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January 30, 1996

Revision pages for

Standard for

Oil-Fired Central Furnaces

UL 727, Eighth Edition

Attached to this transmittal notice is a revision of the Eighth edition of UL 727.

A CHANGE ON A PAGE DATED JANUARY 30, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

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

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the Department of Defense approved text of UL 727.

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

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

Page	Date
1	August 1, 1994(Reprinted January 30, 1996)
2	—
3 – 107	August 1, 1994
108	January 30, 1996
109, 110, A1	August 1, 1994

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UL 727

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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
	1/4 inch (6.4 mm)	—	Not Specified	
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.				
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	Air oven aging for 70 hours at 100°C (212°F)
35 (63)	Thermoplastic	7 days in an air-circulated oven at 87°C (189°F)
50 (90)	Rubber or Neoprene	Air oven aging for 168 hours at 100°C (212°F)
50 (90)	Thermoplastic	10 days in an air-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)

Table 69.2 revised January 30, 1996

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Oil-Fired Central Furnaces





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August 1, 1994

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THIS EDITION OF THE STANDARD IS NOW IN EFFECT.

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Documents

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1

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FOREWORD

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

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

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

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

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

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

PART 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.

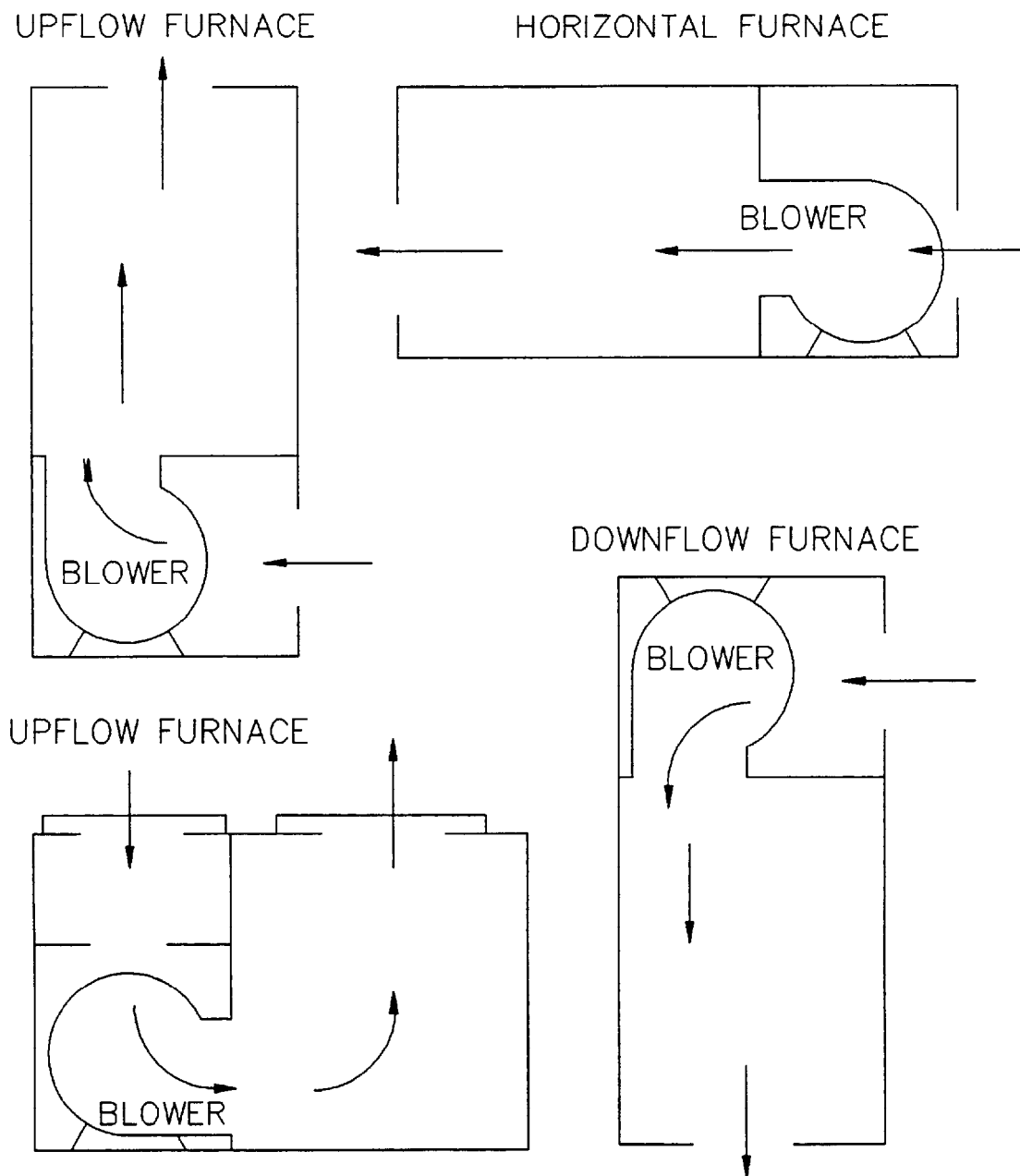
3.26 **INDIRECT-FIRED APPLIANCE** – An appliance constructed so that combustion products or flue gases are not mixed in the appliance with the medium, that is, to be heated; hence is provided with a flue collar.

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



S2590

Note: Arrows indicate direction of air flow.

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:

- All interior surfaces of the heat exchanger, combustion chamber including its bottom, radiators, and flues shall be resistant to corrosion by moisture.
- The firebox liner shall resist deterioration from being wetted by condensation.
- 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.
- 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.

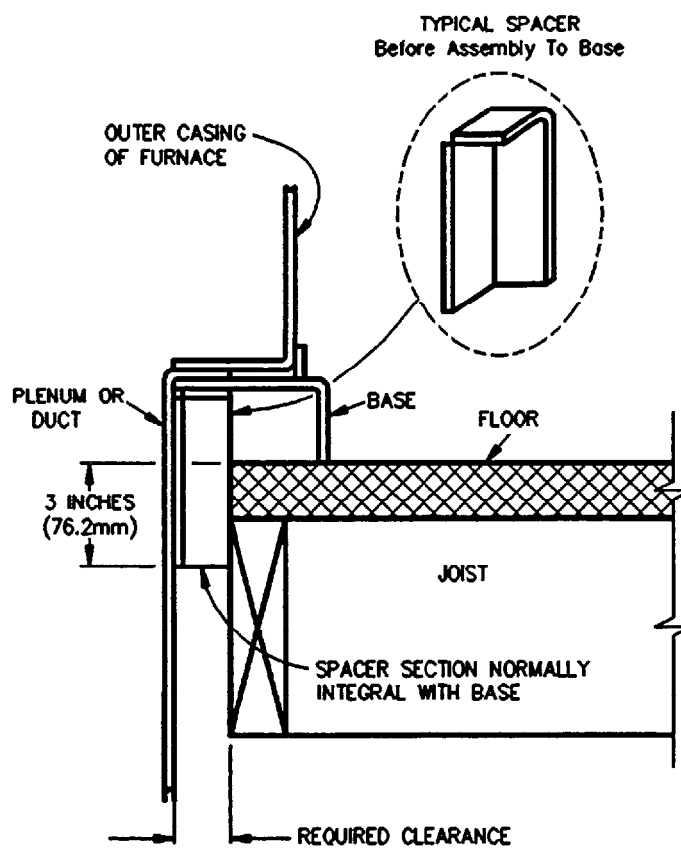
8 Base

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.

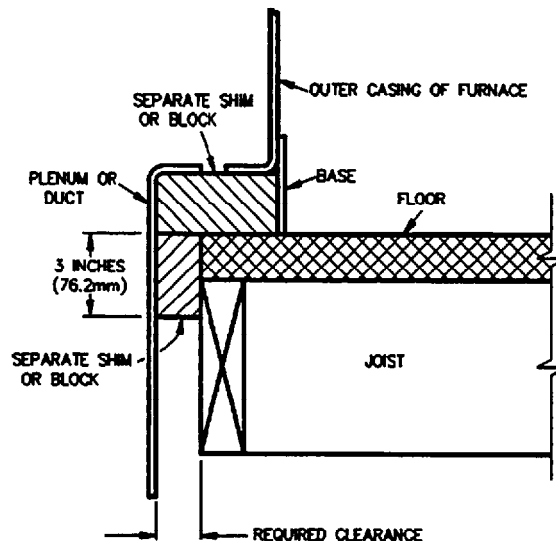
Figure 8.1
Acceptable base construction for
downflow furnace



S2591

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



SZ592

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 m²). 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 m²) 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 bolts, 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

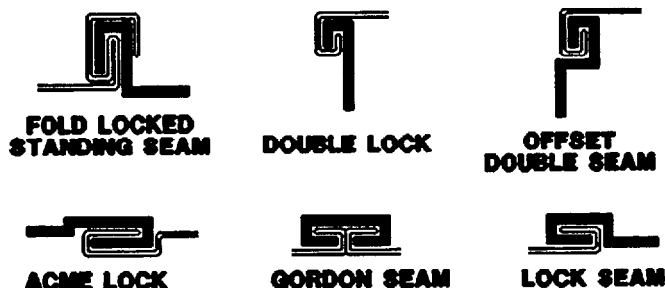
14.1 A radiator shall be made of material not lighter than that designated in 13.1 for a combustion chamber and shall be accessible for cleaning.

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



ED100

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 mm²).

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 them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

^b Trade size 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 mm²) and smaller wires, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates having upturned lugs, or the equivalent, to 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 mm²).

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

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:

- It is not practical to do the wiring in accordance with 21.2.3.
- The cord is not required to be bent, twisted, or otherwise displaced to render routine maintenance and service.
- 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 mm²) 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.