Electrical Code, ANSI/NFPA 70-1993, as follows:

a) A separate overload 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 a marked temperature rise not over 40°C (72°F), 125 percent, and

3) All other motors, 115 percent.

For a multispeed motor, each winding connection shall be considered separately and the motor shall 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 overload 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, and

3) All other motors, 130 percent.

28.3 An integral thermal protective device is to comply with the Standard for Thermal Protectors for Electric Motors, UL 547.

28.4 Separate overload 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 allow unintended operation of the equipment.

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

a) Three properly rated overcurrent devices shall be 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.

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

28.7 In determining compliance with 28.6, when a totally enclosed motor is to be provided, no openings are permitted in portions of the motor frame exterior of the appliance, that is, openings may be in the shaft end of face-mounted oil-burner motors bolted flush to the blower housing of an oil burner, but not in other portions of the motor frame.

28.8 Motors, such as direct-drive fan motors, which are not normally subjected to overloads, and which 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.

28.9 Impedance protection may be accepted for motors which 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; except that impedance protection is not to be accepted where the motors are installed in compartments handling air for circulation to the conditioned space.

28.10 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.

28.11 Motors shall not exceed the temperature rises indicated in Table 47.1 when tested as described herein.

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

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

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

28.15 The enclosure of a motor shall have no openings which will permit a drop of liquid or a particle falling vertically onto the motor to enter the motor as applied to the assembly.

28.16 Conformance to 28.15 may be provided by the motor frame or by another enclosure, structure, shield, or a combination of two or more such items, and is to be determined with the motor applied to the assembly.

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

28.18 The requirement in 28.17 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

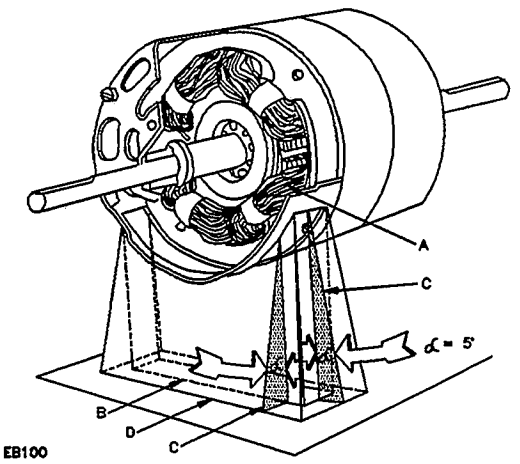
4) Capacitor shorted (permanent split capacitor type), or

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

28.19 The barrier mentioned in 28.18 shall be horizontal, shall be located as indicated in Figure 28.1 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.

Figure 28.1
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 that 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 plane of the barrier.

28.20 Overcurrent protective devices and thermal protective devices for motors shall comply with the requirements of the Short-Circuit Test, Section 53.

29 Overcurrent Protection of High-Voltage Control-Circuit Conductors

29.1 General

29.1.1 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 product. A control circuit does not carry main-power current. If a control circuit is supplied through a transformer provided as part of the product, see Overcurrent Protection of Transformers, Section 30, for additional requirements.

29.2 Direct-connected high-voltage control circuit

29.2.1 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 product. It is not tapped from the load side of the overcurrent device or devices of the controlled circuit or circuits within the product. See 60.14.

29.3 Tapped high-voltage control circuits

29.3.1 For the purpose of these requirements, a tapped high-voltage control circuit is a circuit that is tapped within the product from the load side of the overcurrent device or devices for the controlled load. Such a circuit shall be protected in accordance with 29.3.3 – 29.4.2.

29.3.2 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 70-1993.

29.3.3 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 29.1.

Exception No. 1: A No. 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 a 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 53.14.

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 the requirements specified in Overcurrent Protection of Transformers, Section 30, and

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

Conductor ampacity is to be determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70-1993, for the type of wire or cord employed. If appliance wiring material is used its ampacity is to be based on the values specified for the equivalent wire or cord.

29.4 Overcurrent-protective devices

29.4.1 Overcurrent protection for a tapped high-voltage control-circuit conductor, as required by 29.3.3, shall be provided as part of the product. If a fuse is used, the product shall be marked in accordance with 60.12.

Exception: The overcurrent device or devices need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in Table 29.1.

Table 29.1
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 National Electrical Code, ANSI/NFPA 70-1993.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70-1993.

29.4.2 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 29.3.3, 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, RK, or T cartridge fuse or a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the product, a fuse used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 53.1. If the supplementary device used is a fuse, the product shall be marked in accordance with 60.13.

30 Overcurrent Protection of Transformers

30.1 High-voltage transformers

30.1.1 A transformer, other than as described in 30.2.1 and 30.2.2, is considered to be a high-voltage transformer and shall:

a) Be provided with thermal-overload protection in accordance with the requirements in 30.1.2,

b) Be protected by an overcurrent device or devices in accordance with the requirements in 30.1.4, or

c) Comply with the requirements in the Burnout Test, High-Voltage Transformers, Section 55.

30.1.2 If a high-voltage transformer is provided with a thermal-overload-protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings under overload conditions to those acceptable for the class of insulation employed in the windings. See Overload Test, High-Voltage Transformers, Section 54.

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 55.

30.1.3 A thermal cutoff shall comply with the requirements in the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020. 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.

30.1.4 If a high-voltage transformer is protected by an overcurrent device or devices, such protection shall comply with the requirements specified in 30.1.5, 30.1.6, and 30.2.3 – 30.2.5.

30.1.5 A high-voltage transformer shall be protected by an overcurrent device or devices that are located in the primary circuit and that are rated or set as indicated in Table 30.1 for the primary. See 30.1.6 and 30.2.3.

Table 30.1
Ratings 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 if 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.		

30.1.6 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 30.1 for the secondary.

30.2 Low-voltage transformers

30.2.1 Except as specified in 30.2.2, 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 30.2.3.

30.2.2 A transformer that supplies a Class 2 circuit (see 3.17(b)) shall, in accordance with the requirements in the Standard for Class 2 and Class 3 Transformers, UL 1585, either limit the output current (inherently-limiting transformer) or be equipped with an overcurrent device, or devices (noninherently-limiting transformer).

30.2.3 Overcurrent protection in the primary circuit of a transformer, as described in 30.1.5 and 30.2.1, need not be provided as part of the product if, based on the marked rating of the product, the rating of the branch-circuit overcurrent-protective device or devices does not exceed the values specified in 30.1.5 or 30.2.1, as applicable.

30.2.4 Overcurrent protection in the secondary circuit of a transformer, as required by 30.1.6, shall be provided as part of the equipment. If a fuse is used the product shall be marked in accordance with 60.12.

30.2.5 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 30.1.5, 30.1.6, and 30.2.1, 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, RK, or T cartridge fuse or a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the unit, a fuse used for overcurrent protection may be of the supplementary type provided that the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 53.1. If a supplementary-type fuse is provided, the product shall be marked in accordance with 60.13.

31 Switches and Controllers

31.1 Except as indicated in 31.2, 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.

31.2 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 each motor.

31.3 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 60.8 if the same controller contacts handle a remote motor(s) in addition to the motor(s) in the unit containing the controller.

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

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

31.6 A controller that 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.

31.7 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 without failure. The endurance test is to be determined by the requirements of the appropriate standard for the component. See 4.1.

31.8 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.

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

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

32 Capacitors

32.1 A motor starting or running capacitor shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction of the capacitor. Except as noted in 32.2 and 32.3, 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).

32.2 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 furnace and provided that such box or case is acceptable for the enclosure of current-carrying parts.

32.3 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 53.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 53.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

33 Electrical Insulating Material

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

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

34 Spacings – High-Voltage Circuit

34.1 Except as noted in 34.2, 34.3, and 34.5, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead-metal part shall be not less than the values indicated in Table 34.1.

Table 34.1
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	0 – 150	1/8[b]	3.2	1/4	6.4	1/2	12.7
than	151 – 300	1/4	6.4	3/8	9.5	1/2	12.7
2000	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 be not 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 connected to each terminal.

[c] Includes metal fittings for conduit or cable which are factory installed or which 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.

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

34.3 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.

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

34.5 The spacing requirements in Table 34.1 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 clearance to dead metal or enclosures, are to be those indicated in the table.

34.6 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.

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

35 Spacings – Low-Voltage Circuits

35.1 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire or electric shock shall comply with 35.2 – 35.5.

35.2 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 34.3.

35.3 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 not be less than 1/4 inch (6.4 mm).

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

35.5 The spacings in low-voltage circuits that do not contain devices such as indicated in 35.2 are not specified.

36 Accessibility of Uninsulated Live Parts

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

36.2 Accessibility and protection from the risk of electric shock and accidental contact with moving parts which may cause injury to persons may be obtained 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 and the cover of the control assembly enclosure with the following arrangement. See Figure 36.1.

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 (355 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 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.

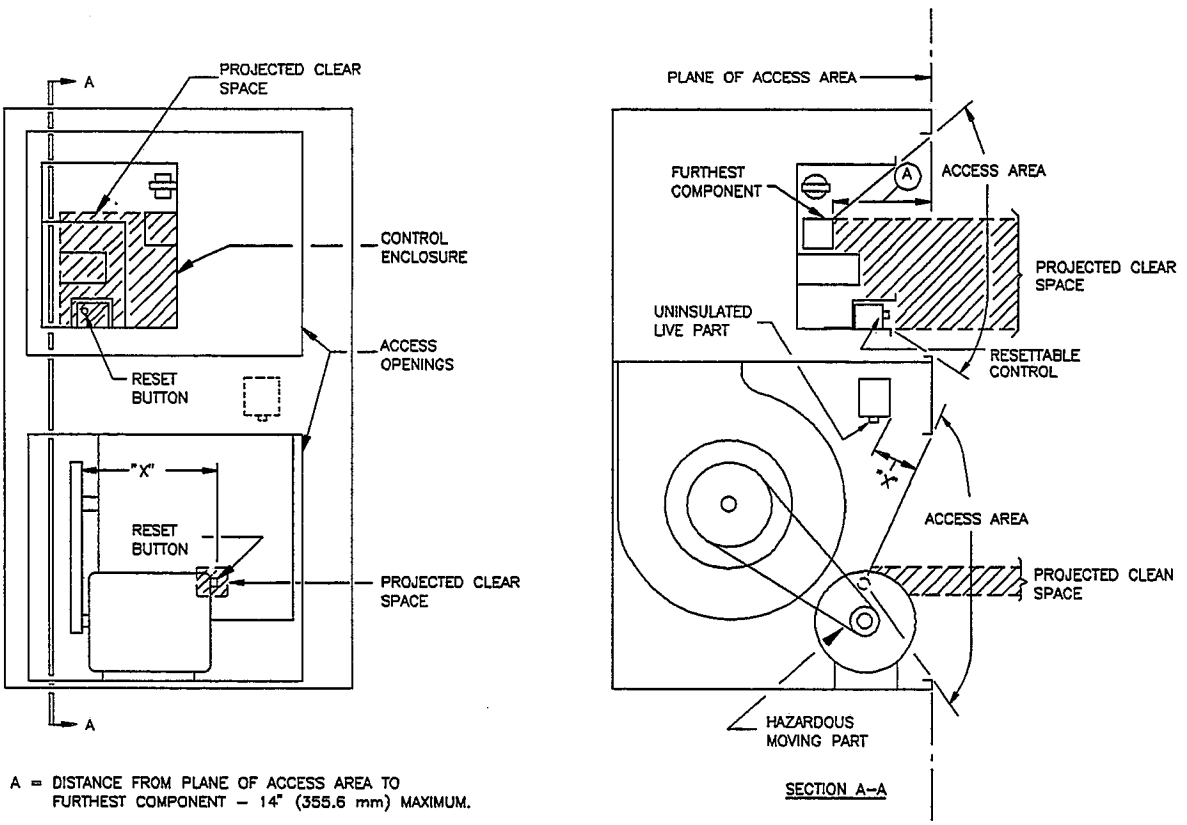
d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

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 24.2.

Figure 36.1
Accessibility and protection



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

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

EA105

36.3 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.

PERFORMANCE

37 General

37.1 A furnace shall comply with the applicable requirements when tested as described herein. A furnace of a type not described specifically herein shall be tested in accordance with the intent of these requirements.

37.2 A floor-mounted furnace of the upflow or downflow type is tested normally for installation on noncombustible floors and with clearances to combustible walls and ceilings as indicated in Table 37.1. Such a furnace is classified under Form I or Form III, depending on its physical size as noted in the table. At the option of the manufacturer, a floor-mounted furnace may be tested for installation on combustible floors and when so tested is classified under Form Ia or Form IIIa, depending on its physical size.

37.3 A horizontal furnace is tested normally with clearances below and to walls and ceilings as indicated in Table 37.1. Such a furnace is classified under Form IIb or Form IIIb, depending on its physical size as noted in the table. At the option of the manufacturer, a horizontal furnace normally classified under Form IIb may be tested for zero clearance below and when so tested is classified under Form IIa.

37.4 At the option of the manufacturer any furnace may be tested with clearances less than those indicated in Table 37.1. See 43.1.

37.5 If an appliance is to be tested in a partial enclosure at clearances less than those designated as standard in Table 37.1, a ceiling of construction equivalent to that required for the walls is to be placed above the partial enclosure. Clearances from chimney connectors are not to be less than 9 inches (230 mm). When the chimney connector clearances are less than those designated as standard in Table 37.1, the connector arrangement is to be as specified in 39.1.9 and Figure 39.4. Except for those modifications of the enclosure and as otherwise provided herein, tests are to be conducted in the manner described for standard clearances.

Table 37.1
Standard clearances

Type of furnace	Minimum clearance, inches (mm)					
	A	B	C	D	E	F
	Above	Front	Chimney connector	Rear	Sides	Below
Form I	2 (50)	24 (610)	18 (460)	6 (150)	6 (150)	NC
Form Ia	2 (50)	24 (610)	18 (460)	6 (150)	6 (150)	C
Form IIa	6 (150)	24 (610)	18 (460)	6 (150)	6 (150)	O (o)
Form IIb	6 (150)	24 (610)	18 (460)	6 (150)	6 (150)	6 (150)
Form III	18 (460)	48 (1220)	18 (460)	18 (460)	18 (460)	NC
Form IIIa	18 (460)	48 (1220)	18 (460)	18 (460)	18 (460)	C
Form IIIb	18 (460)	48 (1220)	18 (460)	18 (460)	18 (460)	18 (460)

C – Combustible

NC – Noncombustible

Forms I and Ia – Warm-air furnaces, upflow, or downflow types not larger than 100 cubic feet (2.8m^3) in size excluding blower compartments and burner).

Forms IIa and IIb – Horizontal forced warm-air furnaces not larger than 100 cubic feet in size (excluding blower compartments and burner).

Forms III and IIIa – Low-heat industrial appliances, floor mounted types, which include furnaces not classified under Forms I and Ia.

Form IIIb – Low-heat industrial appliances, suspended types, which include furnaces not classified under Form IIb.

37.6 At the further option of the manufacturer, a furnace having physical dimensions permitting classification under Forms I, Ia, IIa, and IIb, equipped with an integral limit control which, when adjusted to its maximum allowable setting, does not permit an outlet air temperature in excess of 200°F (93°C), may be tested also for installation in:

a) An attic on combustible floors with clearances as indicated for Forms Ia and IIa, Table 37.1.

b) An alcove or a closet with clearances which may be less than indicated for Forms I, Ia, and IIa, Table 37.1. Under this option, upflow, downflow, and gravity furnaces may be tested for installation on combustible or noncombustible floors, while a horizontal furnace may be tested at a clearance of 6 inches (150 mm) or less below the furnace.

37.7 The standard clearances designated in Table 37.1 are based on the furnace being installed in a room that is large compared to the size of the furnace. See the Test Installation for Alcove or Closet, Section 39. All clearances designated in Table 37.1, or by the manufacturer under an option, are to be in integral inches for testing purposes.

38 Test Installation for Standard Clearances

38.1 Downflow and upflow furnaces (for installation in other than closets or alcoves)

38.1.1 The furnace is to be placed in a partial enclosure in the as-received condition, as described below. The distance from the back, side, and top of the furnace and from the chimney connector to the walls and ceiling of the enclosure is to be as indicated in Table 37.1. If one side of the furnace may create higher wall temperature than the other, that side of the furnace is to be directly opposite one wall.

38.1.2 The furnace is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the furnace the minimum allowable distance above the floor.

38.1.3 The partial enclosure is to be formed by two walls of 1-inch (25.4 mm) nominal thickness wood boards or plywood 3/4 inch (19 mm) thick, set at right angles and finished in flat black. See Figure 38.1. A ceiling of equivalent construction is to be placed above the partial enclosure. The height of the walls is to be such as to obtain the minimum clearance above the furnace specified in Table 37.1 and in accordance with 37.2. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the partial enclosure are to extend 3 feet (0.91 m) beyond the end and side of the furnace. The walls are to be the minimum distance specified in Table 37.1 from the side and back of the furnace; except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the flue collar by a 90-degree elbow. See 38.1.5.

38.1.4 If the furnace is designed for direct installation on combustible flooring, the floor beneath the furnace is to be nominal 1-inch (3/4 inch) (19 mm) white-pine flooring covered with one thickness of building paper, and then by 3/4 inch thick plywood, unpainted or finished with a clear sealer.

38.1.5 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe not heavier than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure; being directly connected to and extended vertically above a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree sheet-metal elbow at the bottom of the vertical section. See Figure 38.2.

38.1.6 Where the chimney connector pierces the enclosure, an opening 8 inches (205 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed sealed on the exterior surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 38.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50 mm) from the outer edge of the annulus.

38.1.7 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown in Figure 38.2(2).

38.1.8 The primary safety control, if furnished separately for mounting in the chimney connector exterior to the furnace, may be located at any appropriate point either within or exterior to the test enclosure. No temperature measurements in or on a control so located are to be made during tests for Standard Clearances.

38.1.9 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 38.2.

Figure 38.1
Test enclosure for standard clearances downflow and upflow furnaces

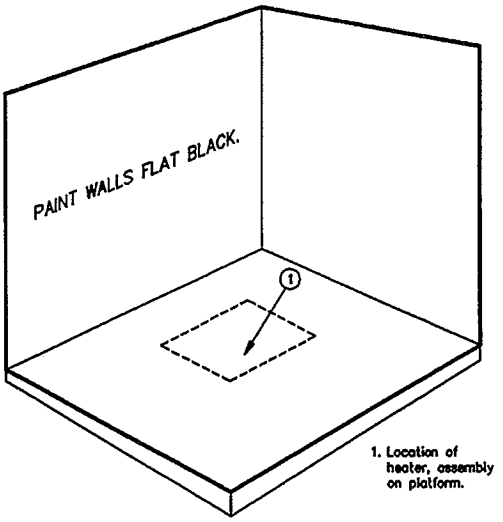
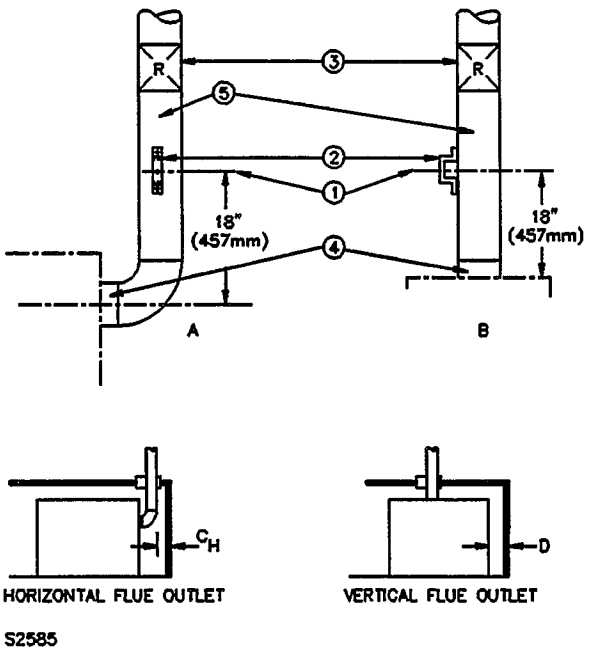
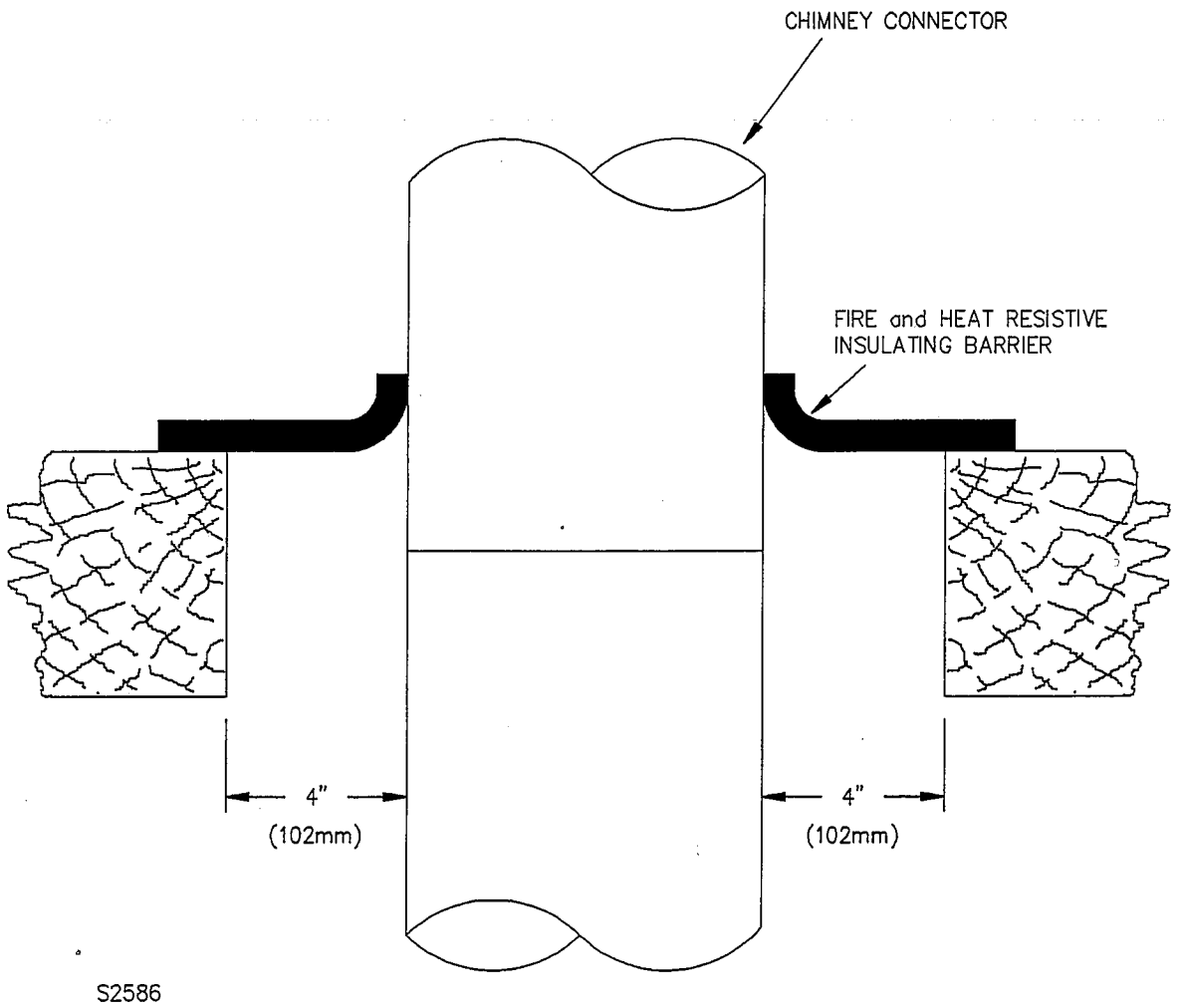


Figure 38.2
Chimney connectors – standard clearance test



1. Centerline of thermocouple.
2. Support bracket.
3. Draft regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.

Figure 38.3
Sealing of annulus around chimney connector

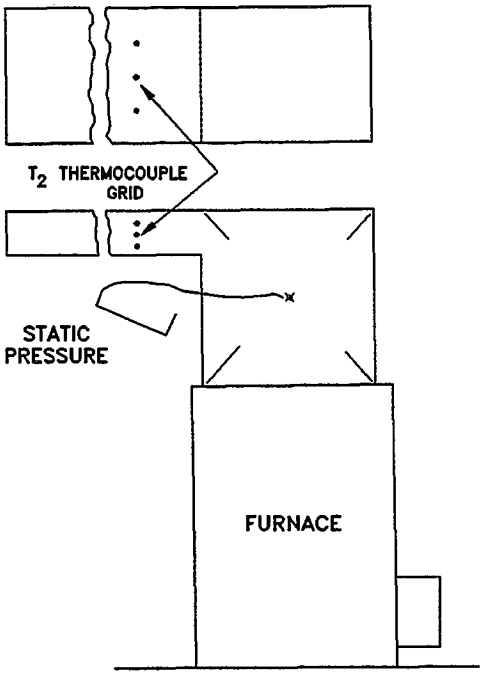


38.1.10 Any built-in draft regulator included as part of the furnace is to be fixed in the position allowing maximum draft.

38.1.11 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

38.1.12 Unless the supply plenum is an integral part of the furnace, a metal plenum chamber or bonnet having the same dimension as the warm-air outlet of the furnace is to be provided by the manufacturer for test purposes. For forced-air upflow furnaces, a separate plenum is to be at least 18 inches (460 mm) high but not less than that required to obtain 2 inches (50 mm) clearance to a ceiling located at least 7 feet 6 inches (2.3 m) above the floor of the test enclosure. See Figure 38.4. For downflow furnaces intended for installation on combustible flooring, the depth of the plenum is to be such as to obtain the specified clearance between the top of the outlet duct and the lower surfaces (ceiling) of the floor structure. See Figure 38.5.

Figure 38.4
Plan of ducts for forced-air upflow furnaces

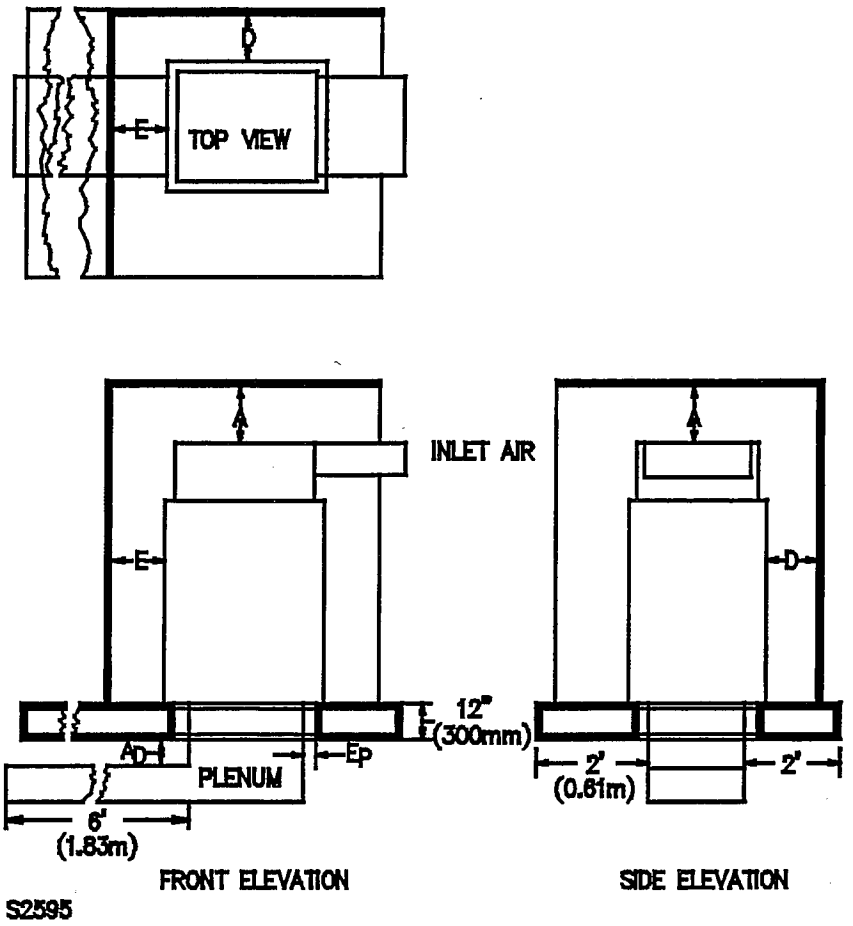


t_2 – Outlet-air temperature

38.1.13 The warm-air outlet opening is to be extended by a duct or ducts beyond the test enclosure and arranged to discharge away from the cold-air inlet of the furnace.

38.1.14 For a forced-air furnace, the size of the outlet duct is to be calculated for a velocity of approximately 900 feet (275 m) per minute of standard air [0.075 pounds per cubic foot (1.2 kg/m^3)] with a 90°F (50°C) temperature rise through the furnace and based on an output equivalent to 75 percent of the rated input [Btu per hour (W)] of the furnace. Specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

Figure 38.5
Test enclosure – downflow furnace
standard clearances – combustible floor



A – From top of furnace casing.
A_D – From top of horizontal warm-air duct within 6 feet of furnace.
D – From back of furnace.
E – From side of furnace.
E_P – From side of supply plenum.

38.1.15 Formulas derived from the above based on the outlet duct area are as follows:

Area ($in.^2$) = (Btu per hour input) x 0.00122

Area (cm^2) = Watts x 0.0000554

38.1.16 The test duct is to be rectangular, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar, but the aspect ratio is not to exceed four to one. See Figure 38.4.

38.1.17 A thermocouple grid, see 40.6.9, is to be located in each warm-air outlet duct in a plane within 6 inches (152 mm) downstream from the location closest to the plenum where any couple will see any surface of the heat exchanger. The duct is to extend at least 6 inches (152 mm) beyond the thermocouple grid. See Figure 38.4.

38.1.18 The cross-sectional area and shape of the air-inlet duct is to be equivalent to the cold-air inlet of the furnace. The inlet-air temperature is to be measured by a thermocouple, not heavier than No. 24 AWG (2.1 mm^2) shielded from direct radiation and located centrally 24 inches (0.61 mm) in front of the furnace and 24 inches above the floor of the test enclosure.

38.1.19 The limit control, if furnished separately for mounting in a field-built plenum, is to be located as specified in the installation instructions furnished with the furnace.

38.2 Horizontal furnace

38.2.1 A horizontal furnace is to be tested when installed in a partial enclosure constructed of 1-inch nominal thickness wooden boards or 3/4-inch (19.1-mm) plywood finished in flat black, with all joints sealed. See Figure 38.6. If the furnace is intended for installation on combustible construction, the clearance beneath the furnace to the enclosure is to be zero. The walls are to be the minimum distance specified in Table 37.1 from the side and back of the furnace; except when the flue outlet is horizontal, in which case the wall opposite the flue collar is to be the specified distance from a vertical chimney connector as connected to the collar by a 90-degree elbow. See 38.2.3.

38.2.2 The furnace is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the furnace the minimum allowable distance above the floor.

38.2.3 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe, not heavier than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure; being directly connected to and extended vertically from a vertical flue outlet and connected to a horizontal flue outlet by using a 90-degree elbow at the bottom of the vertical section. See Figure 38.2.

38.2.4 Where the chimney connector pierces the ceiling, an opening 8 inches (205 mm) larger than the chimney connector is to be cut in the enclosure, and the annulus thus formed sealed on the upper surface with a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick. See Figure 38.3. Temperatures on surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50 mm) from the outer edge of the annulus.

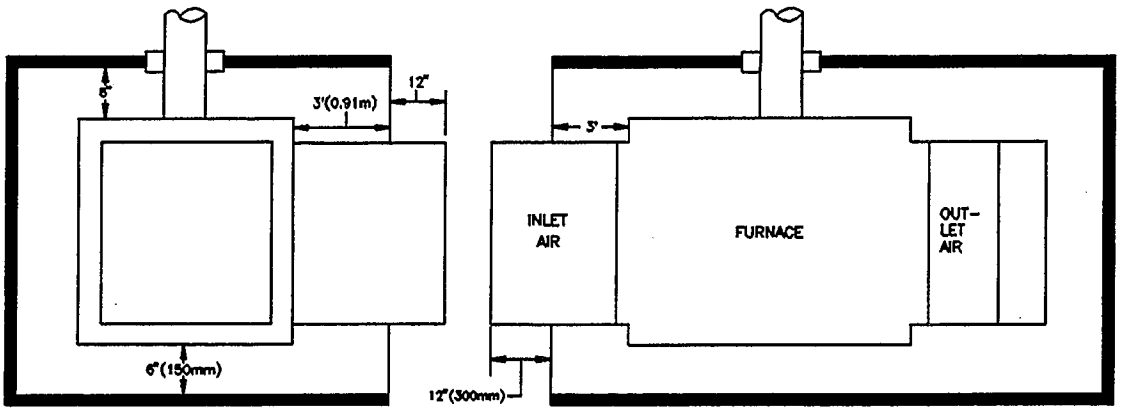
38.2.5 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by Figure 38.2(2).

38.2.6 The primary safety control, if furnished separately for mounting in the chimney connector exterior to the furnace, may be located at any appropriate point either within or exterior to the test enclosure. No temperature measurements in or on a control so located are to be made during tests for standard clearances.

38.2.7 A draft regulator is to be provided for test purposes and located in the chimney connector outside the enclosure. See Figure 38.2.

38.2.8 Any built-in draft regulator included as part of the furnace is to be fixed in the position allowing maximum draft.

Figure 38.6
Enclosure for horizontal furnace – standard clearances



VERTICAL FLUE OUTLET SHOWN

S 2596

38.2.9 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

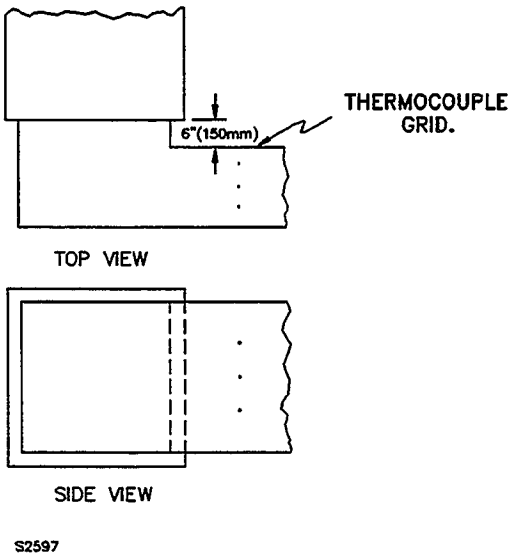
38.2.10 The cold-air inlet and warm-air outlet openings of the furnace are to be extended beyond the test enclosure by appropriate duct work. A metal plenum chamber having the same dimensions as the discharge opening of the furnace is to be provided by the manufacturer for test purposes. The plenum and the warm-air duct are to be arranged as indicated in Figure 38.7. The inlet-air duct is to have the same dimensions as the inlet opening of the furnace. The ducts are to extend at least 12 inches (305 mm) beyond the walls of the test enclosure.

38.2.11 A thermocouple grid, see 40.6.9, is to be located in the warm-air duct in a plane within 6 inches (152 mm) downstream from the position closest to the plenum where any couple will see any surface of the heat exchanger. The duct is to extend at least 6 inches (152 mm) beyond the thermocouple grid. See Figure 38.7.

38.2.12 The room temperature is to be measured by a thermocouple, not heavier than No. 24 AWG (2.1 mm^2) suitably shielded from direct radiation and located centrally 24 inches (610 mm) in front of the furnace and at an elevation midway between the floor and ceiling of the test enclosure.

Figure 38.7
Plenum and outlet duct for horizontal furnace

Style B test arrangement



39 Test Installation for Alcove or Closet

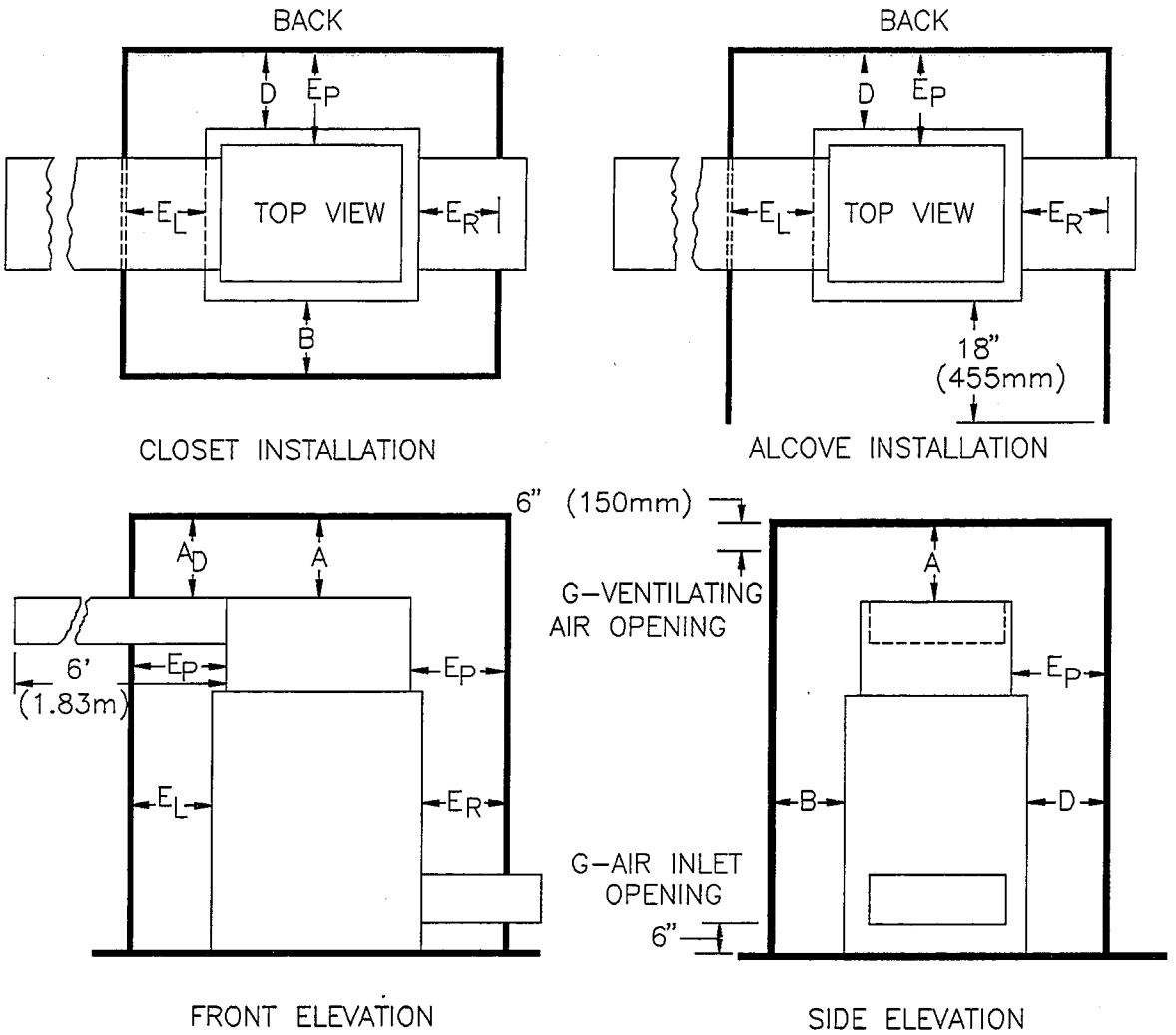
39.1 Downflow, upflow, and horizontal furnaces

39.1.1 The furnace is to be installed in an enclosure, as described below, in the as-received condition, with clearances in integral inches or increments of 25 mm, as selected by the manufacturer, to walls and ceiling of the test enclosure. The ceiling height of the enclosure is to be 7 feet 6 inches (2.3 m), except that for upflow furnaces with integral supply plenums, downflow, and horizontal furnaces, the ceiling height is to be that required to obtain the clearance from the top of the furnace to the ceiling specified by the manufacturer, but in no case is the ceiling height to be more than 7 feet 6 inches. See:

Figure 39.1 – Upflow Furnaces
Figure 39.2 – Downflow Furnaces
Figure 39.3 – Horizontal Furnaces

39.1.2 The walls and ceiling of the enclosure are to be made of 1-inch nominal thickness wooden boards or 3/4 inch (19.1 mm) thick plywood. The walls are to be vertical and at right angles. The interior surfaces of the walls and ceiling are to be finished in flat black. All joints in the enclosure are to be sealed. The floor is to be of combustible or noncombustible material, as selected by the manufacturer for testing purposes. Combustible floors are to be made of 1-inch flooring covered with one thickness of building paper superimposed by 3/4 inch (19.1 mm) thick plywood, unpainted or finished with clear sealer.

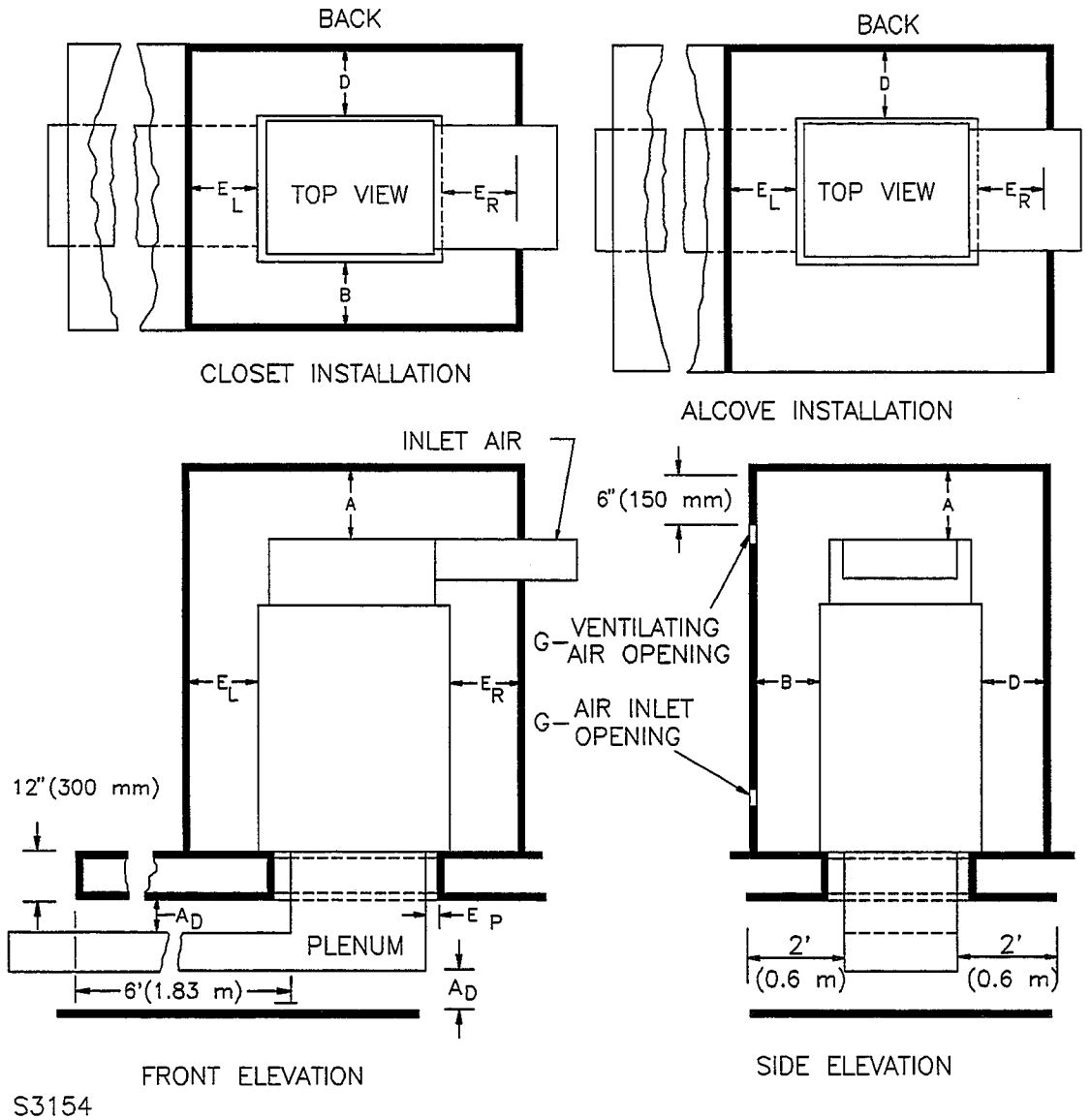
Figure 39.1
Test enclosure for alcove or closet installation upflow furnace



S2598

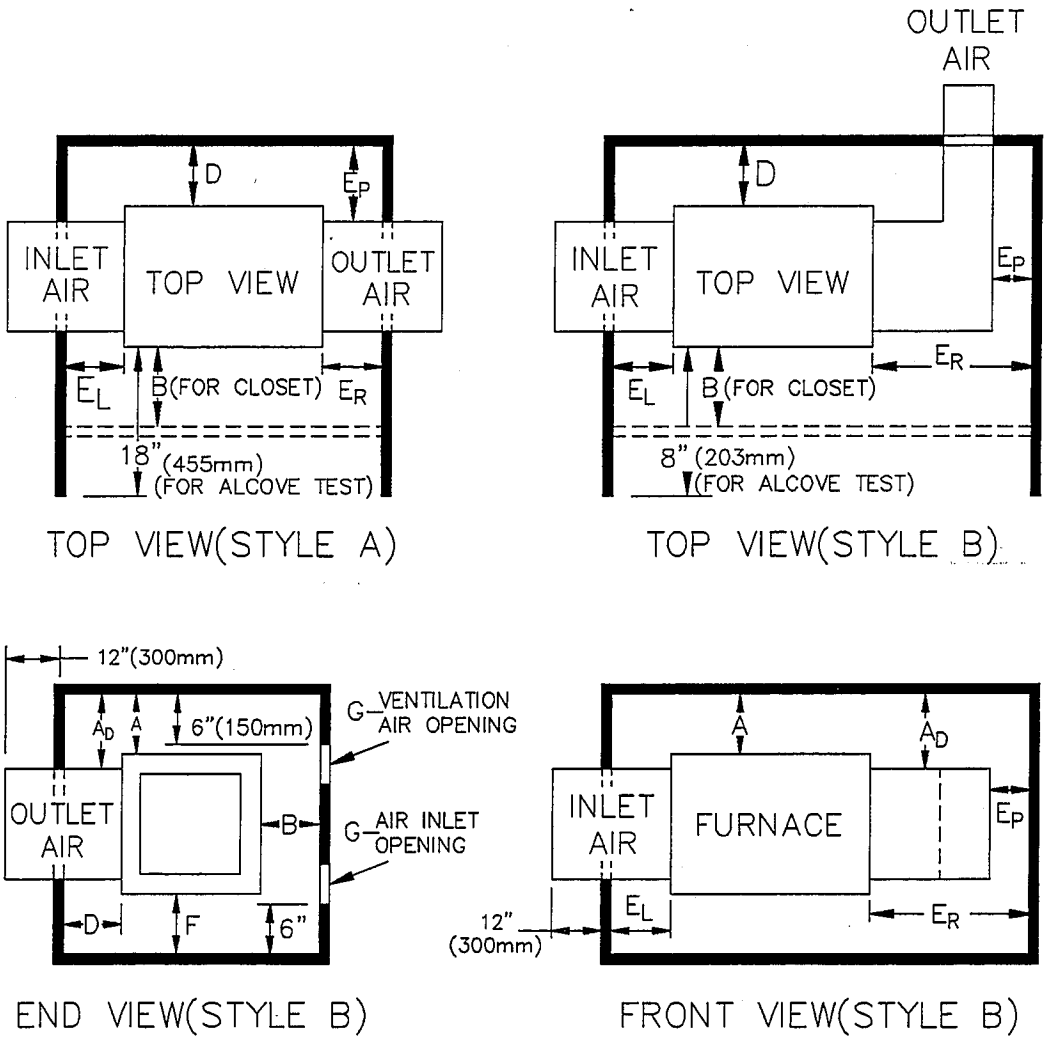
A – From top of furnace casing or plenum.
A_D – From top of horizontal warm-air duct within 6 feet (1.83 mm) of furnace.
B – From front of furnace.
C_H – From chimney connector, measured horizontally or below connector. See Figure 39.4.
C_V – From chimney connector, measured vertically above connector. See Figure 39.4
D – From back of furnace.
E_L – From left side of furnace.
E_R – From right side of furnace.
E_P – From any side of supply plenum and warm-air duct within 6 feet (1.83 mm) of furnace.

Figure 39.2
Test enclosure for alcove or closet installation downflow furnace



A – From top of furnace casing or plenum.
A_D – From top of horizontal warm-air duct within 6 feet (1.83 mm) of furnace.
B – From front of furnace.
C_H – From chimney connector, measured horizontally or below connector. See Figure 39.4.
C_V – From chimney connector, measured vertically above connector. See Figure 39.4
D – From back of furnace.
E_L – From left side of furnace.
E_R – From right side of furnace.
E_P – From any side of supply plenum and warm-air duct within 6 feet (1.83 mm) of furnace.

Figure 39.3
Test enclosure for alcove or closet installation horizontal furnace



S3156

A – From top of furnace casing or plenum.
A_D – From top of horizontal warm-air duct within 6 feet (1.83 mm) of furnace.
B – From front of furnace.
C_H – From chimney connector, measured horizontally or below connector. See Figure 39.4.
C_V – From chimney connector, measured vertically above connector. See Figure 39.4
D – From back of furnace.
E_L – From left side of furnace.
E_R – From right side of furnace.
E_P – From any side of supply plenum and warm-air duct within 6 feet (1.83 mm) of furnace.

39.1.3 For Alcove Installation Test, the enclosure is to be open opposite the front of the furnace. The side walls and ceiling are to extend 18 inches (460 mm) beyond the front of the furnace, and a wall is to be placed opposite the open side of the enclosure at a distance of 48, 36, or 24 inches (1.2, 0.9, or 0.6 m), as specified by the manufacturer for testing purposes.

39.1.4 For Closet Installation Test, a simulated door is to be provided for the enclosure, which door is to have two openings located so that the lower edge of the lower opening is 6 inches (152 mm) above the floor level of the enclosure and the other being located so that its upper edge of 6 inches below the ceiling of the enclosure. The height of each opening is to be one-half the width. The free area of each of the two openings is to be at least 1 square inch per 1000 Btu per hour (1 cm^2 per 45.4 W) of the furnace input rating but not more than an area equivalent to 20 percent of the total area of the simulated door. For an upflow and downflow furnace, both openings are to be centered on the vertical center line of the enclosure. For a horizontal furnace, the two openings are to be centered on vertical center lines in accordance with the instructions furnished with the furnace.

39.1.5 For a downflow furnace, a structure made of nominal 1 inch boards or 3/4 inch (19.1 mm) thick plywood, representing a ceiling, is to be placed above the warm-air outlet duct. The clearance between the duct and the ceiling is to be the minimum selected by the manufacturer for testing purposes. The ceiling is to extend the full length of the duct and at least 2 feet (0.61 m) beyond each side of the duct.

39.1.6 The furnace is to be level. Leveling means, if provided, are to be removed if detachable; or, if not detachable, are to be adjusted to place the base of the furnace the minimum allowable distance above the floor.

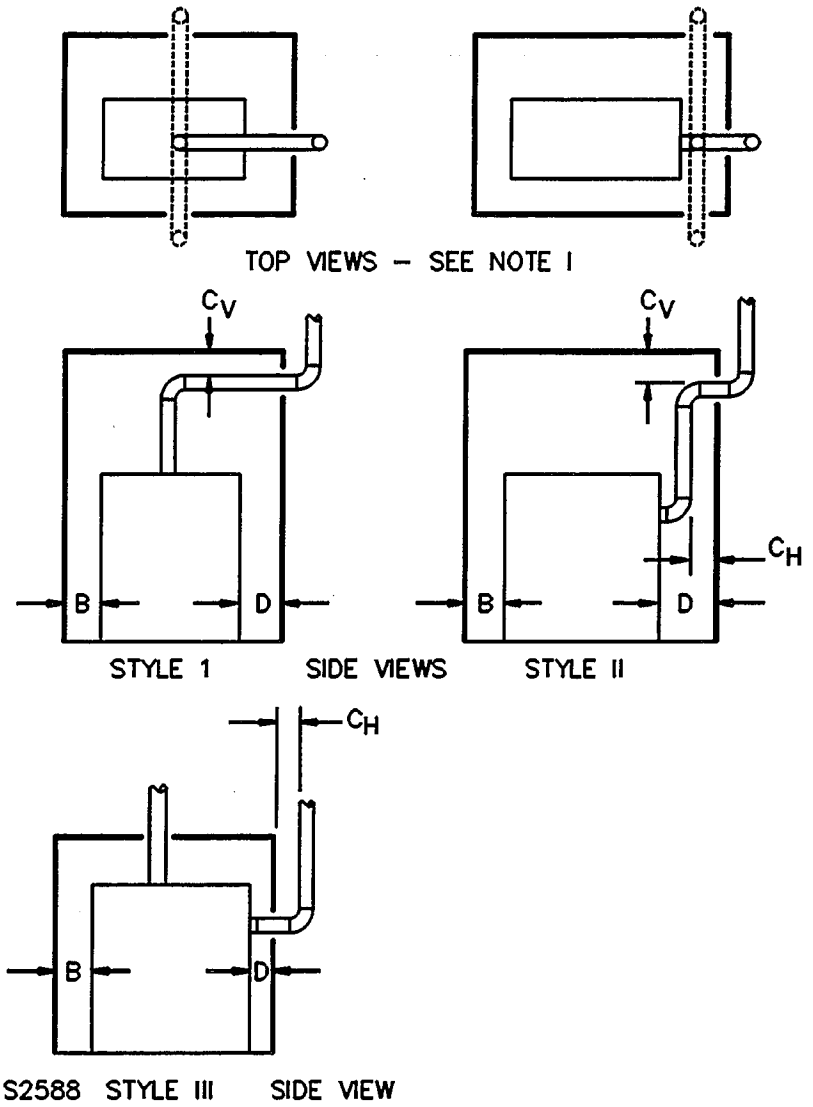
39.1.7 The chimney connector is to be the same nominal size as the flue collar or outlet of the furnace. Galvanized stovepipe not heavier than nominal 0.028 inch (0.71 mm) is to be used.

39.1.8 The clearance between the nearest surfaces of the chimney connector and the walls and ceiling is to be not less than 9 inches (230 mm) nor more than 18 inches (460 mm), with the following exception: If the construction of the furnace is such that, when installed with the clearances selected by the manufacturer, the clearance between the chimney connector and the interior walls of the test enclosure is less than 9 inches (230 mm), the test may be conducted with such lesser clearance from the walls with portions of the wall located within 9 inches (230 mm) of the chimney connector protected in a recognized manner; in which case directions that such surfaces shall be so protected are to be included in the instructions furnished with the furnace.

39.1.9 A furnace with vertical flue outlet is to be tested with two chimney connector arrangements, Styles I and III, and a furnace with horizontal flue outlets is to be tested with two chimney connector arrangements, Styles II and III as indicated by Figure 39.4, unless the manufacturer elects to specify the minimum clearance from the furnace as that obtained when tested with the chimney connector arranged in accordance with Style I or II only.

39.1.10 Where the chimney connector pierces the enclosure, an opening having a diameter 8 inches (205 mm) larger than the diameter of the chimney connector is to be cut and the chimney connector centered in the opening. The annulus thus formed is to be sealed by a fire and heat resistive insulating barrier at least 1/8 inch (3.2 mm) thick, placed on the exterior surface. See Figure 38.3. Temperatures on the surfaces surrounding the chimney connector are not to be determined at points located less than 2 inches (50 mm) from the outer edge of the annulus.

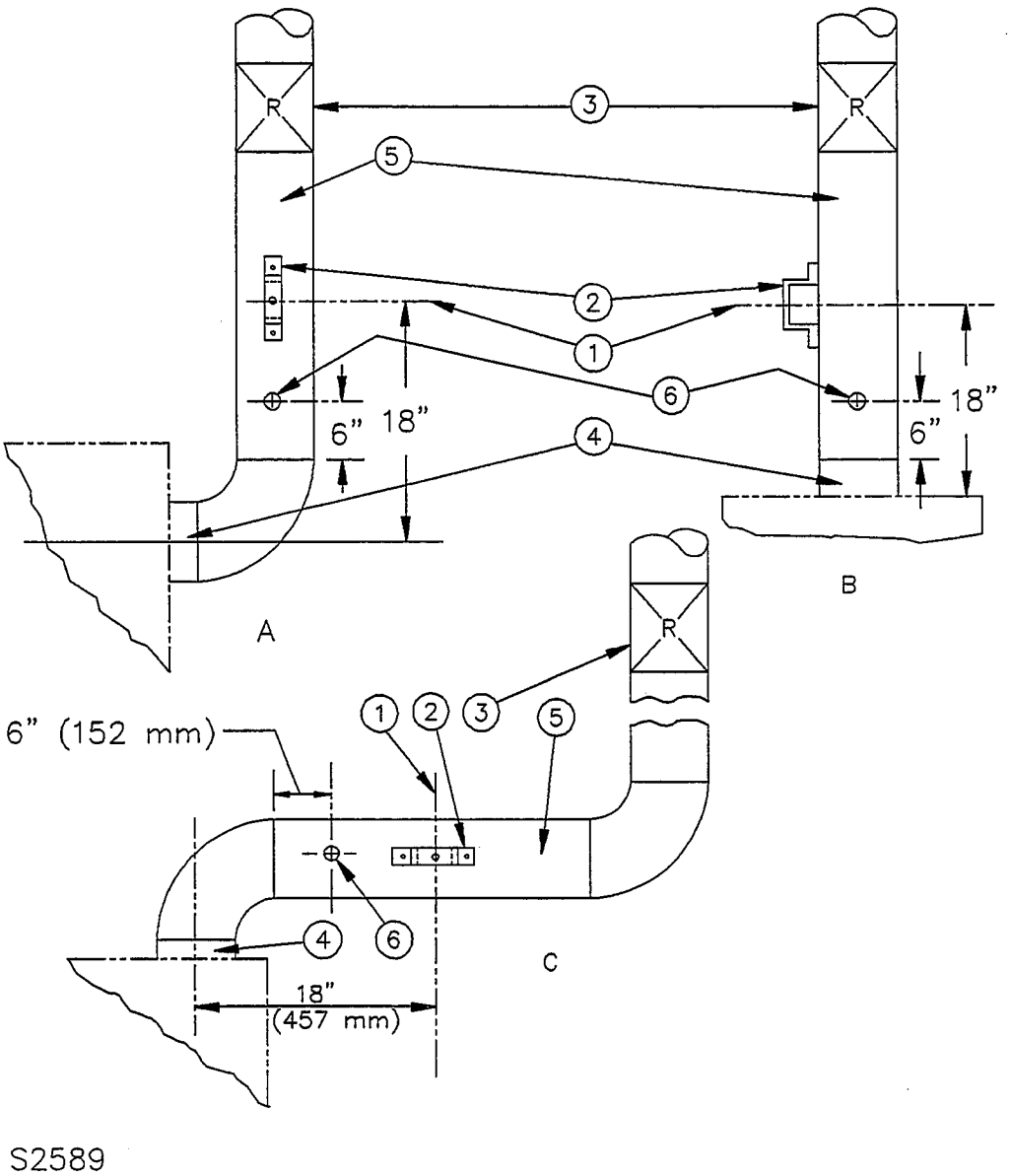
Figure 39.4
Chimney connector arrangement for alcove and closet installation



Note 1: With connector arrangement Styles I and II, the horizontal run is to pierce the back or a side wall, whichever is farthest from the vertical run.

39.1.11 A bracket for supporting the thermocouple for measuring flue-gas temperature is to be located as shown by Figure 39.5(2).

Figure 39.5
Chimney connectors – alcove and closet test



1. Center line of thermocouple.
2. Support bracket.
3. Draft regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.
6. Location of stack element of safety control.

39.1.12 The primary safety control, if furnished separately for mounting in the chimney connector, is to be located with its element in a plane perpendicular to the axis of the flue-gas flow, 6 inches (152 mm) downstream from the flue collar or, if an elbow is attached directly to the flue collar, 6 inches (152 mm) downstream from the downstream end of the elbow. See Figure 39.5(6).

39.1.13 A draft regulator is to be provided for test purposes and located in the chimney connector outside the test enclosure. See Figure 39.5.

39.1.14 Any built-in draft regulator included as part of the furnace is to be fixed in the position allowing maximum draft.

39.1.15 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of imposing the specified draft.

39.2 Air outlet and inlet

39.2.1 Unless the supply plenum is an integral part of the furnace, a metal plenum having the same dimensions as the discharge opening of the furnace is to be provided by the manufacturer for test purposes.

39.2.2 For an upflow or downflow furnace, the height or depth of a separate plenum is to be such that the clearance from the plenum and warm-air duct to surfaces of the test enclosure will be as specified by the manufacturer. See Figures 38.4, 39.1, and 39.2.

39.2.3 For a horizontal furnace, a separate supply plenum is to be arranged as indicated by Figures 38.4, 39.1, and 39.2.

39.2.4 The cold-air inlet and warm-air outlet openings are to be extended to the outside of the test enclosure by appropriate duct work. The openings through which the warm-air duct is carried from the enclosure are to be of such size that the edges of the opening will clear the duct 5/16 inch (7.9 mm) and the space sealed with tape.

39.2.5 The size of the outlet duct is to be calculated for a velocity of approximately 900 feet (275 m) per minute of standard air [0.075 pounds per cubic foot (1.2 kg/m^3)] with a 90°F (50°C) temperature rise through the furnace and based on an output equivalent to 75 percent of the rated input [Btu per hour (W)] of the furnace. Specific heat of air is to be taken as 0.243 Btu per pound (565 J/kg).

39.2.6 Formulas derived from the above based on the outlet duct area are as follows:

Area ($in.^2$) = (Btu per hour input) x 0.00122

Area (cm^2) = Watts x 0.0000554

39.2.7 The test duct is to be rectangular in shape, with a width approximately equivalent to the corresponding dimension of the plenum or plenum collar, but the aspect ratio is not to exceed four to one.

39.2.8 The warm-air duct outlet is to be arranged to discharge away from the cold-air inlet of the furnace; also away from the air inlet to the test enclosure for closet installation. The inlet and outlet ducts should be positioned at least 90 degrees apart.

39.2.9 The arrangement and proportions of the outlet duct for upflow and downflow furnaces are indicated by Figure 38.4.

39.2.10 A horizontal furnace is to be tested with the outlet duct arranged as indicated by Style B, Figure 39.3, but if the manufacturer elects to specify a clearance from the end of the furnace less than obtained when so tested, the furnace may be also tested with the outlet duct arranged as indicated by Style A. The opening in the enclosure through which the warm-air duct is carried is to be of such size that the edges of the opening will clear the duct 5/16 inch (7.9 mm) and the space sealed with tape.

39.2.11 A thermocouple grid, see 40.6.8, is to be located in each warm-air outlet duct in a plane within 6 inches (152 mm) downstream from the position closest to the plenum where any couple will not see any surface of the heat exchanger. The duct is to extend at least 6 inches (152 mm) beyond the thermocouple grid. See Figures 38.4 and 38.7.

39.2.12 The cross-sectional area and shape of the inlet air duct is to be equivalent to the cold-air inlet of the furnace.

39.2.13 The inlet-air temperature is to be measured by a thermocouple, not heavier than No. 24 AWG (0.21 mm^2), shielded from direct radiation. For alcove installation, the thermocouple is placed centrally 24 inches (0.6 m) in front of the furnace and 24 inches above the floor of the test enclosure, except for a horizontal furnace the thermocouple is to be located at an elevation midway between the floor and ceiling of the test enclosure. For closet installation, the thermocouple is to be placed in the center of the lower ventilating opening into the closet.

40 Instrumentation

40.1 Draft

40.1.1 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.

40.2 Fuel input

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

40.3 Power measurement

40.3.1 The total electrical input to a furnace is to be measured in amperes.

40.3.2 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.

40.4 Speed measurement

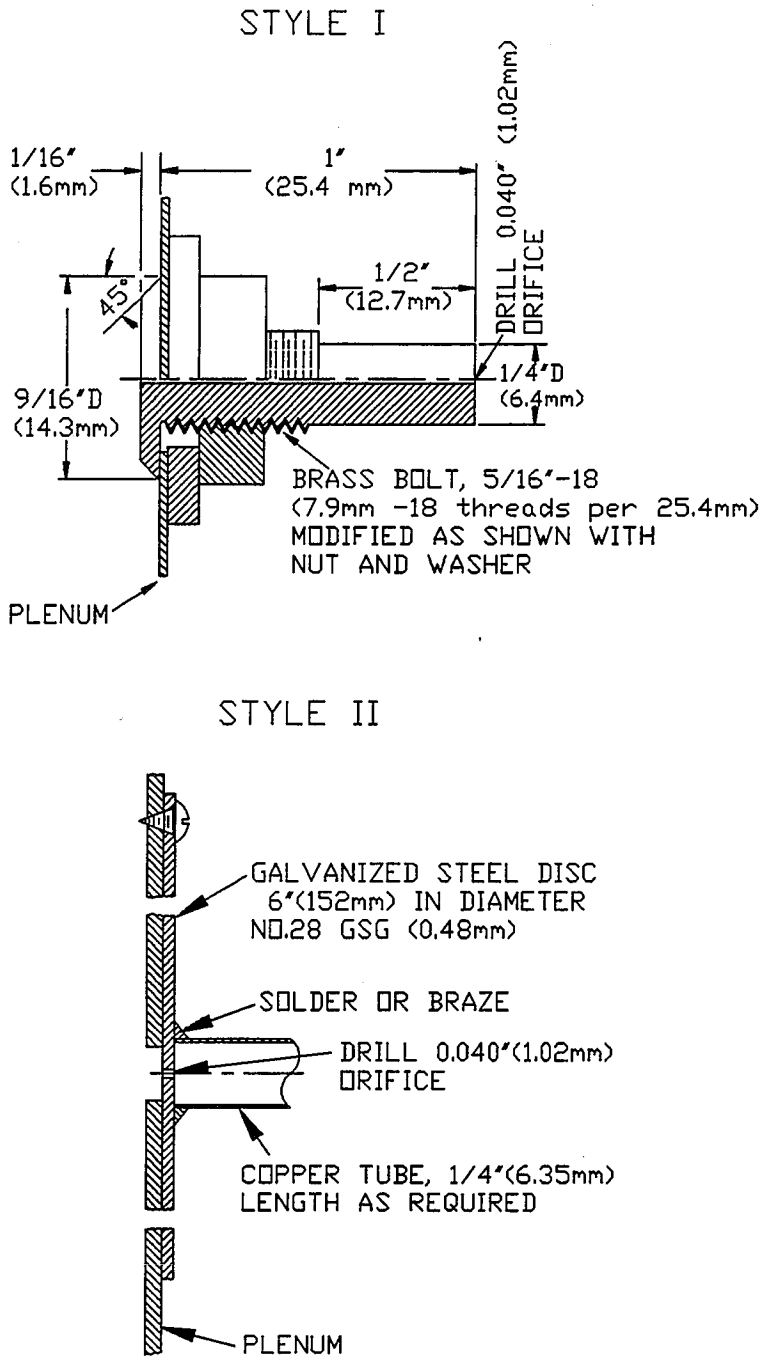
40.4.1 Mechanical or electronic means are to be used to measure the speed of a motor or of a mechanism driven by it. The load imposed by the counter is not to adversely affect motor speed. A stroboscope is recommended for measuring speed of a motor under 1/8 horsepower (93 W output).

40.5 Static pressure

40.5.1 An inclined draft gauge with a pressure tap located as shown in Figure 38.4, is to be used to measure external static pressure in the outlet plenum. The gauge is to have an accuracy of plus or minus 0.0025 inch (plus or minus 0.064 mm) and is to be capable of being read directly to 0.005 inch (0.13 mm).

40.5.2 The static pressure connection is to consist of one of the arrangements shown in Figure 40.1.

Figure 40.1
Static pressure pickup arrangements



40.6 Temperature measurement

40.6.1 Temperatures shall be measured by means of a potentiometer and thermocouples except that the change-of-resistance method may be used to measure the temperature of motor windings or of coils. The thermocouples shall consist of wire not larger than No. 24 AWG (0.21 mm^2) and not smaller than No. 30 AWG (0.05 mm^2). The thermocouple wire shall conform to the requirements for "special" thermocouples as listed in the table of limits of error of thermocouples in the Standard for Temperature-Measurement Thermocouples, ANSI MC96.1-1982.

40.6.2 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 No. 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.

40.6.3 Thermocouples are to be placed on surfaces of the test enclosure at various locations as may be required to observe maximum temperatures during tests. Where the chimney connector pierces the enclosure, temperature measurements on the inside surfaces of the enclosure are to be made 6 inches (152 mm) away from the chimney connector. Thermocouples are to be attached to other pertinent materials and parts such as those mentioned in Table 47.1.

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

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

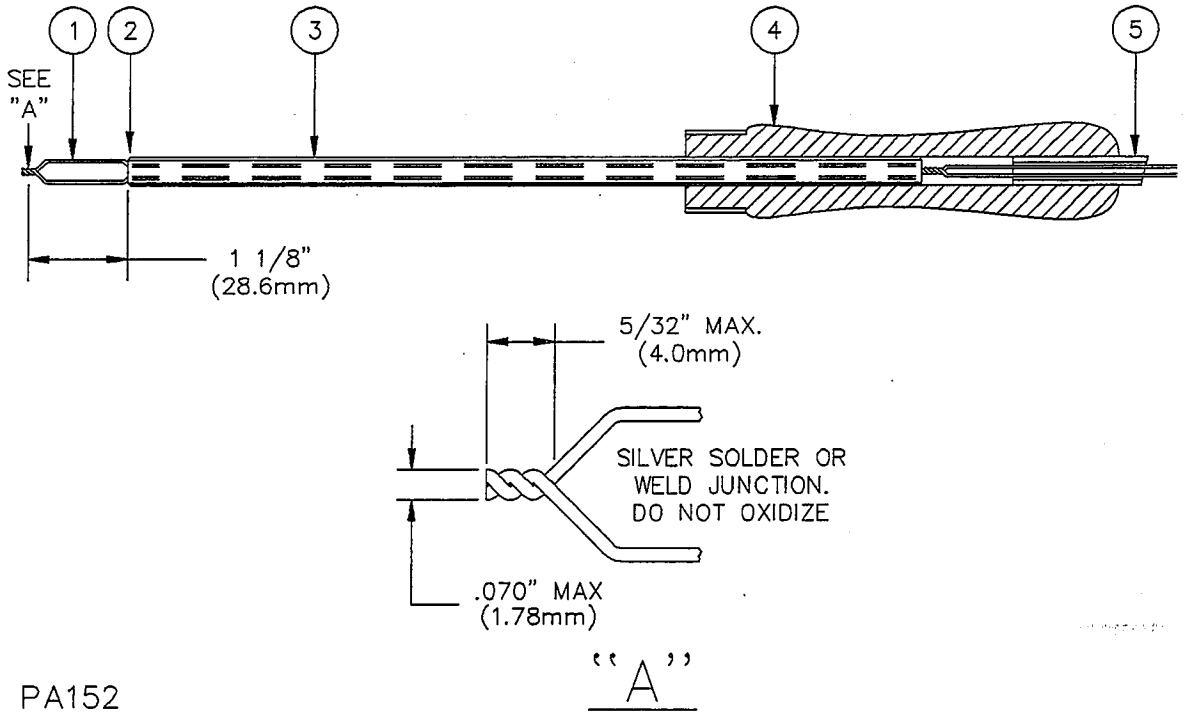
40.6.6 Thermocouples are to be attached to surfaces other than as described above by being cemented or taped to the surface in a manner to assure thermal contact with the surface.

40.6.7 The temperature at points on external surfaces of an attic furnace, except the bottom and at points within 9 inches (230 mm) of the flue collar, are to be determined by a thermocouple attached to the surface under a flexible pad of fire and heat resistive insulating-material 6 inches (152 mm) square, 0.4 inch (10 mm) thick, and weighing 1.0 – 1.4 pounds per square foot (4.9 – 6.8 kg/m^2).

40.6.8 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 40.2, inserted into the chimney connector as shown on Figure 40.3. There is to be no draft control between the furnace and the point where the flue-gas temperature is measured. If a draft control is incorporated in the furnace, it shall be sealed dependably in the position allowing maximum draft during all tests.

40.6.9 The outlet-air temperature in rectangular ducts connected to forced-air furnaces is to be measured by nine thermocouples of identical length wired in parallel. The test duct cross section is to be divided into three equal horizontal and three equal vertical areas with a thermocouple located centrally in each of the nine areas thus obtained. The thermocouple grid is to be located in a plane perpendicular to the axis of air flow and within 6 inches (152 mm) downstream of the location closest to the plenum where any couple will see any surface of the heat exchanger. The duct is to extend at least 6 inches (152 mm) beyond the thermocouple grid.

Figure 40.2
Standard thermocouple for flue-gas temperature



1. No. 20 AWG (0.51 mm^2) iron-constantan, asbestos, or woven-glass-covered thermocouple wires extending from hot junction to potentiometer or reference junction.

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

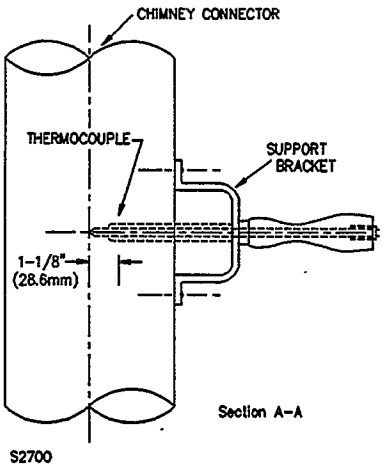
3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

4. 1 – Small wooden handle.

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

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

Figure 40.3
Flue gas thermocouple and support bracket



1 – Thermocouple, 2 – Support bracket

41 Initial Test Conditions

41.1 General

41.1.1 The furnace is to be set up for test in the appropriate enclosure and manner described in a preceding section of these requirements.

41.1.2 A furnace equipped with an air-circulating fan, the capacity of which is intended to be varied only by the installer, such as with a belt-drive or a motor-speed control, is to be tested with the fan speed adjusted so that approximately rated air delivery is obtained. This adjustment is to be maintained during the conduct of all tests described herein.

41.1.3 A furnace equipped with a device intended for manual change or adjustment by the user, such as a motor speed control or a circulating air damper, the positioning of which could affect the results of the following tests, is to be tested with the adjustable device in the position(s) likely to develop maximum temperatures or to disclose malfunction.

41.1.4 If the results of a furnace test involving the operation of a limit control are likely to be affected by the temperature of the inlet air, the test is to be conducted under conditions which maintain the inlet-air temperature between 60 and 80°F (15.6 and 26.7°C).

41.1.5 If a furnace is to be equipped with air filters, they are to be in place.

41.1.6 Unless otherwise specified in the paragraphs describing the tests, furnaces are to be tested at the potentials indicated in Table 41.1.

Table 41.1
Test voltages

Nameplate voltage rating	Normal test voltage
110 to 120	120
208	208
220 to 240	240
254 to 277	277
440 to 480	480
550 to 600	600
Other	Rated

41.2 Furnace equipped with mechanical atomizing burner

41.2.1 The furnace is to be fired at its rated Btu per hour (W) input, ±2 percent, with a grade of fuel for which the burner is rated. The draft at the flue collar is to be as recommended by the manufacturer but not more than 0.06-inch (1.5 mm) water column for burners fired at 5 gallons (18.9 liters) per hour or less and not more than 0.09 inch (2.3 mm) for burners fired at rates from 5 to 16 gallons (18.9 to 60.6 liters) per hour.

41.3 Furnace equipped with vaporizing burner

41.3.1 The furnace is to be fired at its rated Btu per hour (W) input, ±2 percent.

41.3.2 No. 1 fuel oil having a viscosity conforming to the following is to be used for firing vaporizing burners.

Oil viscosity	Maximum	Mean	Minimum
Centistokes at 38°C (100°F)	2.04	1.97	1.90
Centistokes at 25°C (77°F)	2.44	2.34	2.24

41.3.3 The firing rate at high fire is to be equivalent to the rated input of the furnace.

41.3.4 The pilot-fire burning rate is to be a rate equivalent to the pilot-fire rate obtained at the maximum allowable setting of the metering device with No. 1 oil plus the valve manufacturer's plus tolerance.

41.3.5 If adjustable oil shut-off controls are provided, they are to be adjusted to the maximum allowed timing for shut-off.

41.3.6 The depth of oil in the burner under pooled condition is to be the maximum to be allowed in production.

41.3.7 The draft at the flue collar is to be as recommended by the manufacturer, which is to be not less than 0.02-inch (0.5 mm) water column.

41.4 Static pressures for tests

41.4.1 Table 41.2 defines the relation of furnace input to external static pressure, inches (mm) water column.

Table 41.2
Relation of furnace input to external static pressure

Input to furnace btu per hour (W) col. I	External static pressure inches (mm) water column[a]	
	Temperature of outlet air determined by function of limit control	
	Above 74°C (165°F), col. II	74°C (165°F) or less, col. III
80,000 and under (23,500)	0.12 (3.65)	0.30 (7.62)
Over 80,000 to 100,000 (23,500 – 29,300)	0.15 (3.81)	0.30 (7.62)
Over 100,000 to 200,000 (29,300 – 58,600)	0.20 (5.08)	0.40 (10.16)
Over 200,000 to 375,000 (58,000 – 109,900)	0.25 (6.35)	0.50 (12.70)
Over 375,000 (109,900)	0.30 (7.62)	0.60 (15.24)

[a] For furnaces not equipped with air filters, add 0.08 (2.03 mm) to these values. A furnace may be tested at external static pressures in excess of those specified above, as recommended by the manufacturer.

42 Combustion Test – Burner and Furnace

42.1 A central furnace shall be capable of functioning uniformly and reliably without producing excessive smoke when installed and adjusted in accordance with the manufacturer's instructions.

42.2 When the furnace is fired at rated input and operated under the conditions of the Temperature Test, Section 47, until steady-state combustion conditions of draft, fuel-input rate, and flue-gas temperature have been established, the smoke in the flue gases is not to exceed that indicated by a number 2 spot for furnaces firing a distillate fuel and a number 4 spot for furnaces firing a residual type fuel as indicated on the Shell-Bacharach Scale with the Model RDC Smokemeter. When operated as described above the stack loss for a furnace is not to exceed 25 percent.

43 Operation Tests

43.1 A limit control, when adjusted to its maximum setting allowed by a fixed stop, shall prevent a furnace when tested as described herein from delivering air at a temperature in excess of:

a) 200°F (93°C for an attic, downflow, or horizontal furnace, except as indicated in (d) below.

b) 200°F for a furnace to be tested for alcove or closet installation.

c) 200°F for any furnace tested for less than standard clearances.

d) 250°F (121°C) for a forced-air upflow furnace to be tested for standard clearances, and a downflow or horizontal furnace classified under Forms III, IIIa, and IIIb, Table 37.1.

e) The design outlet-air temperature, if higher than 250°F for a furnace to be used only with a special duct system. See Limit Control Cutout Test, Section 44.

43.2 A furnace fired at rated input shall be capable of continuous operation without the limit control functioning to cause reduction in the input when the furnace is tested as described herein. See the Continuity of Operation Test, Section 45.

43.3 During the intended operation of a downflow or horizontal furnace from a cold start, the fan control shall operate to prevent reverse air flow through the furnace. See the Airflow, Downflow, or Horizontal Furnace Test, Section 46.

44 Limit Control Cutout Test

44.1 The automatic-reset type limit controls to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting. An auxiliary limit control, if adjustable, is to be set to the minimum allowable setting.

44.2 A furnace designed for distributing air through a special duct system is to be tested while maintaining a static pressure not more than the designed value.

44.3 The furnace is to be placed in operation. Each outlet air duct is to be restricted symmetrically until the limit control functions. The restriction is to be removed to permit return of the furnace to the intended operation. The outlet air duct is then to be restricted to obtain an outlet air temperature 10°F (5.6°C) below that which will cause the limit control to function. If this restriction results in a static pressure greater than specified in Table 41.2, the restriction is lessened sufficiently to obtain a static pressure as specified in Table 41.2. No further adjustment of the outlet air duct restriction is to be made throughout this test.

44.4 A preliminary test is to be made to determine the degree of blocking of the cold-air inlet required to produce the air temperature that will cause the limit control to function.

44.5 The cold-air inlet blocking is then to be relieved sufficiently to permit continuous operation of the furnace on high fire and the furnace operated until substantially equilibrium outlet-air temperature is obtained.

44.6 The cold-air inlet is then to be gradually blocked over a period of 10 minutes until any automatic-reset type limit control acts to shut off the main burner flame. During this test an auxiliary limit control is not to function. The outlet-air temperature (T_L) at the instant any automatic-reset type limit control functions is to be measured. The temperature thus obtained is not to exceed the appropriate value specified in 43.1.

44.7 The furnace is to be allowed to operate until it recycles on the limit control. An auxiliary limit control is not to function. The temperature obtained is not to exceed the appropriate value specified in 43.1 at the time the limit control functions.

45 Continuity of Operation Test

45.1 Each limit control is to be bypassed to permit continued operation during this test. The furnace is to be placed in operation.

45.2 Each warm-air duct outlet of a forced-air furnace is to be restricted symmetrically to maintain an external static pressure in the supply plenum of the appropriate value indicated in Table 41.2.

45.3 Operation of the furnace is to be continued until equilibrium outlet-air temperature is obtained. The inlet-air temperature (T_1) and the outlet-air temperature (T_2) are to be measured. For this test, the inlet-air temperature (T_1) is to be measured by a thermocouple located in the center of the inlet-air duct.

45.4 During this test, the firing of the furnace is not to be interrupted by the functioning of any control, and is to be in conformance with 43.2.

T_2 minus T_1 is to be not more than T_L minus 70°F (39°C)

where:

T_1 = inlet-air temperature in this test, degrees C or F

T_2 = outlet-air temperature in this test, degrees C or F

T_L = outlet-air temperature at which limit control functioned in the Limit Control Cutout Test, Section 44, degrees C or F.

45.5 During the test the total furnace electrical input and the electrical input of each component, except those having a pilot duty rating only, are to be measured.

46 Airflow, Downflow or Horizontal Furnace Test

46.1 This test is to be conducted on downflow and horizontal furnaces only. See 43.3.

46.2 For a downflow furnace, a rectangular duct the same size as the inlet-air opening of the furnace is to be attached to the return-air inlet of the furnace and extended vertically, using a 90-degree elbow if the furnace has only a side inlet-air opening, to a distance of 7-1/2 feet (2.29 m) above the floor of the test structure. For a horizontal furnace, a rectangular duct the same size as the inlet-air opening of the furnace is to be attached to the return-air inlet of the furnace and extended vertically by a 90-degree elbow to a distance of 6 feet (1.83 m) above the top of the return-air opening of the furnace. The furnace is to be arranged to operate against an external static pressure as specified in Table 41.2. Any fan or limit control, if adjustable, is to be adjusted to the maximum temperature setting allowed by a fixed stop and minimum differential.

46.3 Air temperature is to be measured by three individual bead-type No. 24 AWG (0.21 mm^2) thermocouples located in the plane of the return-air (inlet-air) opening of the furnace. For a downflow furnace, the thermocouples are to be on the horizontal centerline of the return-air opening. For a horizontal furnace the thermocouples are to be on a horizontal line one-third of the distance below the top of the return-air opening of the furnace. One thermocouple is to be located 1 inch (25 mm) from one side of the opening, one at the center, and the other 1 inch from the opposite side of the opening.

46.4 The furnace is to be adjusted for firing at rated input, and if a pilot is used it is to be adjusted for minimum normal input. Starting with the furnace at room temperature, the pilot, if used, is to be lighted and allowed to burn for 15 minutes. The furnace is then to be fired and allowed to operate until the blower becomes operative.

46.5 The maximum temperature indicated by any one of the three thermocouples at the return-air opening of the furnace is not to exceed 90°F (50°C) above room temperature prior to functioning of the fan control to cause air to be circulated in the normal direction. A limit control is not to function to shut off the burner, except an automatic-reset type limit control may function to cause one cycle of the burner before the fan control functions.

47 Temperature Tests

47.1 General

47.1.1 When a furnace is tested in accordance with these requirements, see Sections 48 – 56, no part shall attain a temperature sufficient to damage required corrosion protection, to adversely affect operation of safety controls, to impair the value of required thermal or electrical insulation, nor to cause creeping, distortion, sagging, or similar damage if such damage to the material or part may cause the furnace to become unsafe for use. The temperature rises at specific points shall be not greater than those specified in Table 47.1 unless otherwise indicated.

Table 47.1
Maximum temperature rises

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
A. Motor[a,b]				
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).				
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 systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
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 systems on coil windings of alternating-current motors having a frame diameter of 7 inches or less (not including universal motors).				
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 systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches and of direct-current motors and universal motors.				
a. In open motors –				
Thermocouple method	85	153	140	252
Resistance method	95	171	140	252

(Continued)

Table 47.1 (Cont'd)
Maximum temperature rises

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
b. In totally enclosed motors –				
Thermocouple method	90	162	140	252
Resistance method	100	180	140	252
B. Components				
1. Capacitors				
Electrolytic type[c]	40	72		
Other types[d]	65	117	(Not specified)	
2. Field wiring	35	63	60	108
3. Relay, solenoid, and other coils with:[b]				
a. Class 105 insulated windings –				
Thermocouple method	65	117	115	208
b. Class 130 insulated windings –				
Thermocouple method	85	153	140	252
4. Sealing compounds	40°C (104°F) or 72°F less than its melting point			
5. Transformer enclosures[b] –				
a. Class 2 transformer	60	108	85	153
b. Power and ignition transformers	65	117	90	162
C. Insulated Conductors [e,f]				
1. Appliance wiring material				
75°C rating	50	90	65	117
80°C rating	55	99	70	126
90°C rating	65	117	80	144
105°C rating	80	144	95	171
200°C rating	175	315	200	360
250°C rating	225	405	250	450
2. Flexible cord –				
Types SO, ST, SJO, SJT	35	63	60	108
3. GTO cable	35	63	60	108

(Continued)

Table 47.1 (Cont'd)
Maximum temperature rises

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
4. Wire, Code	25°C (45°F) less than temperature rating in National Electrical Code, ANSI/NFPA 70-1993		Temperature rating in National Electrical Code, ANSI/NFPA 70-1993	
D. Electrical Insulation – General[f]				
1. Class C electrical insulation material	Not specified			
2. Class (180) electrical insulation material	As determined by test			
3. Fiber used as electrical insulation or cord bushings	65	117	90	162
4. Phenolic composition used as electrical insulation or as part the deterioration of which may result in a risk of fire or electric shock	125	225	150	270
5. Thermoplastic material	25°C (77°F) or 45°F less than its temperature rating			
6. Surfaces of test enclosure (ceiling, walls, and the like)	50	90	97	175
E. Metals				
1. Aluminum Alloys				
a. 1100	183	330	239	430
b. 3003	239	430	294	530
c. 2014, 2017, 2024, 5052	294	530	350	630
2. Aluminum-Coated Steel[g]	656	1180	767	1380
3. Carbon Steel Sheet, Cast Iron	517	930	683	1230
4. Carbon Steel-Coated with Type A19 Ceramic	572	1030	683	1230
5. Galvanized Steel[h]	267	480	350	630
6. 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
Type 430	711	1280	822	1480
Type 442	877	1580	933	1680
Type 446	961	1730	1072	1930
7. Zinc Castings	89	160	145	260
F. General				
1. Air Filter	50	90	97	175
2. Flue gases	517	930	738	1330

(Continued)

Table 47.1 (Cont'd)
Maximum temperature rises

Device or material	Column 1 Degrees C	Column 1 Degrees F	Column 2 Degrees C	Column 2 Degrees F
3. Oil inconstant level valve or tank	14	25	22	40
4. Surfaces of unit at points of zero clearance to test structure	50	90	97	175
5. Surface of floor beneath and within 3 feet (0.91 m) of unit to be classified for installation on combustible floors	50	90	97	175
6. Surfaces of test enclosure (ceiling, walls, and the like)	50	90	97	175

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

[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 or more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil (not including universal motors) where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum by the following amounts, provided that the temperature rise of the coil as measured by the resistance method is not more than specified in the table.

1. 5°C (9°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type;

2. 10°C (18°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type;

3. 15°C (27°F) for Column 1 limits for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches, open type; or

4. 20°C (36°F) for Column 1 limits for Class B insulation on coil windings of alternating-current motor having a diameter of more than 7 inches open type.

[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] A capacitor which operates at a temperature higher than a 65°C rise may be judged on the basis of its marked temperature rating.

[g] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and found to have heat resistant properties.

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

[i] The specified maximum temperature uses apply if the galvanizing is required as a protective coating, or the reflectivity of the surface is utilized to reduce the risk of fire.

48 Continuous Operation Test

48.1 Each limit control is to be bypassed to permit continued operation during this test.

48.2 If the inlet-air temperature is not higher than 77°F (25°C) but not less than 73°F (23°C), the outlet-air temperature is to be maintained at 5°F (3°C) less than that measured during the limit-control-cutout test. If the inlet-air temperature is higher than 77°F, the outlet-air temperature is to be adjusted to 5°F less than that measured during the Limit-Control-Cutout Test plus the difference between the observed inlet-air temperature and 77°F.

48.3 The outlet-air temperature is to be established by a gradual symmetrical restriction of the outlet and inlet air ducts until the outlet-air temperature reaches the value specified above, plus or minus 5°F (3°C). The static pressure in the supply plenum of a forced-air furnace is to be the appropriate value indicated in Table 41.2.

48.4 Firing of the furnace is to be continued until equilibrium temperatures are attained as evidenced by no changes in temperature rises for three consecutive readings taken 15 minutes apart at observed maximum temperature points.

48.5 During this test, the temperature rise above room temperature for any item is not to exceed the value indicated for such item in Column 1, Table 47.1. See 47.1.1.

48.6 During this test, the temperature rise on external surfaces of a furnace intended for installation in an attic, measured in accordance with 40.6.6 is not to exceed 90°F (50°C) above room temperature.

49 Blocked Inlet Test

49.1 The bypass is to be removed from any limit controls and they and any fan controls are to be adjusted to the maximum temperature setting allowed by a fixed stop and minimum differential.

49.2 The furnace is to be fired and the flow of circulating air regulated to maintain an outlet-air temperature, enough below that required to operate the limit control, which will allow continuous operation of the furnace, maintaining a static pressure in the supply plenum not more than the appropriate value indicated in Table 41.2.

49.3 The furnace inlet-air opening or filter is to be gradually restricted until the limit control functions. Then the furnace is to be allowed to cycle on the limit control, if of the automatic-reset type, until equilibrium temperatures have been attained. If the furnace is of the type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

49.4 During this test, the temperature rises above room temperature are not to exceed the values specified in Column 2 of Table 47.1 during the period terminating 1 hour after the first shut-off effected by the limit control. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 47.1 except that a motor may attain a temperature not in excess of 115°C (208°F) above room temperature during any part of this test. See 47.1.1.

49.5 If the furnace is of a type equipped with an auxiliary manual reset limit control and the control functions during this test, the temperature rises above inlet-air temperature during the test are not to exceed the values specified in Column 2, Table 47.1. See 47.1.1.

50 Fan Failure Test

50.1 The furnace is to be operated under the conditions described in 49.1 and 49.2 to begin this test.

50.2 The circulating-air fan drive is to be disengaged unless the fan is directly attached to the driving motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The furnace is then allowed to be cycled by the limit control if of the automatic-reset type. If the furnace is of the type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

50.3 If the furnace is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 47.1 during the period terminating 1 hour after the first shut-off effected by the limit control. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 47.1, except that a motor may attain a temperature not in excess of 115°C (208°F) above room temperature during any part of this test. See 47.1.1.

50.4 If the furnace is of a type equipped with an auxiliary manual-reset limit control and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 47.1. See 47.1.1.

50.5 If the furnace is equipped with a vaporizing burner which may be ignited from a pooled condition, the following additional test is to be conducted.

50.6 The furnace is to be readied so that it may be operated under the conditions described in 49.1 and 49.2 to begin this test.

50.7 The circulating air fan drive is to be disengaged unless the fan is directly attached to the driving motor shaft, in which case the fan motor only is to be disconnected from the electrical circuit. The burner is to be pooled to the maximum oil level allowed by the oil control device, as follows, constant-level valve, the main burner flame lighted, and the furnace allowed to function as it will. The furnace is then allowed to be cycled by the limit control if of the automatic reset type. If the furnace is of the type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

50.8 If the furnace is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 47.1 during the period terminating 1 hour after the main burner flame was lighted. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 47.1, except that a motor may attain a temperature not in excess of 115°C (208°F) above room temperature during any part of this test. See 47.1.1.

50.9 If the furnace is not equipped to avoid pooling and of a type equipped with an auxiliary manual-reset limit control and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 47.1. See 47.1.1.

50.10 If the furnace is equipped with a device to avoid pooling, the temperature rise limits given in Table 47.1 do not apply, but the furnace is not to show any manifestation of a risk of fire. A part damaged as a result of the test is not to be cause for unsafe operation of the appliance when attempts to operate the appliance are made following the test.

50.11 During this test, no flame is to burn outside the combustion chamber, and no excessive smoke is to be expelled into the room.

51 Stalled Fan Motor Test

51.1 This test needs to be conducted on a fan-type furnace only if the impedance of the circulating-air fan motor provides the overcurrent protection for that motor. Only the fan-motor temperatures need be recorded.

51.2 The furnace is to be operated under the conditions described in 49.1 and 49.2.

51.3 The rotor of the fan motor is to be locked, while the furnace is temporarily de-energized. The furnace is to be immediately re-energized and allowed to remain energized until the fan-motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test. The maximum temperature rise above room temperature attained by the motor during the test is to be not more than 125°C (225°F).

51.4 If the furnace is equipped with a vaporizing burner which may be ignited from a pooled condition, the following additional test is to be conducted.

51.5 The furnace is to be readied so that it may be operated under the conditions described in 49.1 and 49.2 to begin this test.

51.6 The rotor of the fan motor is to be locked. The burner is to be pooled to the maximum oil level allowed by the oil-control device, as follows, constant-level device, the main burner flame lighted, and the furnace allowed to function as it will. The furnace is allowed to remain energized until the fan motor temperature reaches a maximum. Any manually reset control that functions is not to be reset during this test. The maximum temperature rise above room temperature attained by the motor during the test is to be not more than 125°C (225°F).

52 Blocked Outlet Test

52.1 The furnace is to be operated under the conditions described in 49.1 and 49.2 to begin this test.

52.2 The warm-air outlets are to be closed and the furnace allowed to be cycled by the limit control if of the automatic-reset type or otherwise to function as it will. If the furnace is of the type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

52.3 If the furnace is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 47.1 during the period terminating 1 hour after the first shut-off effected by the limit control. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 47.1 except that a motor may attain a temperature not in excess of 115°C (208°F) above room temperature during any part of this test. See 47.1.1.

52.4 If the furnace is of a type equipped with an auxiliary manual-reset limit control and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 47.1. See 47.1.1.

52.5 If the furnace is equipped with a vaporizing burner which does not include means to avoid pooling, the additional test as described in 52.6 is to be conducted.

52.6 The furnace is to be readied so that it may be operated under the conditions described in 49.1 and 49.2 to begin this test. The warm-air outlets are to be closed. The burner is to be pooled to the maximum oil level allowed by the oil-control device, as follows, constant-level valve. The main burner flame is to be lighted, and the furnace is then allowed to be cycled by the limit control if of the automatic-reset type or otherwise to function as it will. If the furnace is of the type equipped with an auxiliary manual-reset limit control, the test is to be continued until maximum temperatures are attained.

52.7 If the furnace is of a type equipped with an automatic-reset limit control only, the temperature rises above room temperature are not to exceed the values specified in Column 2, Table 47.1 during the period terminating 1 hour after the main burner flame was lighted. Thereafter, the temperature rises are not to exceed the values specified in Column 1, Table 47.1, except that a motor may attain a temperature not in excess of 115°C (208°F) above room temperature during any part of this test. See 47.1.1.

52.8 If the furnace is of a type equipped with an auxiliary manual-reset limit control and the control functions during this test, the temperature rises above room temperature during the test are not to exceed the values specified in Column 2, Table 47.1. See 47.1.1.

52.9 During this test, no flame is to burn outside the combustion chamber, and excessive smoke is not to be expelled into the room.

53 Short-Circuit Test

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

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

b) A branch-circuit protective device of the type and maximum rating specified on the product nameplate.

There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line- and low-voltage circuits.

53.2 For the purpose of these tests:

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

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

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

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

53.3 The device is to be connected in a circuit having a capacity based on the full-load current and voltage rating of the furnace. See Table 53.1. The furnace full-load current is determined by adding the motor full-load current of each motor, as determined in accordance with the National Electrical Code, ANSI/NFPA 70-1993, for the marked horsepower rating of the motor, and the current rating of each other load. Each simultaneous load condition is to be considered separately, and the maximum resulting current employed as the basis of selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating-current supply and the circuit capacity is to be measured without the device in the circuit. See 53.4.

Table 53.1
Short-circuit test currents

Full-load amperes[a]				
Single phase				Circuit capacity, amperes
115 V	208 V	230 – 240 V	277 V	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
	Three phase			
208 V	220 – 240 V	440 – 480 V	550 – 600 V	Circuit capacity, amperes
2.12 or less	20.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000
[a] Product				

53.4 Except as indicated in 53.6 – 53.9, an overcurrent protective or a thermal protective device on a furnace having more than one motor wired for connection to one supply line shall withstand short-circuiting without creating a risk of fire or electric shock when protected by a fuse rated at 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

53.5 The nearest standard size fuse, rated not higher than the current indicated in 53.4 but not less than 15 amperes, is to be employed for the test. The maximum fuse size marked on the furnace, see 70.1, is not to exceed this value.

53.6 With reference to 53.4, the protective device may be tested with a fuse having a lower rating than indicated; provided the furnace will start and operate without blowing the fuse and is marked to indicate such a maximum limit of fuse protection.

53.7 The test specified in 53.1 may be waived if:

a) A thermally protected motor or a separately enclosed motor-overload protective device is within an outer cabinet of a product or section of a product,

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

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

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 21.2.16.

However, if short-circuiting between live parts of different circuits may result, the test shall be waived.

53.8 Short Circuit Tests are not required for an assembly with more than one motor each not exceeding 1 horsepower (746 W output) in rating, and intended to be used on a branch circuit protected at not more than 20 amperes at 125 volts or less or 15 amperes at 126 – 600 volts, provided the following conditions are met:

a) The marked maximum branch circuit protective device size does not exceed the values specified above, and

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

53.9 Short Circuit Tests are not required for an assembly with more than one motor if the motor(s) have full-load current or horsepower rating(s) in excess of those specified in 53.8, provided:

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

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

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

53.11 Bonding conductors and bonding connections shall not open when samples are subjected to the conditions of this test.

53.12 Motor-circuit conductors shall not become damaged when samples are subjected to the conditions of this test.

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

53.14 For the test specified in exception No. 2 to 29.3.3, three samples of each conductor under consideration are to be subjected to each test condition specified and a new protective device is to be used for each test. The conductor and connection to be tested are to be connected in series with the overcurrent-protective device. Consideration is to be given to both short-circuit and ground-fault conditions. The capacity of the circuit is to be based on the ratings of the unit in accordance with Table 53.1 and is to be measured without the lead to be tested in the circuit. The voltage source for the test circuit is to be in accordance with Table 41.1, and the power factor is to be 0.9 – 1.0 unless a lower power factor is agreeable to those concerned. None of the conductors or lead terminations shall be damaged as a result of this test.

54 Overload Test, High-Voltage Transformers

54.1 A high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type (see 30.1.2), shall be subjected to the test described in 54.4 and 54.5.

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

54.3 The transformer shall comply with the Dielectric Voltage-Withstand Test, Section 56, immediately following the test specified in 54.4 and 54.5.

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

54.5 A variable-resistance load is to be connected to the output terminals and the transformer is to be operated continuously at the normal test voltage specified in Table 41.1. If the protective device controls a switching device that, in turn, interrupts primary current to the transformer, the switching device is to be in the circuit. The ambient (room) temperature during the test is to be approximately 25°C (77°F). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 10°C (18°F) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

55 Burnout Test, High-Voltage Transformers

55.1 A high-voltage transformer shall be subjected to the test described in 55.2 and 55.3. There shall be no emission of flame or molten metal from the transformer enclosure.

Exception: A high-voltage transformer that is provided with thermal-overload protection of other than the nonrenewable thermal-cutoff type (see 30.1.2), or that is protected by an overcurrent device, or devices, in accordance with the requirements in 30.1.4 need not be tested.

55.2 Three samples of the transformer are to be operated continuously at the normal test voltage specified in Table 41.1, and at rated frequency, with the enclosure grounded. The test is to be conducted at an ambient (room) temperature of approximately 25°C (77°F) and operation is to be continued until:

a) Burnout occurs, or

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

The test circuit is to be protected by fuses rated not less than required for the product.

55.3 Except as indicated in 55.4, the load connected to the output terminals of the transformer is to be the highest of the following and is to be readjusted, if necessary, to the specified value after 2 minutes of operation, with no further readjustment during the remainder of the test:

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

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

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

55.4 A transformer that cannot provide the output current required by 55.3 is to be tested with its output terminals short-circuited.

56 Dielectric Voltage-Withstand Test

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

a) 1000 volts plus twice rated voltage, except as noted in (b).

b) 1000 volts for a motor rated at not more than 1/2 horsepower (373 W output) and not more than 250 volts.

56.2 Where higher than rated voltage is developed in a motor circuit through the use of capacitors, the rated voltage of the appliance is to be employed in determining the dielectric withstand test potential; unless the developed steady-state capacitor voltage exceeds 500 volts, in which case the test potential for the parts affected is to be 1000 volts plus twice the developed voltage.

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

56.4 The dielectric withstand test between low-voltage parts of opposite polarity may be waived on the complete assembly provided the components have been separately subjected to this test condition and the wiring is with material as tabulated in Table 21.1.

56.5 A 500 VA or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with the foregoing. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute. The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment during the duration of the test.

57 Flammability Test

57.1 Samples shall be removed from the oven at the end of 60 days of exposure and subjected to 57.2 – 57.5. The samples shall not show weakening, embrittlement, or other evidence of deterioration, and shall comply with the requirements of the Flammability Test.

57.2 With respect to Section 11, Materials in Air Handling Compartments, samples are to consist of at least three of each part, or of sections of each part as large as is practical to test. Sections shall include the thinnest portions of the parts. Preferred sample size is 1/2 by 5 inches (13 by 125 mm).

57.3 The test flame is to be obtained by means of a Tirrill or Bunsen laboratory type burner having a nominal tube diameter of 3/8 inch (9.5 mm) and a length above the primary air inlets of approximately 4 inches (100 mm). The flame is to be adjusted to an overall height of 5 inches (125 mm) with an inner blue cone of 1-1/2 inches (40 mm). The area in which the test is to be conducted is to be shielded from drafts.

57.4 The part or section is to be arranged with the major axis of the sample area vertical, exposing thin sections to the maximum sweep of flame if practical. The test flame is to be applied to a lower edge of the specimen with the flame 20 degrees from the vertical. The flame is to be applied for 5 seconds and removed for 5 seconds until five such cycles of exposure have been completed. The specimen shall not continue to burn for more than 1 minute following the last exposure to the flame nor shall any material fall from the specimen during the test. Complete destruction of the sample shall not be acceptable.

57.5 A set of identical samples is to be aged in a full-draft, circulating air oven at the aging temperature and time determined by the intended use of the finished part in accordance with Table 57.1.

Table 57.1
Aging temperature and time

Maximum intended operating temperature, degrees C (F)[a]	Aging temperature, degrees C (F)	Aging time, days
50 (122)	75 (167)	60
75 (167)	100 (212)	60
100 (212)	121 (250)	60

[a] If the intended operating temperature is between two values shown in table, the higher of these two values is used in determining the aging conditions.

MANUFACTURING AND PRODUCTION TESTS

58 General

58.1 In order to ensure compliance with these requirements in production, the manufacturer of furnaces shall check, inspect, and test the components and the assemblies of each as indicated in 58.2.

58.2 Factory inspections and tests shall include the following:

a) Inspection of all raw materials.

b) Check of relationship between a constant-level device and a vaporizing burner of each furnace. Distance from maximum normal level of oil to be maintained by constant-level device in the burner to the lowest opening through which oil can overflow the burner is to be not less than 3/4 inch (19.1 mm).

c) Examination of all vaporizing burners to ensure that they are free from defects. If of cast iron, the burner is to be tested for porosity and leakage by filling it with No. 1 oil and allowing it to stand for at least 1/2 hour, or with mineral spirits for at least 5 minutes.

d) Inspection of combustion chambers and heat exchangers to determine conformance with manufacturing specifications.

e) Subjecting at least 3 percent of all constant-level valves with integral metering stems to a flow test before being mounted on the furnace to assure that at specified adjustment the pilot fire flow rate does not exceed the amount specified.

f) In the case of power-operated burners not separately inspected, each burner or its essential components is to be tested to reveal and eliminate the following:

1) Oil leaks.

2) Electrical defects.

3) Misalignment.

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

1) Proper oil pressure.

2) Total motor input.

3) Proper adjustment of igniters.

h) If furnaces are not assembled at the factory, the manufacturer is to assemble periodically a furnace from production to check compatibility of the subassemblies. The components are to be capable of being readily assembled. It is suggested that one unit be so checked for each 100 units produced, but not more than one for each week of production.

i) Dielectric Voltage-Withstand Tests on each furnace incorporating high-voltage electrical circuit(s). The test shall be conducted in accordance with the requirements of the Production Line Dielectric Voltage-Withstand Test, Section 59.

j) Conduction of Grounding Continuity Tests.

59 Production Line Dielectric Voltage-Withstand Test

59.1 The manufacturer shall conduct a dielectric voltage-withstand test on each furnace. A 60 hertz potential as indicated below shall be applied between high-voltage live parts and dead metal parts for a period of 1 minute, except that the time of application of the potential may be reduced to 1 second if the value of the test potential is 120 percent of the value shown:

a) 1000 volts plus twice rated voltage, except as noted in (b).

b) 1000 volts for a motor rated at not more than 1/2 horsepower (373 W output) and not more than 250 volts.

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

59.3 If a furnace employs components such as a solid state control which can be damaged by the dielectric potential, the test may be conducted before the component(s) is electrically connected. However, a random sampling of each day's production is to be tested with the components electrically connected to ensure compliance with 59.1.

59.4 A 500 VA or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 59.1. The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment during the duration of the test.

59.5 The test equipment used for the test in 59.1 is to include a visible indication of application of the test potential and an audible and/or visible indication of breakdown. In the event of breakdown, manual-reset of an external switch is to be required, or an automatic reject of a furnace under test is to result. Other arrangements may be considered and accepted if found to achieve the results contemplated.

MARKING

60 General

60.1 The following information shall appear on each furnace:

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

b) The voltage rating, frequency, and total current in amperes of the furnace. If a furnace includes more than one circuit to be supplied by individual external supply circuits, the current of each circuit shall be indicated.

c) The firing rate of the furnace expressed to the nearest 0.1 gallons per hour (0.5 liters per hour) and the grade of fuel. [Assume Nos. 1 and 2 fuel oils have caloric values of 138,500 and 140,000 Btu per gallon (38.6 and 39.1 MJ per liter), respectively].

d) Instructions for replacing the air filter with like material permanently pasted or imprinted upon the filter service panel or adjacent thereto. Such marking is to be evident during replacement. Also explicit directions for locating the air filter when not factory-located if safe operation in accordance with these requirements is obtained only when the filter is so located.

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

f) The type of flooring, combustible or noncombustible, and the minimum clearances to adjacent construction to be provided when installed. The location and size of ventilation openings to be provided in closet doors or panels.

g) The designed maximum outlet-air temperature of the furnace, if 200°F (93°C) or less. Furnaces equipped with a limit control that functions to limit the outlet-air temperature between 166°F (74°C) and 200°F shall be marked "Designed maximum outlet-air temperature – 200°F (93°C) or less." Furnaces equipped with a limit control that functions to limit the outlet-air temperature to 165°F (74°C) or less shall be marked "Designed maximum outlet-air temperature – 165°F (74°C) or less."

h) A furnace tested for operation at an external static pressure in excess of that designated in Column II of Table 41.2 shall be marked to declare the static pressure at which the furnace was tested.

60.2 All markings required by these requirements shall be appropriately located and be readable when the furnace is in the intended installed position. A location within a burner compartment equipped with a door or removable panel for access is considered an acceptable location. The marking shall be reasonably permanent, as afforded by a metal nameplate or decalcomania transfer or pressure-sensitive material.

60.3 Among the factors taken into consideration when judging the acceptability of a nameplate depending on adhesives, are the adhesive properties and the resistance to defacement or removal at temperatures and in atmospheres to which it may be subjected under conditions of intended or abnormal use.

60.4 Each essential individual assembly not a part of the furnace shall include on the assembly the manufacturer's or private labeler's identification and catalog designation.

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

60.6 In addition to the information required in the preceding paragraphs, the following shall appear on the nameplate of a furnace: the minimum circuit ampacity and the maximum rating of the circuit protective device if the furnace employs more than one motor incorporating inherent overheating or overcurrent protection and is to be operated from a single supply line. If a furnace is intended for use on two or more circuits the nameplate shall include the above information for each circuit.

60.7 The minimum circuit ampacity shall be equal to the sum of all of the following loads that may operate concurrently:

a) Full load current rating of each motor,

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

c) Rating of all other loads.

60.8 If a motor that is connected in a circuit as described by 31.3 is installed remote from its controller, the rating of the remote motor, the size of the conductors supplying it, and reference to the location of the disconnect device for the remote motor shall be shown.

60.9 If more than one disconnect switch may be required to disconnect all power within a control assembly or compartment, the assembly or compartment shall be clearly marked to so indicate. The marking shall be in letters not less than 1/8 inch (3.2 mm) high, preceded by the word "CAUTION" and shall be located where it will be apparent before or immediately after exposing the live parts which may be connected to different circuits.

60.10 The maximum size of branch circuit fuses shall be marked if more than one motor is operated from a single supply line.

60.11 The marking indicated in 60.10 may additionally specify a maximum HACR Type circuit-breaker size if the required short-circuit tests have been conducted in accordance with 53.1 using an HACR Type circuit breaker.

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

60.13 If a supplementary fuse is provided in accordance with the exceptions to 29.4.2 or 29.2.5, the marking specified in 60.12 shall also include the identification of acceptable fuses by manufacturer's or private labeler's name, catalog designation, and voltage rating.

60.14 If a product employs a direct-connected high-voltage control circuit, see 29.2.1, it shall be marked with the maximum size of an overcurrent device or devices for that control circuit. The rating of an overcurrent device shall be based on the ampacity of the control circuit conductors, as determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70-1993 for No. 14 AWG (2.1 mm^2) or larger conductors and shall not exceed 10 amperes for No. 16 AWG (1.3 mm^2) conductors or 7 amperes for No. 18 AWG (0.82 mm^2) conductors. The marking shall appear on the wiring diagram, adjacent to the field-wiring terminals, or on the product nameplate.

60.15 Unless proper field-wiring connections are evident, a wiring diagram shall be provided on the furnace. A paper sticker glued or shellacked to an accessible cover is considered as conforming to this requirement.

60.16 If the unit requires a time-delay fuse, it shall be marked to so indicate.

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

60.18 A unit employing a 3 phase motor which has been investigated in accordance with 28.5(b), shall be marked in accordance with that paragraph.

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

INSTRUCTIONS

61 Operating and Installation Instructions

61.1 The instructions shall include the following statement or the equivalent:

"FOR YOUR SAFETY

Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance."

61.2 A copy of the manufacturer's operating and installation instructions intended to accompany each central furnace as produced is to be used as a guide in the examination and test of the appliance.

61.3 The instructions shall include such directions and information as deemed by the manufacturer to be necessary to cover the intended installation, maintenance, and use of the appliance. See 61.1.

PART 2 – OUTDOOR-USE EQUIPMENT

CONSTRUCTION

62 General

62.1 An outdoor-use furnace shall comply with the applicable requirements in Sections 1 – 61 of this standard and shall, in addition, comply with Sections 63 – 71.

63 Enclosure

63.1 General

63.1.1 An enclosure or enclosures shall be so constructed as to prevent the wetting of live parts as indicated in 63.1.2 – 63.1.7 and protect the system against the risk of shock due to weather exposure.

63.1.2 To determine compliance with 63.1.1, a complete assembly, with supply conduit connections, but without pipe-thread compounds, is to be subjected to the Rain Test, Section 67.

63.1.3 A water-absorbing insulating material shall not become wetted by rain when installed as intended if such wetting will depreciate its durability or insulating value.

63.1.4 Any panel or cover in the outer enclosure shall require the use of tools to open; unless it can be determined that removal or opening of the panel or cover will not result in exposure to electrical shock due to weather exposure or to moving parts.

63.1.5 Enclosures for electrical components shall have provision for drainage if knockouts or unthreaded openings in the enclosure are employed.

63.1.6 Cabinets and enclosures shall have a thickness of not less than 0.032 inch (0.81 mm) if uncoated sheet steel, not less than 0.034 inch (0.86 mm) if zinc coated sheet steel, and not less than 0.029 inch (0.74 mm) if copper, brass, or aluminum; except as stated in 63.1.7.

63.1.7 Enclosures less than 0.032 inch (0.81 mm) thick which comply with Table 27.1 or 27.2, whichever applies, are acceptable if they are protected by an outer cabinet.

63.2 Corrosion protection

63.2.1 Metal shall not be used in combinations such as to cause galvanic action which will adversely affect cabinets or enclosures.

63.2.2 Hinges and other attachments shall be resistant to corrosion.

63.2.3 Sheet steel cabinets and electrical enclosures exposed to the effects of weathering shall be protected against corrosion by the means indicated in Table 63.1 or by other metallic or nonmetallic coatings which have been shown to give equivalent protection.

Table 63.1
Corrosion protection

Type of cabinet and enclosure	For uncoated sheet metal 0.053 inch and thicker or for metal coated sheet metal 0.056 inch and thicker as specified by paragraph	For uncoated sheet metal less than 0.053 inch thick or for metal coated sheet metal less than 0.056 inch thick as specified by paragraph
Outer cabinets that protect motors, wiring, or enclosed current-carrying parts	63.2.4	63.2.5
Inside enclosures that protect current-carrying parts other than motors	63.2.4	63.2.5
Outer cabinets that are the sole enclosure of current-carrying parts	63.2.4	63.2.5

63.2.4 To comply with 63.2.3 referenced to this paragraph, one of the following coatings shall be used:

a) Hot-dipped mill galvanized steel sheet conforming with the coating Designation G60 or A60 in Table I of Specification of Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, ASTM A525-91b, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may be determined by any recognized method; however, in case of question the weight of coating shall be established in accordance with the Tests for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81. An A60 (alloyed) coating shall also comply with 63.2.7.

b) A zinc coating, other than that provided on hot-dipped mill galvanized steel sheet, uniformly applied to an average thickness of not less than 0.00041 inch (0.01041 mm) on each surface with a minimum thickness of 0.00034 inch (0.00864 mm) the thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 70. An annealed coating shall also comply with 63.2.7.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The suitability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.

63.2.5 To comply with 63.2.3 referenced to this paragraph, one of the following coatings shall be used:

a) Hot-dipped mill galvanized steel sheet conforming with the coating Designation G90 in Table I of ASTM A525-91b, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating may be determined by any recognized method; however, in case of question the weight of coating shall be established in accordance with the Test Method of ASTM A90-81.

b) A zinc coating, other than that provided on hot-dipped mill galvanized steel sheet, uniformly applied to an average thickness of not less than 0.00061 inch (0.01549 mm) on each surface with a minimum thickness of 0.00054 inch (0.01372 mm) the thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 70. An annealed coating shall also comply with 63.2.7.

c) A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 70.

d) A zinc coating conforming with 63.2.4(a) or (b) with one coat of outdoor paint as specified in 63.2.4(c) on each surface.

e) A cadmium coating not less than 0.00075 inch (0.01905 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 inch (0.0127 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 70 and the paint shall be as specified in 63.2.4(c).

63.2.6 With reference to 63.2.3, other finishes, including paints, special metallic finishes and combinations of the two may be accepted when comparative tests with galvanized-sheet steel (without annealing, wiping or other surface treatment) conforming with 63.2.4(a) or 63.2.5, as applicable, indicate they provide equivalent protection. Among the factors which are taken into consideration when judging the suitability of such coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light and water.

63.2.7 A hot-dipped mill galvanized A60 (alloyed) coating or an annealed zinc coating which is bent or similarly formed after annealing and which is not otherwise required to be painted shall be painted in the bent or formed area if the bending or forming process damages the zinc coating, except that such areas on the inside surface of a cabinet or enclosure which water does not enter during the Rain Test need not be painted.

63.2.8 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall conform with 63.2.7.

63.2.9 Nonferrous cabinets and enclosures may be employed without corrosion protection. The thickness of the material is to be judged on the basis of its strength and rigidity.

63.2.10 Nonmetallic cabinets and enclosures are judged on the basis of the effect of exposure to ultraviolet light and water.

64 Field-Wiring Connections

64.1 Openings for connection of conduit provided for field-wiring connections shall be threaded unless:

a) They are located wholly below the lowest uninsulated live part within the enclosure, or

b) The location prevents drainage into the enclosure.

Threaded holes for conduit shall be reinforced to provide metal at least 1/4 inch (6.4 mm) in thickness; and shall be provided with a conduit end stop unless the thread is tapered.

65 Internal Wiring

65.1 The internal wiring shall be so constructed and assembled as to provide protection against the risk of electric shock due to weather exposure.

65.2 The use of moisture-resistant wiring material, such as Type RH, RHW, RUW, TW, THW, THWN, TFN, or TFNN, enclosed in rigid or flexible-steel conduit or electrical metallic tubing, or moisture-resistant nonmetallic sheathed cable for the wiring between electrical component enclosures is considered acceptable. Wiring materials of the type indicated in Table 21.1, Group A, installed in either rigid conduit or electrical metallic tubing with rain-tight fittings or in liquid-tight flexible-metal conduit with fittings are acceptable. The use of cords or appliance wiring material as described in Table 21.1, Group B is also acceptable. Bushings, where used, are to be nonabsorptive.

65.3 The wiring assembly shall be so constructed and located as to exclude water from electrical enclosures.

65.4 All wires and cords shall be routed and supported so that they will not be immersed in water.

66 Electrical Insulating Material

66.1 Nonabsorptive electrical insulation shall be used in the construction of electrical components. Unglazed porcelain and asbestos are examples of materials that shall not be used, while vulcanized fiber on electrical components is acceptable, if the components are not wetted as a result of the Rain Test.

PERFORMANCE

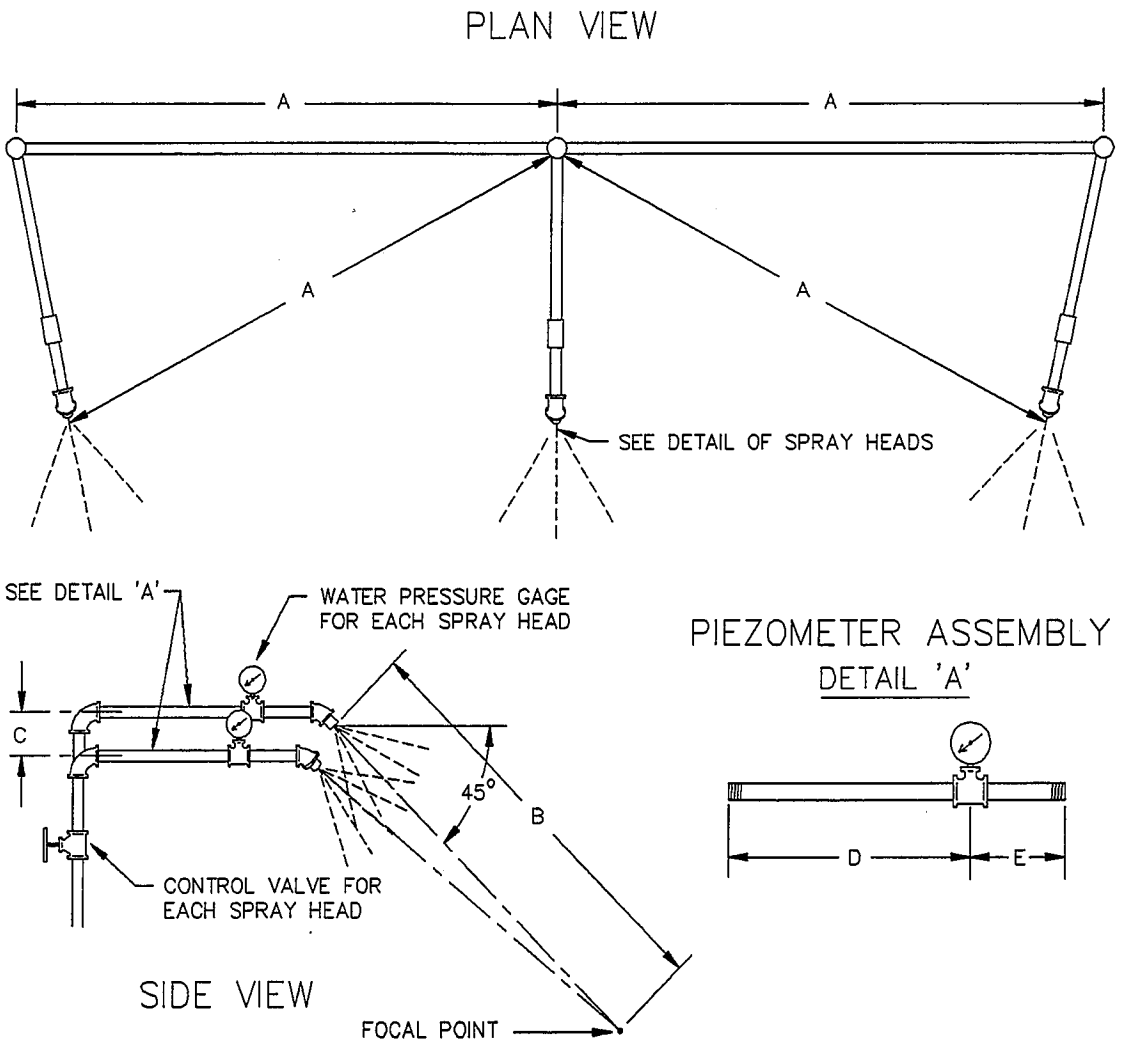
67 Rain Test

67.1 A furnace for outdoor use shall withstand rain exposure for 1 hour without creating a risk of electric shock. The assembly shall also comply with the requirements of 67.7 following the test.

67.2 The furnace is to be positioned and leveled in accordance with the manufacturer's instructions. The insulation resistance of the furnace is to be measured before the test using the series voltmeter method or other equivalent means, and a direct-current circuit. The insulation resistance between live parts and dead-metal parts is to be not less than 50,000 ohms before the test.

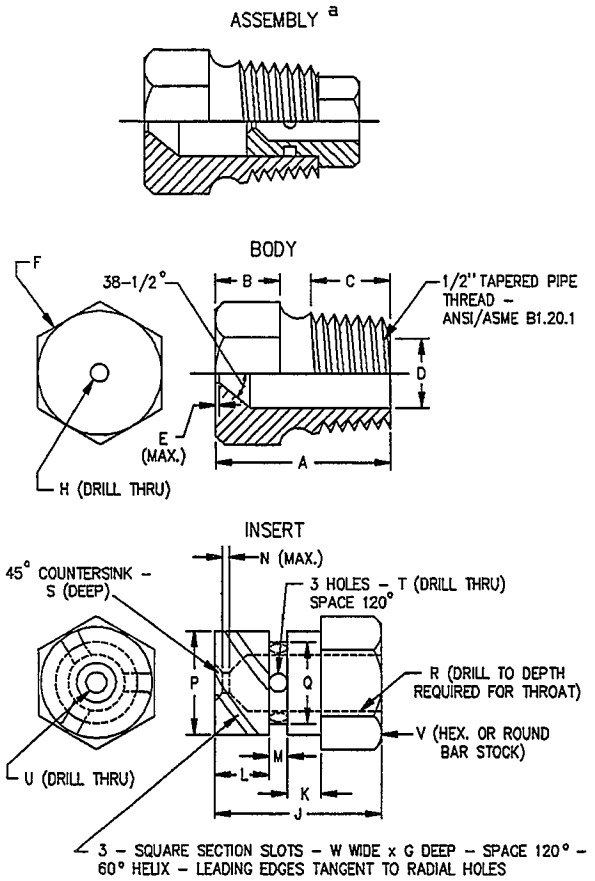
67.3 The rain test apparatus is to consist of three spray heads mounted in a water supply rack as shown in Figure 67.1. Spray heads are to be constructed as shown in Figure 67.2. The water pressure is to be maintained at 5 psig (34.5 kPa) at each spray head. The furnace is to be centrally located within the focal area of the three spray heads in such position and under such conditions that the greatest quantity of water will enter into or on the electrical components and vent assembly. The spray is to be directed at an angle of 45 degrees to the vertical toward openings in the cabinet, door, and gasketed covers and panels, including the door. The distance between the center nozzle and the furnace is to be approximately 3 feet (0.91 m); however, since the overall size of furnaces vary, it may be necessary to make adjustments in the position of the nozzles to allow the greatest quantity of water to enter openings in the furnace.

Figure 67.1
Rain-test spray-head piping



Item	Inch	mm
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

Figure 67.2
Rain-test spray head



RT100C

Item	Inch	mm	Item	Inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	[c]	[c]	S	1/32	0.80
G	.06	1.52	T	(No.35)[b]	2.79
H	(No.9)[b]	5.0	U	(No.40)[b]	2.49
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Molded nylon Rain-Test Spray Heads are available from Underwriters Laboratories Inc.

[b] ANSI B94.11 Drill Size.

[c] Optional - To serve as wrench grip.

67.4 Field-wiring connections are to be made in accordance with the wiring method specified for the unit. Openings intended to terminate conduit are to be sealed. Openings intended for the entry of a conductor(s) in a low-voltage circuit are not to be sealed.

67.5 The furnace is to be operated for a total of 1 hour during which the unit is to be running so that electrical components located in vulnerable areas are energized. If it is evident that certain conditions, such as position of the furnace under water spray, may affect the results, the test is to be repeated with the furnace subjected to these other conditions.

67.6 The furnace, after exposure, is to have an insulation resistance between current-carrying parts and noncurrent-carrying parts of not less than 50,000 ohms, and is to withstand, without breakdown, the voltage indicated in the Dielectric Voltage-Withstand Test, Section 56.

67.7 The test is not to result in the entrance of water into enclosures above the lowest live part or in wetting live parts, except as follows:

a) Motor windings may be judged by the insulation resistance and by the Dielectric Voltage-Withstand Test, Section 56, provided the motors are constructed, located or shielded so that the windings are not directly exposed to water in the Rain Test.

b) Water may enter an enclosure above the lowest live electrical part providing the point of entrance is not in proximity to live electrical parts and it can definitely be established that live parts will not be wetted due to weathering effects.

68 Wind Test

68.1 The burner of a furnace designed for outdoor installation shall not become extinguished and shall ignite without excessive delay when the furnace is exposed to a wind velocity of 40 miles (64 km) per hour.

68.2 A draft produced by a blower having sufficient capacity to develop a 40 mile (64 km) per hour wind is to be directed against the outer surface of the furnace and the outlet of the integral venting system at points deemed to be most critical. The blower is to be located so that a uniform draft is directed horizontally toward the furnace at a velocity of 40 miles per hour measured in a vertical plane 18 inches (455 mm) from the windward surface of the furnace.

68.3 With the furnace operating under the above wind conditions, the main burner is to be operated for a sufficient length of time to determine whether or not it will be extinguished and will be reliably ignited.

69 Accelerated Aging Test – Gaskets, Adhesives, and Sealing Compounds

69.1 Neoprene or rubber compounds, except formed materials, used for gaskets to seal electrical enclosures, shall have physical properties as indicated in Table 69.1 before and after accelerated aging under the conditions indicated in Table 69.2.

69.2 Foamed neoprene or rubber compounds forming gaskets to seal an electrical enclosure shall be subjected to accelerated aging under the conditions indicated in Table 69.2. The compounds shall not harden or otherwise deteriorate to a degree which will affect their sealing properties.

Table 69.1
Physical properties for gaskets

	Neoprene or rubber compound		Polyvinyl chloride materials	
	Before test	After test	Before test	After test
Recovery – Maximum set when 1-inch (25.4 mm) gas marks are stretched to 2.5 inches (63.5 mm), held for 2 minutes and measured 2 minutes after release.	1/4 inch (6.4 mm)	–	Not Specified	
Elongation – Minimum increase in distance between 1-inch gage marks at break.	250 percent, (1 to 3.5 inches) (25.4 – 89.0 mm)	65 percent of original	250 percent, (1 to 3.5 inches) (25.4 – 89.0 mm)	75 percent of original
Tensile Strength – Minimum force at breaking point.	850 psi (5.86 MPa)	75 percent of original	1200 psi (8.27 MPa)	90 percent of original

Table 69.2
Accelerated aging test criteria

Measured temperature rise degrees C (F)	Material	Test program
35 (63)	Rubber or Neoprene	4 days at 70°C (158°F) in an oxygen bomb at 300 psig (2070 kPa)
35 (63)	Thermoplastic	7 days in an air-circulated oven at 87°C (189°F)
50 (90)	Rubber or Neoprene	7 days at 80°C (176°F) in an oxygen bomb at 300 psig (2070 kPa)
50 (90)	Thermoplastic	10 days in an air-circulated oven at 100°C (212°F)
65 (99)	Rubber, Neoprene, or Thermoplastic	7 days in an air-circulated oven at 113°C (235.4°F)
65 (117)	Rubber or Neoprene	10 days in an air-circulated oven at 121°C (249.8°F)
65 (117)	Thermoplastic	7 days at 121°C or 60 days at 97°C (206°F) in an air-circulated oven
80 (144)	Rubber, Neoprene, or Thermoplastic	7 days in an air-circulated oven at 136°C (276.8°F)

69.3 Thermoplastic materials forming gaskets to seal an electrical enclosure shall be subjected to accelerated aging under the conditions indicated in Table 69.1. Thermoplastic material shall not deform or melt, or otherwise deteriorate to a degree which will affect its sealing properties. Solid polyvinyl-chloride gasket material shall have physical properties as indicated in Table 69.1 before and after the accelerated aging.

69.4 Gaskets of materials other than those mentioned in 69.1 – 69.3 shall be nonabsorptive and shall provide equivalent resistance to aging and temperature.

70 Metallic Coating Thickness Test

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

70.2 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is tapered to form a tip, the drops from which are above 0.025 ml each. To preserve an effectively constant level, a small glass tube is 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.

70.3 The sample and the test solution should 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).

70.4 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.

70.5 The sample to be tested is to be supported from 0.7 – 1 inch (18 – 25 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 about 45 degrees from horizontal.

70.6 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.

70.7 Each sample of a test lot is to be subjected to test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface 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.

70.8 To calculate the thickness of the coating being tested, select from Table 70.1 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 70.6.

Table 70.1
Coating thickness factors

Temperature, degree F (C)	Thickness factors, 0.00001 inches (0.00025 mm) per second	
	Cadmium plating	Zinc platings
70 (21.1)	1.331	0.980
71 (21.7)	1.340	0.990
72 (22.2)	1.352	1.000
73 (22.8)	1.362	1.010
74 (23.3)	1.372	1.015
75 (23.9)	1.383	1.025
76 (24.4)	1.395	1.033
77 (25.0)	1.405	1.042
78 (25.6)	1.416	1.050
79 (26.1)	1.427	1.060
80 (26.7)	1.438	1.070
81 (27.2)	1.450	1.080
82 (27.8)	1.460	1.085
83 (28.3)	1.470	1.095
84 (28.9)	1.480	1.100
85 (29.4)	1.490	1.110
86 (30.0)	1.501	1.120
87 (30.6)	1.513	1.130
88 (31.1)	1.524	1.141
89 (31.7)	1.534	1.150
90 (32.2)	1.546	1.160

MARKING

71 General

71.1 A nameplate to be used on outdoor-use equipment is to be of corrosion resistant material.

71.2 A unit which has been investigated and found to be acceptable for outdoor use shall be legibly marked with the wording "OUTDOOR USE" or similar wording on or near the nameplate.

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are judged include the following:

Title of Standard – UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Capacitors – UL 810
Circuit Breakers, Molded Case, and Circuit-Breaker Enclosures – UL 489
Conduit, Flexible Metal – UL 1
Conduit, Rigid Metal – UL 6
Controls, Limit – UL 353
Controls, Primary Safety, for Gas- and Oil-Fired Appliances – UL 372
Fittings for Conduit and Outlet Boxes – UL 514B
Fittings, Tube, for Flammable and Combustible Fluids, Refrigeration Service, and Marine Use – UL 109
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Fuses, Class H – UL 198B
Fuses, Class R – UL 198E
Fuses, Class T – UL 198H
Fuses for Supplementary Overcurrent Protection – UL 198G
Fuses, Plug – UL 198F
Grounding and Bonding Equipment – UL 467
Industrial Control Equipment – UL 508
Marking and Labeling Systems – UL 969
Motors, Electric – UL 1004
Oil Heaters, Electric – UL 574
Outlet Boxes, Metallic – UL 514A
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Fabricated Parts – UL 746D
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed Wiring Boards – UL 796
Protectors for Electric Motors, Thermal – UL 547
Pumps for Oil-Burning Appliances – UL 343
Strainers for Flammable Fluids and Anhydrous Ammonia – UL 331
Switches, Enclosed and Dead Front – UL 98
Switches, Snap, General-Use – UL 20
Switches, Special Use – UL 1054
Systems of Insulating Materials, General – UL 1446
Temperature-Indicating and -Regulating Equipment – UL 873
Terminal Blocks – UL 1059
Transformers, Specialty – UL 506
Transformers, Class 2 and Class 3 – UL 1585
Tubing, Electrical Metallic – UL 797

APPENDIX A (Cont'd)

Standards for Components

Standards under which components of the products covered by this standard are judged include the following:

Title of Standard – UL Standard Designation

Tubing, Extruded Insulating – UL 224
Valves, Constant-Level Oil – UL 352
Valves, Electrically-Operated – UL 429
Valves for Flammable Fluids – UL 842
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wire Connectors for Use with Aluminum Conductors – UL 486B
Wires and Cables, Thermoplastic-Insulated – UL 83