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UL 1096

STANDARD for SAFETY

ELECTRIC CENTRAL AIR HEATING EQUIPMENT

UNDERWRITERS LABORATORIES INC.®

UNDERWRITERS LABORATORIES INC.®

an independent, not-for-profit organization testing for public safety

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Revision pages for

STANDARD FOR
ELECTRIC CENTRAL AIR HEATING EQUIPMENT

UL 1096, FOURTH EDITION

Attached is a revision of the fourth edition of UL 1096.

These pages have been revised to make editorial corrections and contain no change in requirements. Although vertical lines in the margins are usually used only to indicate a change in requirements, for your convenience vertical lines on the revised pages show only the editorial corrections.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 1096—1985.

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 check list:

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UL 1096

STANDARD FOR ELECTRIC CENTRAL AIR HEATING EQUIPMENT

First Edition — January, 1973
Second Edition — December, 1973
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Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Electric Space-Heating Equipment, UL 573.

FOURTH EDITION

July 15, 1986

Approval as an American National Standard covers the numbered paragraphs on pages dated July 15, 1986. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the approved text. Revisions of this standard will be made by issuing revised or additional pages bearing their dates of issue.

Approved as ANSI C33.104—1973, September 20, 1973
Approved as ANSI/UL 1096—1980, December 5, 1980
Approved as ANSI/UL 1096—1985, June 26, 1985

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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 the 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 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.

ALL EQUIPMENT

GENERAL

1. Scope

1.1 These requirements cover duct heaters, central heating furnaces, similar fixed electric space heating equipment, and remote control assemblies for such equipment, rated at 600 volts or less to be employed in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements do not cover fan-coil units, panel or cable type radiant heating equipment, electric boilers, baseboard heaters, air heaters, nor any other electric heating equipment or appliances which are covered in or as a part of separate, individual requirements.

1.3 Electric space heating equipment intended for use in a hazardous location is judged on the basis of its compliance with the requirements in this standard, together with the requirements for hazardous location equipment included in other applicable standards.

1.4 Electric space heating equipment designed to be connected to air-duct systems is intended for installation in accordance with the Standard for Air Conditioning and Ventilating Systems, NFPA 90A, and the Standard for Warm Air Heating and Air Conditioning Systems, NFPA 90B.

2. General

2.1 Requirements under this heading apply generally to all of the heating equipment mentioned in paragraph 1.1 and are supplemented by requirements in separate sections applying specifically to those different classes of heaters. The term "heater" as used in this standard refers to any equipment covered by this standard.

2.2 A circuit classified as low voltage is one involving a potential of not more than 30 volts alternating current (42.4 peak), or direct current, and supplied by a primary battery, by a Class 2 transformer or by a combination of transformer and fixed impedance which, as a unit, complies with all the performance requirements for a Class 2 transformer.

2.3 A circuit classified as high voltage is one involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit as defined in paragraph 2.2.

2.4 A circuit derived from a high-voltage circuit, see paragraph 2.3, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current as a means of limiting the voltage and current is not considered to be a low-voltage circuit.

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

2.6 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. Components

3.1 A component used with a heater covered by this standard shall comply with the requirements for that component and shall be used in accordance with its recognized rating and other limitations of use. See Appendix A for a list of standards covering components generally used in the heaters covered by this standard. 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 heater covered by this standard, or

B. Is superseded by a requirement in this standard.

CONSTRUCTION

4. General

4.1 A heating element or a moving part is not required to be enclosed by the heater manufacturer if it will be enclosed in a duct or plenum when installed and if an open wire-type heating element is within a metal frame or the equivalent which will provide the degree of resistance to the abuses described in paragraph 5.1 as the result of deflection of the duct or plenum enclosing the element. See also paragraph 4.2.

4.2 The enclosure of a heater shall be provided with means for mounting in the intended manner. Any special fittings necessary for such mounting shall be shipped with the heater. Except as indicated in paragraph 55.1, a freestanding floor supported heater need not be provided with mounting means.

4.3 The enclosure of a heater shall not have any projections likely to cause persons to trip when walking near the heater after it is installed in the intended manner.

4.4 The rotors of motors, pulleys, belts, gears, and the like, shall be so enclosed or guarded as to adequately reduce the risk of injury to persons.

4.5 An interlocking mechanism which operates to disconnect power to the drive motor when the cover or panel is removed or opened for access to moving parts is considered to provide the protection required by paragraph 4.4.

4.6 With reference to the requirement in paragraph 4.4, the degree of protection required depends upon the general design and intended use of the heater. Factors to be taken into consideration in judging the acceptability of the protection for moving parts are (1) the degree of exposure, (2) the sharpness of the moving parts, (3) the likelihood of accidental contact with the moving parts, (4) the speed of movement of those parts, and (5) the likelihood of fingers, arms, or clothing being drawn into the moving parts, such as at points where gears mesh, where belts travel onto a pulley, or where moving parts close in a pinching or shearing action.

4.7 The requirement of paragraph 4.4 will ordinarily necessitate that an opening in a required guard or enclosure around a moving part comply with Table 4.1.

TABLE 4.1
SIZE OF OPENINGS

Straight line distance to moving part from external plane of opening, inches (mm)	Maximum diameter rod that will pass through the opening, inches (mm)
2 (50.8) or less	1/4 (6.4)
6 (152) or less (but greater than 2)	1/2 (12.7)
15 (381) or less (but greater than 6)	1 (25.4)

4.8 Where the starting or restarting of a motor driving a moving part such as described in paragraph 4.4 is provided by an automatic cycling device, such as a thermostat, overcurrent device, or thermal protector, the requirement of paragraph 4.4 will necessitate the use of a guard if the part is exposed when making operating adjustments or changing air filters or if the part is accessible without requiring the use of tools.

4.9 With reference to paragraph 4.8, the scroll of a centrifugal blower is an acceptable guard for the blower wheel.

4.10 Except as noted in paragraph 4.11, ferrous parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means if the failure of such unprotected parts could increase the risk of accident, electric shock, or fire.

4.11 In certain equipment where the oxidation of steel is not likely to be accelerated due to the exposure of metal to air and moisture or other oxidizing influence, thickness of metal and temperature also being factors, surfaces of sheet steel within an enclosure may not be required to be protected against corrosion. Cast iron parts are not required to be protected against corrosion. A sheath employed on a heating element operating in air and terminal parts attached directly to the heating element need not be protected against corrosion.

4.12 The aging characteristics of plating or other finish shall be such that deterioration of the finish will not result eventually in unacceptable performance of the heater.

5. Enclosure

General

5.1 The frame and enclosure of a heater shall be sufficiently strong and rigid to resist the abuses likely to be encountered during shipment, installation and use. The degree of resistance inherent in the heater shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects which alone or in combination constitute an increase in the risk of fire, electric shock, and/or accident.

5.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are considered in determining compliance with this requirement.

5.3 Among the factors taken into consideration when an enclosure is being judged for acceptability are its (1) physical strength, (2) resistance to impact, (3) moisture absorptive properties, (4) combustibility, (5) resistance to corrosion, and (6) resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use. For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal aging.

5.4 An outer cabinet is evaluated with respect to the size, shape, thickness of metal, and its suitability for the particular application. Sheet steel having a thickness of less than 0.026 inch (0.66 mm) if uncoated, or 0.029 inch (0.74 mm) if galvanized, or nonferrous sheet metal having a thickness of less than 0.036 inch (0.91 mm) shall not be used except for relatively small areas or for surfaces which are curved or otherwise reinforced.

5.5 Except as indicated in paragraph 5.6, openings in the enclosure of a heater or in an externally mounted component shall be so located that they will not vent into concealed spaces of a building structure, such as into a false ceiling space, into hollow spaces in the wall, or the like, when the heater is installed as intended.

5.6 The requirement in paragraph 5.5 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) if the opening has no dimension more than 17/64 inch (6.75 mm) or an area no more than 0.055 square inch (35.49 mm^2).

5.7 Except as noted in paragraph 5.8, an opening for ventilation in the enclosure, other than in the bottom, shall be provided with one or more baffles that will prevent the emission of flame, molten metal, burning insulation, or the like, from the heater.

5.8 In a compartment other than one that houses a motor overload relay or overcurrent protective device, such as a fuse or circuit breaker, the baffles mentioned in paragraph 5.7 may be omitted if:

A. No ventilating opening in a vertical wall is more than 3/8 inch (9.5 mm) in width, or

B. The heater is so constructed that it is suitable for the purpose, as shown by appropriate investigation, including short circuit tests.

Doors and Covers

5.9 The door or cover of an enclosure shall be provided with means for securing it in place in the closed position.

5.10 Except as indicated in paragraphs 5.12 and 5.13, the door or cover of an enclosure shall be hinged (1) if it gives access to any fuse, circuit breaker, or manually resettable temperature control in other than a low-voltage circuit, and (2) if uninsulated live parts are exposed during the replacement of the fuse or resetting of the manually resettable device. Such a door or cover shall also be provided with an automatic latch, see paragraph 5.15, or the equivalent, and if live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, a captive screw or equivalent means, requiring the use of a tool to open, to reliably secure the door or cover in place. See paragraph 5.11.

5.11 The captive screw may be omitted from the door or cover over the compartment housing the uninsulated live parts if it is provided in the cover that must be opened to gain access to the door or cover. Arrangements employing two mating hinged doors are acceptable where the automatic latch and captive screw are provided only on one door (1) if that door is designed to be opened first and closed last, and (2) if the latch and screw will hold the other door closed.

5.12 A hinged cover is not required for a device in which the only fuses enclosed are (1) 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, or (2) an extractor type fuse with its own enclosure.

5.13 The removable portion of a fused pullout switch which complies with the requirements in paragraphs 5.1—5.8, 5.14, and 5.25—5.32 is considered to be the cover for the fuseholder required by paragraph 22.1 and need not comply with the requirements in paragraph 5.10.

5.14 A door or cover giving access to a fuse, circuit-breaker, overload relay, or other overload protective device in other than a low-voltage circuit shall be tight-fitting and shall overlap the surface of the enclosure around the opening.

5.15 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door closed, and would require some effort on the user's part to open it, is considered to provide the automatic latching means for holding the door closed as required in paragraph 5.10.

5.16 A cover interlocking mechanism which (1) must be engaged in the closed position of the cover before parts are energized, and (2) will secure the cover in the closed position, when provided as the sole means for securing the door or cover closed, is considered to comply with paragraph 5.10.

5.17 An unexpectedly heavy hinged or pivoted panel or cover — such as a cover having components mounted on its interior surface — shall be positioned or arranged so that when the panel or cover is first unfastened, it does not fall or swing open due to gravity or equipment vibration in such a manner as to cause injury to persons from the panel or cover, from other moving parts, or from uninsulated live parts. See paragraphs 6.2 and 6.7.

Field Wiring System Connections

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

5.19 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 or more than five threads in the metal. Construction of the device shall be such that a standard 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 that will 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.

5.20 A knockout in a sheet metal enclosure complying with the requirements of paragraph 5.21 shall be capable of being removed without deformation of the enclosure which would impair the intended attachment of a conduit fitting.

5.21 A knockout shall remain in place when a force of 10 pounds (44 N) is applied at right angles to the knockout by a 1/4 inch (6.4 mm) diameter mandrel with a flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

5.22 A knockout or opening for connection of a field wiring system shall be provided with a flat surrounding surface for seating of a conduit bushing and shall be so located that installation of a bushing will not result in spacings between uninsulated live parts and the bushing less than those required by this standard.

Paragraph 5.22 revised July 16, 1986

5.22A Provisions may be made for field cutting the opening(s) necessary for field wiring system connections in accordance with the requirements specified in paragraphs 5.18, 5.22, and 8.5. Such openings shall be located so that the necessary cutting or drilling operation is not likely to damage components or wiring within the enclosure. In general, a distance of 6 inches (152 mm) from the opening is considered adequate to prevent damage due to cutting or drilling. See paragraph 43.23 for marking requirements.

Exception No. 1: Provision for field cut openings shall not be made on units intended for installation outdoors. See paragraph 66.1.

Exception No. 2: The 6-inch separation need not be maintained if either (1) the portion of the enclosure in which the opening is to be made, or (2) a subassembly containing the components and wiring and designed to be removable without disturbing any internal wiring connections, is intended to be removed prior to the cutting or drilling operation.

Paragraph 5.22A added July 16, 1986

Components

5.23 A component of a heater intended to be manually operated or adjusted by the user or that will definitely require periodic servicing by the user, for example, replacement or cleaning, shall be accessible by use of ordinary tools or without the use of tools. See paragraph 5.24.

5.24 With reference to paragraph 5.23, ordinary tools are considered to be pliers, flat-bladed and cross-recessed head (Phillips) screwdrivers and hexagonal recessed-head screw (Allen) wrenches.

Enclosure Thickness

5.25 Sheet metal which serves as an electrical enclosure shall comply with Tables 5.1 and 5.2, whichever applies, except that where the (1) location of the enclosure, (2) design and location of components, or (3) the strength and rigidity of the frame and enclosure, are adequate to comply with paragraph 5.1, an enclosure thinner than specified in Tables 5.1 and 5.2 may be employed.

TABLE 5.1
MINIMUM THICKNESS OF SHEET-METAL 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] Inches (cm)	Maximum Length[c] Inches (cm)	Maximum Width[b] Inches (cm)	Maximum Length Inches (cm)	Uncoated (MSG)	Metal Coated (GSG)
4.0 (10.2) 4.75 (12.1)	Not limited 5.75 (14.6)	6.25 (15.9) 6.75 (17.1)	Not limited 8.25 (21.0)	0.020[d] (0.51) (24)	0.023[d] (0.58) (24)
6.0 (15.2) 7.0 (17.8)	Not limited 8.75 (22.2)	9.5 (24.1) 10.0 (25.4)	Not limited 12.5 (31.8)	0.026[d] (0.66) (22)	0.029[d] (0.74) (22)
8.0 (20.3) 9.0 (22.9)	Not limited 11.5 (29.2)	12.0 (30.5) 13.0 (33.0)	Not limited 16.0 (40.6)	0.032 (0.81) (20)	0.034 (0.86) (20)
12.5 (31.8) 14.0 (35.6)	Not limited 18.0 (45.7)	19.5 (49.5) 21.0 (53.3)	Not limited 25.0 (63.5)	0.042 (1.07) (18)	0.045 (1.14) (18)
18.0 (45.7) 20.0 (50.8)	Not limited 25.0 (63.5)	27.0 (68.6) 29.0 (73.7)	Not limited 36.0 (91.4)	0.053 (1.35) (16)	0.056 (1.42) (16)
22.0 (55.9) 25.0 (63.5)	Not limited 31.0 (78.7)	33.0 (83.8) 35.0 (88.9)	Not limited 43.0 (109.2)	0.060 (1.52) (15)	0.063 (1.60) (15)
25.0 (63.5) 29.0 (73.7)	Not limited 36.0 (91.4)	39.0 (99.1) 41.0 (104.1)	Not limited 51.0 (129.5)	0.067 (1.70) (14)	0.070 (1.78) (14)
33.0 (83.8) 38.0 (96.5)	Not limited 47.0 (119.4)	51.0 (129.5) 54.0 (137.2)	Not limited 66.0 (167.6)	0.080 (2.03) (13)	0.084 (2.13) (13)
42.0 (106.7) 47.0 (119.4)	Not limited 59.0 (149.9)	64.0 (162.6) 68.0 (172.7)	Not limited 84.0 (213.4)	0.093 (2.36) (12)	0.097 (2.46) (12)
52.0 (132.1) 60.0 (152.4)	Not limited 74.0 (188.0)	80.0 (203.2) 84.0 (213.4)	Not limited 103.0 (261.6)	0.108 (2.74) (11)	0.111 (2.82) (11)
63.0 (160.0) 73.0 (185.4)	Not limited 90.0 (228.6)	97.0 (246.4) 103.0 (261.6)	Not limited 127.0 (322.6)	0.123 (3.12) (10)	0.126 (3.20) (10)

a
A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: (1) single sheet with single formed flanges (formed edges), (2) a single sheet which is corrugated or ribbed, and (3) an enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

d
Sheet metal for an enclosure intended for outdoor use shall comply with paragraphs 65.6 and 65.7.

TABLE 5.2
MINIMUM THICKNESS OF SHEET METAL FOR ENCLOSURES, ALUMINUM, COPPER, OR BRASS

Without Supporting Frame[a]				With Supporting Frame or Equivalent Reinforcing[a]					
Maximum Width[b] In		Maximum Length[c] In		Maximum Width[b] In		Maximum Length In		Minimum Thickness	
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	In Inches (mm)	AWG
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	22
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	20
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	18
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	16
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	14
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	12
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	10
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	8
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	6
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)	

a
A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: (1) single sheet with single formed flanges (formed edges), (2) a single sheet which is corrugated or ribbed, and (3) an enclosure surface loosely attached to a frame, for example, with spring clips.

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

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

d
Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall be at least 0.029 inch (0.74 mm) in thickness.

5.26 With reference to item (1) of paragraph 5.25, the surface of an enclosure which will be protected from damage, such as by being mounted against a duct, may be not less than No. 22 MSG or GSG (steel) or No. 18 AWG (aluminum, copper, or brass) unless a lesser thickness would be acceptable in accordance with Tables 5.1 and 5.2. See paragraphs 5.4 and 5.18.

5.27 With reference to item (2) of paragraph 5.25, the surface of an enclosure may be two gage sizes less than indicated in Tables 5.1 and 5.2 if the electrical components are located at least 2-1/2 inches (64 mm) from the surface, and may be four gage sizes less if the components are located at least 5 inches (128 mm) from the surface. The thickness is not to be less than No. 22 MSG or GSG (steel) or No. 18 AWG (aluminum, copper, or brass) unless a lesser thickness would be acceptable in accordance with Tables 5.1 and 5.2. See paragraphs 5.4 and 5.18. An example of two gage sizes less is No. 18 MSG instead of No. 16 MSG. An example of four gage sizes less is No. 20 MSG instead of No. 16 MSG.

5.28 With reference to item (3) of paragraph 5.25, consideration is to be given to the degree of deflection or distortion which may affect the objectives contemplated by the requirements of paragraph 5.1.

5.29 The enclosure of a heater shall prevent molten metal, burning insulation, flaming particles, or the like, from falling onto flammable materials, including the surface upon which the heater is supported.

5.30 All intended mounting positions of the unit are to be considered when determining if it complies with the requirement in paragraph 5.29. An air filter is not considered to be a part of the enclosure under this requirement.

5.31 The requirement in paragraph 5.29 necessitates use of a barrier of noncombustible material:

A. Under a motor unless:

1. The structural parts of the motor or of the heater provide the equivalent of such a barrier,

2. The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the heater when the motor is energized under each of the following fault conditions:

a. Open main winding

b. Open starting winding,

c. Starting switch short-circuited,

d. Capacitor shorted (permanent split capacitor type), or

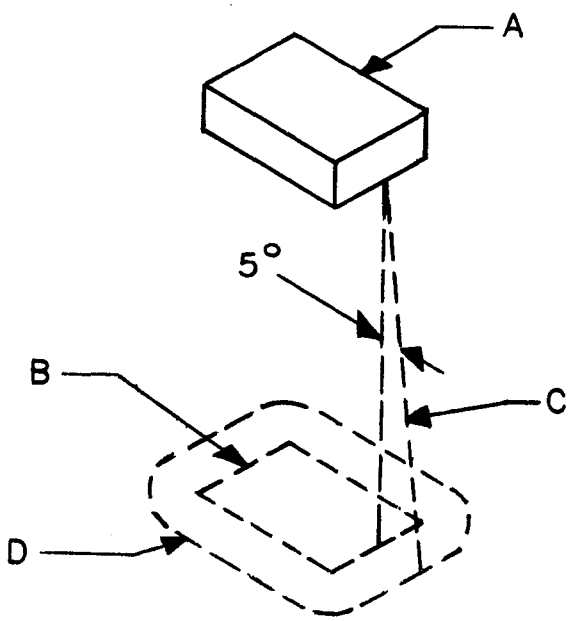
3. The motor is provided with a thermal protector (a protective device that is sensitive to both temperature and current) that will prevent the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load under which the motor will run without causing the protector to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

B. Under wiring, unless it is of the flame retardant type. Neoprene, asbestos, or thermoplastic insulated wires are considered to be of this type.

It will also necessitate that a switch, transformer, relay, solenoid, or the like, be individually and completely enclosed except at terminals, unless it can be shown that failure of the component would not result in a risk of fire, or unless there are no openings in the bottom of the enclosure. An opening in the bottom of the enclosure is not acceptable if it is located directly below field or factory made splices or overload or overcurrent protective devices.

5.32 The barrier mentioned in paragraph 5.31 shall be horizontal, shall be located as indicated in Figure 5.1, and shall have an area not less than described in that illustration. Openings for drainage, ventilation, and the like, may be employed in the barrier, provided that such openings would not permit molten metal, burning insulation, or the like, to fall on combustible material.

FIGURE 5.1
LOCATION AND EXTENT OF BARRIER



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A — Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded, and will consist of the unshielded portion of a component which is partially shielded by the component enclosure or equivalent. B — Projection of outline of component on horizontal plane. C — Inclined line which traces out minimum area of barrier. When moving, the line is always (1) tangent to the component, (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 that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

6. Protection of Service Personnel

6.1 An uninsulated high-voltage live part and a moving part within the cabinet shall be located, guarded or enclosed so as to reduce the risk of injury as the result of contact by service personnel performing mechanical service functions that may have to be performed with the equipment energized. See paragraphs 6.2—6.4.

6.2 Mechanical service functions which may have to be performed with the equipment energized include: (1) adjusting the setting of temperature or pressure controls with or without marked dial settings, (2) resetting control trip mechanism, (3) operating manual switches, and (4) adjusting air-flow dampers. A factory set and sealed control is not considered to be adjustable.

6.3 Live parts disconnected by an interlock switch, including a circuit breaker, operated by an actuator that must be placed in the off position before the cover giving access to the live parts can be opened are exempted from the requirements in Section 6 if:

A. The interlock feature of the switch is not likely to be accidentally rendered ineffective, and

B. The live parts are related to components involving service functions that need not be performed with the equipment energized. Such service functions include replacing a fuse, resetting a circuit breaker, adjusting an adjustable pneumatic-electric control, or resetting a manual reset limit control, but do not include adjusting an adjustable air flow switch.

6.4 The requirements of paragraph 6.1 are not applicable to mechanical service functions which are not intended to be performed with the equipment energized. Such functions include adjusting or replacing drive belts, replacing components, and the like.

6.5 Adjustable or resettable electrical control or manual switching devices, including circuit breakers, may be located or oriented with respect to uninsulated high-voltage live parts or moving parts likely to cause injury to persons 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 likely to cause injury to persons are (1) not located in front (in the direction of access) of the mechanism, and (2) not located within 6 inches (152 mm) on any side or behind the mechanism, unless guarded.

Exception: Live parts integral to a switching device that can be reset or adjusted without opening a door or cover serving to enclose these parts need not comply with item (2).

Revised paragraph 6.5 effective October 18, 1988

6.6 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 servicemen to the risk of electric shock or injury from adjacent uninsulated live parts or moving parts.

6.7 Accessibility and protection from the risk of electric shock and accident may be obtained by mounting the control components in an assembly so that unimpeded access is provided to each component through an access cover or panel in the outer cabinet and the cover of the control assembly enclosure with the following arrangement. See Figure 6.1.

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

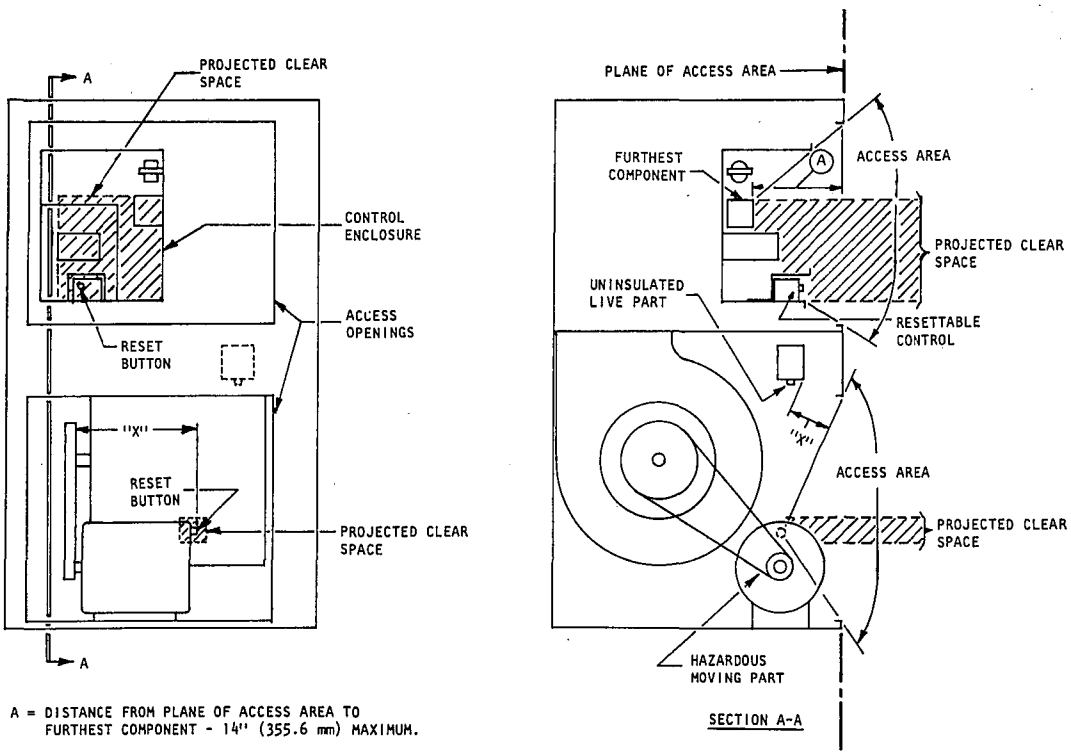
B. Uninsulated high-voltage live parts outside the control assembly projected clear space, except for live parts within a control panel or unguarded moving parts likely to cause injury to persons, are located not closer than 6 inches (152 mm) from any side of the access area. The projected clear space 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 of 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 paragraph 6.5.

FIGURE 6.1
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" (152.4 mm) MINIMUM.

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6.8 Component or control assemblies which may be rotated or otherwise displaced for service may also be acceptable provided the electrical control components are accessible for service as indicated by paragraph 6.6.

6.9 Other arrangements or location of components and/or guarding are also acceptable where electrical control components are accessible for service as indicated by paragraph 6.6.

6.10 Except as indicated in paragraph 6.11, the electrical components referred to in paragraphs 6.6—6.9 include the following: fuses; adjustable or resettable overload relays; manual or magnetic motor controllers; magnetically operated relays; adjustable or resettable temperature controllers; manual switching devices; clock timers; and incremental voltage-tap and motor-speed tap terminals for variable-speed motors. Such components in a low-voltage circuit, see paragraph 2.2, are to comply with the requirements for paragraph 6.6 in their relation to uninsulated live parts in a high-voltage circuit, see paragraph 2.3, and to moving parts likely to cause injury to persons.

6.11 Under certain conditions, some of the components referred to in paragraph 6.10 are not required to be accessible for service as follows: (1) nonadjustable magnetic motor controllers or magnetically operated relays which are inaccessible for service while energized because they are located behind subbases or the equivalent and are not visible when the access panel or panels are removed; and (2) incremental voltage taps or motor speed taps for variable speed motors which require contact with uninsulated live parts of the voltage or speed tap to effect the speed or voltage change, such as uninsulated screw or quick-connect terminals.

6.12 The following are not considered to be uninsulated live parts: (1) coils of controllers, relays and solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps; (2) enclosed motor windings, (3) terminals and splices with insulation, and (4) insulated wire.

7. Materials in Air-Handling Compartments

7.1 Materials in a compartment handling conditioned 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 Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723, except that this requirement does not apply to the following:

A. Air filters, drive belts, wire insulation, paint as applied for corrosion protection, and tubing of material equivalent to one of the types of wire insulation permitted by this standard.

B. Gaskets forming air or water seals between metal parts.

C. Miscellaneous small parts, such as bushings or resilient or vibration mounts, wire ties, clamps, labels, and drain line fittings with an exposed surface area not exceeding 25 square inches (0.016 m^2).

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

E. Molded or formed components (not liners) made of polymeric materials in such quantity that the total exposed surface area of such components in the compartment does not exceed 10 square feet (0.93 m^2). See paragraph 7.9.

7.2 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.

7.3 Thermal or acoustic insulation shall be of such nature and so located and mounted or supported that it will not be adversely affected by any intended operation of the heater. See paragraph 31.11.

7.4 Thermal or acoustic insulating material shall be securely positioned if (1) loosening may reduce or block air flow to cause temperatures in excess of those acceptable in the temperature tests or (2) if 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.

7.5 A mechanical fastener for each square foot (0.093 m^2) of exposed surface is considered to securely position insulating liners in compliance with paragraph 7.4. 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. Rigid or semirigid sheets of insulating material do not require fastening to the extent needed for less rigid material or protection of leading edges.

7.6 An adhesive provided to secure insulating material to comply with paragraph 7.4 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 minus 17.8°C (0°F) for indoor use equipment, or minus 28.9°C (minus 20°F) for outdoor use equipment.

7.7 Combustible or electrically conductive thermal or acoustic insulation shall not make contact with uninsulated live parts of a heater.

7.8 Some types of mineral wool insulation contain conductive impurities in the form of slag which precludes its use if in contact with uninsulated live parts.

7.9 Polymeric materials exempted by item E of paragraph 7.1 shall not have a flame spread rating exceeding 25 or shall comply with the flammability test requirements of paragraphs 7.10—7.13.

7.10 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 (12.7 by 127 mm).

7.11 The test flame is to be obtained by means of a Tirrill 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) high. The area in which the test is to be conducted is to be shielded from drafts.

7.12 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.

7.13 An essentially identical set of samples is to be placed in an oven having forced circulation of air maintained at the conditions shown in Table 7.1 for 1440 hours. Samples shall be removed from the oven at the end of 30 and 60 days of exposure and subjected to the flammability test, paragraph 7.12. If there is evidence of progressive deterioration, an additional sample is to be tested after 90 days of exposure. The samples shall comply with the requirements of the flammability test, see paragraph 7.12.

TABLE 7.1
AGING TEMPERATURES

Maximum Operating Temperature Degrees C (F)[a]	Aging Temperature Degrees C (F)
50 (122)	75 (167)
75 (167)	100 (212)
100 (212)	121 (250)

a This temperature includes the maximum temperature measured after the first hour of any applicable abnormal tests. If normal operating temperature is between two values shown in the table, the higher of these two values is used in determining the aging conditions.

8. Field Wiring Connections

General

8.1 A heater shall have provision for the connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70—1984, would be acceptable for the appliance.

Paragraph 8.1 revised July 16, 1986

8.2 The location of a field wiring compartment in which power supply connections are to be made shall be such that these connections may be readily inspected after the heater is installed as intended.

8.3 A field wiring compartment for the connection of a supply raceway and intended to be rigidly attached to the heater shall be so secured as to be prevented from turning with respect to the heater.

8.4 The wiring of the heater may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the heater to the wiring system specified in paragraph 8.1. Unless the conduit is terminated in an outlet box no larger than 4 by 4 by 2 inches (102 by 102 by 51 mm) for splice connection, locknuts on the fittings are not considered to be an acceptable means for reducing the risk of loosening of the conduit fittings. A grounding conductor of the size specified by the National Electrical Code, ANSI/NFPA 70—1984, shall be included unless:

A. The total length of the flexible metal conduit of any ground return path in the product does not exceed 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 are identified as providing grounding.

Paragraph 8.4 revised July 16, 1986

8.5 A knockout or opening for connection of a field wiring system to a field wiring compartment shall accommodate a conduit of the trade size determined by applying Table 8.1.

8.6 An opening for the entry of a conductor or conductors in a low-voltage circuit as described in paragraph 2.2 shall be provided with an insulating bushing. The bushing may be mounted in place in the opening or may be provided with the enclosure so that it may be mounted when the equipment is installed.

Exception: An insulating bushing need not be provided if:

A. A wiring assembly for low-voltage control is furnished with the equipment, and

B. The edges of the opening will not abrade the insulation on the wiring assembly, and

C. The insulation between any conductor of the wiring assembly and edges of the opening is at least 3/64 inch (1.2 mm) thick.

8.7 A bushing of rubber or rubber-like material provided in accordance with paragraph 8.6 shall be 1/8 inch (3.2 mm) or more in thickness, except that it may be not less than 3/64 inch (8.6 mm) minimum thickness if the metal around the hole is eyeletted or treated to ensure smooth edges. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, or projections.

Leads and Terminals

8.8 For the purpose of these requirements, field wiring terminals (or leads) are considered to be the terminals (or leads) to which power supply, control, or equipment grounding connections will be made in the field when the heater is installed. It is to be assumed that 60°C (140°F) wire will be used for connections requiring an ampacity of 100 amperes or less and that 75°C (167°F) wire will be used for connections requiring an ampacity of more than 100 amperes, even if such wire would not be necessary because of the temperatures measured in the temperature test. See paragraph 43.9.

TABLE 8.1
TRADE SIZE OF CONDUIT IN INCHES[a,b]

Wire Size	Number of Wires				
	2	3	4	5	6
AWG (mm^2)					
14 (2.1)	1/2	1/2	1/2	1/2	1/2
12 (3.3)	1/2	1/2	1/2	3/4	3/4
10 (5.3)	1/2	1/2	1/2	3/4	3/4
8 (8.4)	3/4	3/4	1	1	1-1/4
6 (13.3)	3/4	1	1	1-1/4	1-1/4
4 (21.2)	1	1	1-1/4	1-1/4	1-1/2
3 (26.7)	1	1-1/4	1-1/4	1-1/2	1-1/2
2 (33.6)	1	1-1/4	1-1/4	1-1/2	2
1 (42.4)	1-1/4	1-1/4	1-1/2	2	2
0 (54.0)	1-1/4	1-1/2	2	2	2-1/2
2/0 (67.4)	1-1/2	1-1/2	2	2	2-1/2
3/0 (85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0 (107.2)	2	2	2-1/2	2-1/2	3
MCM					
250 (127)	2	2-1/2	2-1/2	3	3
300 (152)	2	2-1/2	3	3	3-1/2
350 (177)	2-1/2	2-1/2	3	3-1/2	3-1/2
400 (203)	2-1/2	3	3	3-1/2	4
500 (253)	3	3	3-1/2	4	4

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 Specification for Zinc-Coated Rigid Steel Conduit, ANSI C80-1.

8.9 A heater or remote control assembly shall be provided with field wiring terminals or leads for connection to the field wired conductors as follows:

A. Except as indicated in paragraphs 8.15 and 8.16, each such terminal or lead shall be adequate for connection of a conductor having an ampacity, according to the National Electrical Code, ANSI/NFPA 70—1984, no less than 125 percent of the rated current at the terminal or lead. If a single conductor larger than No. 600 MCM (304 mm^2) is required, the product shall have provision for the connection of conductors in parallel; and

B. Except as indicated in paragraphs 8.13 and 43.2, if such rating is 24 amperes or less, the terminal or lead shall be acceptable for connection of a No. 10 AWG (5.3 mm^2) copper conductor and shall also be adequate for connection of a No. 8 AWG (8.4 mm^2) aluminum conductor if the equipment is intended to be field connected with aluminum conductors.

Exception: Other means, such as quick-connect terminals or mating connectors, may be utilized for field wiring connections of conductors of Class 2 low-voltage circuits if:

A. (1) The connection means are part of a wiring assembly furnished with the equipment, or (2) if more than one type of identified wiring assembly is available from the equipment manufacturer and the equipment is marked at or near the connection point to specify the wiring assemblies to be used; and

B. The wiring assemblies do not require cutting, splicing, or similar alterations for field connection on the equipment; and

C. Installation instructions furnished with the equipment clearly indicate the use of the wiring assembly.

Paragraph 8.9 revised January 30, 1988

8.10 A field wiring terminal of a heater or remote control assembly, which is marked as being acceptable for either copper or aluminum (and/or copper-clad aluminum) conductors as indicated in paragraph 43.13, shall be adequate for connection of both copper and aluminum conductors of the sizes determined in accordance with paragraph 8.9.

8.11 Except as indicated in paragraph 8.12, a lead for connection of field wiring shall be no more than two standard wire sizes smaller than the branch circuit power supply or control circuit conductor (copper) to which it will be connected, and, except as indicated in paragraphs 8.13, 8.15, and 43.2, shall be no smaller than No. 14 AWG (2.1 mm^2) copper in any case.

8.12 The lead described in paragraph 8.11 may be more than two wire sizes smaller than the field-provided conductor (copper) to which it will be connected but not smaller than No. 18 AWG (0.82 mm^2) if more than one factory-provided copper lead is intended for connection to the same field-provided lead, and the construction meets the following conditions:

A. The wire connector for the splice connection to the field provided wire is provided as part of the unit or remote control assembly, and the wire connector is recognized for the combination of wires which will be spliced.

B. A marking is included indicating that the provided wire connector is to be used for the field wiring splice connection. The marking is to be plainly visible in the field wiring area during installation and inspection. See also paragraph 43.13.

C. The factory provided leads are grouped in a manner to prevent stress in an individual lead.

8.13 Equipment rated 16 amperes or less, which is not acceptable for connection of No. 10 AWG (5.3 mm^2) copper power supply conductors and such equipment intended for field connection with aluminum conductors shall be suitable for connection to a 15 or 20 ampere branch circuit, as appropriate for the rating of the equipment, and shall be marked in accordance with paragraph 43.2.

8.14 In determining the size of the power supply conductors in equipment intended for connection to multiple power supplies and in which it is likely that more than six such conductors will occupy the same raceway, the additional ampacity deratings given in the National Electrical Code, ANSI/NFPA 70—1984, shall be applied.

Paragraph 8.14 revised July 16, 1986

8.15 With reference to paragraph 8.9, a terminal for field connection of a control circuit conductor is acceptable if it is suitable for the connection of No. 14 AWG (2.1 mm^2) copper conductor, except that such a terminal in a low-voltage circuit, as defined in paragraph 2.2, is acceptable if it is suitable for connection of a No. 16 AWG (1.3 mm^2) or No. 18 AWG (0.82 mm^2) copper conductor. With reference to paragraph 8.11, a lead for field connection of a control circuit conductor may be No. 16 AWG or No. 18 AWG copper.

Paragraph 8.15 revised January 30, 1988

8.16 With reference to item A of paragraph 8.9, each terminal or lead shall be adequate for connection of a conductor having an ampacity, according to the National Electrical Code, ANSI/NFPA 70—1984, no less than 100 percent of the rated current at that terminal or lead provided:

A. The rated load at the terminal or lead is 500 kilowatts or more,

B. The minimum conductor size is marked. See paragraph 42.7, and

C. The heater element circuits connected to the terminal or lead specified in item A are subdivided (see paragraph 18.1) and are arranged to be controlled by a temperature-actuated device(s) so that continuous simultaneous operation of all the element circuits is not the normal operating condition.

Paragraph 8.16 revised July 16, 1986

8.17 With reference to item C of paragraph 8.16, arrangements, such as (1) two or more temperature-regulating controls (room thermostats), (2) a temperature-regulating control with two or more stages, or (3) a single stage temperature-actuated proportioning control, are considered as precluding continuous simultaneous operation of all the element circuits as a normal operating condition.

8.18 Leads provided for connection 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 unless (1) the screws or connectors are rendered unusable for field wiring connections, or (2) the leads are insulated at the unconnected ends and a marking on the unit clearly indicates the use of these leads.

8.19 The free end of any lead that may not be used in every installation (such as an equipment grounding lead) shall be insulated if that end could reduce spacings below the minimum acceptable values indicated in Section 28.

8.20 It is assumed that wire with a temperature rating in accordance with the marking will be used for the power supply conductors if the heater is marked in accordance with paragraph 43.9.

8.21 Except as indicated in paragraph 8.23, a field wiring terminal or lead for connection of an equipment grounding conductor shall be provided as follows:

A. The equipment grounding terminal or lead shall be located in the field wiring compartment and shall be identified in accordance with paragraphs 8.35 and 8.37.

B. The equipment grounding terminal or lead shall be acceptable for connection of an equipment grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70—1984, Table 250-95, based on the size of the overcurrent device protecting the circuit.

C. If more than one circuit is to be connected to the equipment, the terminal or lead provided for field connection of an equipment grounding conductor shall be adequate for connection of a separate grounding conductor for each circuit.

D. If there is provision for connection of two or more power supply conductors in parallel at each terminal as mentioned in item A of paragraph 8.9, provision shall be made for connection of an equal number of equipment grounding conductors. The size of each of these equipment grounding conductors shall conform with item B above, except that it need be no larger than one of the power supply conductors.

Item B of paragraph 8.21 revised July 16, 1986

8.22 With reference to items C and D of paragraph 8.21, an individual terminal or lead for each field wired equipment grounding conductor may be provided. A single terminal for connection of all such conductors may be employed if recognized for the application. A lead for connection of an equipment grounding conductor may serve for connection of more than one circuit.

8.23 The equipment grounding terminal or lead mentioned in paragraph 8.21 is not required for a low-voltage (National Electrical Code, ANSI/NFPA 70—1984 — Class 2) control circuit connection, and may be omitted for a high-voltage circuit connection if:

A. The rating of the product is such that the power supply conductors are likely to be larger than No. 2 AWG (33.6 mm^2), see paragraph 8.24;

B. The construction is such that a recognized terminal can be installed in the field, that is, the terminal can be secured as intended without a drilling or cutting operation upon installation, and space for the equipment grounding conductor is provided; and

C. The product is marked as required in paragraph 43.20.

Paragraph 8.23 revised July 16, 1986

8.24 With reference to item A in paragraph 8.23, a field wiring power supply conductor is likely to be larger than No. 2 AWG (33.6 mm^2) if:

A. The marked minimum circuit ampacity for the circuit under consideration is more than 95.5 amperes (for copper conductors) or 75.5 amperes (for aluminum or copper-clad aluminum conductors).

B. A minimum circuit ampacity is not required to be marked (see paragraph 42.6) and if the rated current is more than 76.4 amperes (for copper conductors) or more than 60.4 amperes (for aluminum or copper-clad aluminum conductors), or

C. Any marking on the product indicates use of a conductor larger than No. 2 AWG (33.6 mm^2). See paragraph 43.13.

Paragraph 8.24 revised January 30, 1988

8.25 A field wiring terminal shall be provided with a pressure terminal connector securely fastened in place (for example, bolted or held by a screw).

Exception No. 1: A wire binding screw may be employed at a field wiring terminal intended to accommodate a No. 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

Exception No. 2: A soldering lug may be used in place of a pressure terminal connector on a field wiring terminal intended for connection of other than an equipment grounding conductor.

Replaces page 19 dated July 16, 1986

8.26 A field wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

8.27 A wire binding screw at a field wiring terminal shall be not smaller than No. 10 (4.8 mm diameter) except that a No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm^2) conductor and a No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 16 AWG (1.3 mm^2) or No. 18 AWG (0.82 mm^2) control-circuit conductor.

8.28 It should be noted that according to the National Electrical Code, ANSI/NFPA 70—1984, No. 14 AWG (2.1 mm^2) is the smallest conductor that may be used for branch circuit wiring, and this is the smallest conductor that may be anticipated at a terminal for the connection of a power supply wire.

Paragraph 8.28 revised January 30, 1988

8.29 A terminal plate tapped for a wire binding screw shall be of metal no less than 0.050 inch (1.27 mm) in thickness, except that a plate no less than 0.030 inch (0.76 mm) in thickness is acceptable if the tapped threads have adequate mechanical strength. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

8.30 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned either in paragraph 8.9 or 8.13, but no smaller than No. 14 AWG (2.1 mm^2), or in paragraph 8.33, whichever is applicable, under the head of the screw or the washer.

8.31 A wire binding screw shall thread into metal.

8.32 A heater or remote control assembly provided with field wiring terminals or leads and intended to be connected to a grounded power supply conductor shall have one terminal or lead identified for the connection of that conductor if necessary because of the requirement in paragraph 21.4, 24.1, 25.3, or 26.2.

8.33 A field wiring terminal for the connection of the grounded conductor shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or identification of the terminal for connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

8.34 A lead provided for connection of a grounded conductor shall be finished to show a white or natural gray color and no other leads, other than grounded conductors, shall be so identified. See paragraph 8.36.

8.35 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green with or without one or more yellow stripes, and except as indicated in paragraph 8.36, no conductor not connected to that lead shall be so identified.

8.36 The requirements in paragraphs 8.34 and 8.35 relating to color coding of a lead apply to internal wiring that is visible in a wiring compartment in the area in which field connections are to be made. These requirements do not apply to leads or wiring of low-voltage circuits intended to be field connected to Class 2 wiring and which are separated or segregated from high-voltage circuit field wiring connections by barriers.

8.37 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified, such as by being marked G, GR, GND, GROUND, GROUNDING, or the like, or by a marking on a wiring diagram provided on the heater. The wire binding screw or pressure wire connector shall be so located that it is unlikely to be removed during the servicing of the heater and shall have upturned lugs or the equivalent to retain the conductor.

8.38 Except as noted in paragraph 8.39, the free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

8.39 The lead may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead may result in a risk of fire or electric shock.

9. Internal Wiring

General

9.1 The internal wiring of a heater shall consist of wires of acceptable size (as determined by the performance tests in this standard) that are rated for the particular application when considered with respect to (1) the temperature and voltage to which the wiring is likely to be subjected, (2) its exposure to oil or grease, and (3) to other conditions of service to which it may be subjected. Determination of the acceptability of the size of wiring shall include consideration of mutual heating of adjacent conductors that are bundled together in the unit.

Paragraph 9.1 revised July 16, 1986

9.2 For the purpose of these requirements, the internal wiring of a heater is considered to be all the interconnecting wiring beyond the wiring terminals or leads for field wiring connections even though some of it (1) may not be completely enclosed, or (2) may be in the form of flexible cord.

9.3 No temperature limit is applicable to a conductor (except as noted in Table 31.2) provided with beads of noncarbonizable material or the equivalent.

9.4 Insulated wire employed for internal wiring shall be standard building wire, fixture wire, flexible cord, or appliance wiring material acceptable for the particular application. Unimpregnated asbestos insulated wire shall not be used. See paragraphs 2.2—2.4 and 9.5—10.13.

9.5 Building wires acceptable for internal wiring include rubber insulated conductors, such as Types RH, RHH, and RHW; thermoplastic insulated conductors, such as Types T, TW, THHN, THW, THWN, and MTW; and impregnated asbestos insulated conductors, such as Types A, AA, AI, and AIA.

9.6 Fixture wires acceptable for internal wiring include rubber insulated conductors, such as Types RF-2, RFH-2, SF-2, SFF-2, FF-2, and FFH-2 and thermoplastic insulated conductors, such as Types TF, TFF, TFN, and TFFN.

9.7 Flexible cords acceptable for internal wiring include Types HPN, HS, HSJ, HSJO, HSO, S, SJ, SJO, SJT, SJTO, SO, ST, STO, SP-2, SP-3, SPT-2, and SPT-3.

9.8 Appliance wiring material having thermoplastic insulation no less than 2/64 inch (0.8 mm) thick for No. 18—10 AWG (0.82—5.3 mm^2), 3/64 inch (1.2 mm) thick for No. 8 AWG (8.4 mm^2), and 4/64 inch (1.6 mm) thick for No. 6—2 AWG (13.3—33.6 mm^2) is acceptable for internal wiring.

9.9 Appliance wiring material having rubber, neoprene, or thermoplastic insulation with properties equivalent to the jacket of Type SJ, SJO, SJTO, or SJT cord, with an insulation thickness no less than 4/64 inch (1.59 mm) for No. 18—16 AWG (0.82—1.3 mm^2), 5/64 inch (1.93 mm) for No. 14—10 AWG (2.1—5.3 mm^2), is acceptable for internal wiring where permitted by paragraph 9.17.

9.10 Wiring which may be subject to moisture, such as from an air conditioner evaporator coil, shall be of a type which is rated for use in moist locations.

Methods

9.11 The wiring and connections between parts of a heater shall be protected or enclosed, except that a length of recognized flexible cord may be employed for external interconnections, or for internal connections that may be exposed during servicing, if flexibility of the wiring is essential.

9.12 Internal wiring that is exposed through an opening in the enclosure of a heater is considered to be protected as required in paragraph 9.11 if, when judged as though it were enamel insulated wire, the wiring would be acceptable according to paragraphs 15.2—15.4. Internal wiring within an enclosure is acceptable, even though it can be touched with the probe, if it is so protected or guarded that it cannot be grasped or hooked in a manner that would subject the wire to stress.

9.13 If the wiring of a heater is so located that it may be in proximity to combustible material or may be subjected to physical damage, it shall be in metal-clad cable, rigid metal conduit, electrical metallic tubing, metal raceway, or shall otherwise be equivalently protected.

9.14 Except as indicated in paragraphs 9.15—9.17, wiring in a compartment through which air, to or from the heated space, is circulated shall be in metal-clad cable, rigid metal conduit, electrical metallic tubing, metal raceway, or shall otherwise be equivalently protected.

9.15 The requirement in paragraph 9.14 does not apply to wiring in a furnace control compartment through which bypass air is circulated; that is, a portion of the total air that is taken from within the unit, passed through openings in the compartment, and returned within the unit. The total area of openings for bypass air in any surface of a control compartment shall not exceed 10 percent of the total area of that surface.

9.16 Lengths, not exceeding 4 inches (102 mm), except as noted in paragraph 9.17, of unenclosed wiring of the types mentioned in paragraphs 9.5, 9.6, and 9.8, or equivalent, may be employed where enclosed within the heater cabinet and where supported to prevent damage from air movement.

9.17 Flexible cords, Type SJO, SJT, SJTO, SO, ST, STO, or SPT-3, or equivalent appliance wiring material, see paragraph 9.9, without limitation on length, may be employed when protected as described in paragraph 9.16.

9.18 Wiring shall be protected from sharp edges (including male screw threads), burrs, fins, moving parts, and other features that might abrade the insulation on conductors.

9.19 A hole by means of which insulated wires pass through a sheet metal wall within the overall enclosure of a heater shall be provided with a smooth, rounded bushing, or shall have smooth, rounded surfaces upon which the wires may bear. A flexible cord used for external interconnection as mentioned in paragraph 9.11, shall be provided with bushings and strain relief in accordance with paragraphs 9.22—9.25, unless the construction is such that the cord will be protected from stress or motion.

9.20 If relative motion between asbestos insulated wire and the metal surrounding the opening through which the wire passes is likely because of expansion and contraction of the metal, resulting from changes in temperature, the openings shall be fitted with an insulating bushing or the equivalent.

9.21 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of a heater.

9.22 Strain relief shall be provided to prevent a mechanical stress on a flexible cord from being transmitted to terminals or splices.

9.23 Means shall be provided to prevent a flexible cord from being pushed into the enclosure through the cord entry hole if such displacement is likely to subject the cord to mechanical damage or to expose the cord to a temperature higher than that for which it is rated, or if it is liable to reduce spacings, such as to a metal strain-relief clamp, below the minimum acceptable values.

9.24 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a standard bushing or the equivalent that shall be secured in place, and shall have a smooth, rounded surface against which the cord may bear. The heat and moisture resistant properties of the bushing material shall be rated for the particular application. See paragraph 9.25.

9.25 A smoothly rounded hole in the wall or barrier is acceptable in lieu of a separate bushing.

9.26 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.

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

9.28 Insulation consisting of two layers of friction tape, or two layers of thermoplastic tape, or of one layer of friction tape wrapped over one layer of rubber tape is acceptable on a splice. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, and heat resistant and moisture resistant characteristics. Thermoplastic tape wrapped over a sharp edge is not acceptable.

9.29 The means of connecting stranded internal wiring to a wire binding screw shall be such that loose strands of wire will be prevented from contacting other live parts not always of the same polarity as the wire 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, or other equivalent means.

10. Separation of Circuits

10.1 Conductors of different circuits in internal wiring, including insulated wires in a wiring compartment, shall be either (1) provided with insulation rated for the highest voltage involved, or (2) shall be separated by a barrier or otherwise spaced from an uninsulated live part connected to a different circuit.

10.2 Low-Voltage and high-voltage circuits, for example, are considered to be different circuits with reference to the requirement in paragraph 10.1.

10.3 Spacing of insulated conductors may be accomplished by clamping, routing, or an equivalent means that provides permanent separation from insulated and uninsulated live parts of a different circuit.

10.4 Except as noted in paragraphs 10.5, 10.6, 10.9, and 10.10, barriers shall be provided to separate conductors that will be field installed from:

A. Conductors of any other circuit that will be field installed.

B. Conductors of any other circuit that are factory installed,

C. Uninsulated live parts of any other circuit, and

D. Uninsulated live parts of the same circuit, if unsafe operation can result from short circuiting of the live parts.

10.5 The barriers required by items A and B of paragraph 10.4 may be omitted if the conductors involved are, or will be, insulated for the maximum voltage of either circuit.

10.6 The barriers required by items C and D of paragraph 10.4 may be omitted if the field installed conductors are rated for use in a National Electrical Code — Class 1 system. See paragraph 43.7.

10.7 With respect to items A and B of paragraph 10.4 a removable barrier, or one having openings for the passage of conductors, may be employed provided instructions for the use of the barrier are given in a permanent manner on the heater.

10.8 If complete instructions, in conjunction with a wiring diagram, will provide for the separation of the high-voltage and low-voltage circuits, the barrier mentioned in paragraph 10.7 may, upon investigation, be omitted.

10.9 Segregation of field installed conductors from other field installed conductors and from uninsulated live parts of the heater connected to different circuits may be accomplished by arranging the location of the opening 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 the recognized method of wiring of the heater and if each such opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with paragraph 10.4 that the conductors entering an opening will be connected to the terminals opposite that 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.

C. To determine if a heater complies with the requirement in paragraph 10.4, 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 in the wiring compartment.

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

10.11 A metal barrier shall have a thickness of at least 0.026 inch (0.66 mm) if uncoated steel, 0.029 inch (0.74 mm) if galvanized steel, and 0.036 inch (0.91 mm) if nonferrous metal. A barrier of insulating material shall be no less than 0.028 inch (0.71 mm) and shall be of greater thickness if its deformation may be accomplished so as to defeat its purpose.

Exception: The thickness of a metal barrier need be no more than that required if it were part of an enclosure.

10.12 The output of a transformer device supplying a National Electrical Code — Class 2 low-voltage circuit, see paragraph 2.2, shall not be interconnected with the output of another such transformer device provided as part of the equipment unless the voltage and current measurements at the output terminals of the interconnected devices do not exceed the limits for a single Class 2, 30 volt or less, transformer device.

10.13 Two or more transformer devices supplying circuits classified as low-voltage circuits and provided as a part of the equipment shall be treated as separate circuits unless the devices are interconnected as permitted in paragraph 10.12. If more than one such circuit is to be field wired, the several circuits shall be segregated or separated by barriers in accordance with paragraph 10.4, and the transformer output of each circuit shall be marked to warn that the separation shall be maintained.

11. Bonding for Grounding

11.1 All exposed dead metal parts and all dead metal parts inside the enclosure that are exposed to contact during any servicing operation, including maintenance and repair, and that are likely to become energized shall be electrically connected to the equipment grounding terminal or lead, and to the metal surrounding the knockout, hole, or bushing provided for field power supply connection.

11.2 Except as indicated in paragraph 11.14, uninsulated dead metal parts of cabinets, electrical enclosures, motor frames, and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding.

11.3 A bonding conductor shall be of material acceptable for use as an electrical conductor. If of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall be of acceptable size. A separate bonding conductor or strap shall be so installed that it is protected from mechanical damage. See paragraph 9.13.

11.4 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connections, brazing, or welding. The bonding connections shall reliably penetrate nonconductive coatings, such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material, except as indicated in paragraph 11.7.

11.5 A bolted or screwed connection that incorporates a star washer or serrations under the screwhead is acceptable for penetrating nonconductive coatings where required for compliance with paragraph 11.4.

11.6 If the bonding means depends upon screw threads, then two or more screws, or two full threads of a single screw engaging metal, shall be provided to comply with the requirement in paragraph 11.4.

11.7 A connection that depends upon the clamping action exerted by rubber of similar material is acceptable if it will not open (1) when carrying twice the current equal to the rating of the branch circuit overcurrent device for the interval indicated in paragraph 11.11 and (2) during the Short Circuit Tests, Section 37, 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 likely to occur in service. The effect of assembling and disassembling such a clamping device, as for maintenance purposes, is also to be considered, with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

11.8 Metal-to-metal hinge bearing members for a door or cover are considered to be a means for bonding the door or cover for grounding if a multiple-bearing pin-type hinge(s) is employed.

11.9 The size of the conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch circuit overcurrent device by which the heater or section of the heater will be protected. Except as indicated in paragraph 11.11, the size of the conductor or strap shall be no smaller than that indicated in Table 11.1.

TABLE 11.1
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 (8.4)
40	10 (5.3)	8 (8.4)
60	10 (5.3)	8 (8.4)
100	8 (8.4)	6 (13.3)
200	6 (13.3)	4 (21.2)

[a] Or equivalent cross-sectional area.

11.10 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in paragraph 11.9 is acceptable if the cross-sectional area of the conductor is no less than that of the wire that would be required in accordance with Table 11.1.

11.11 A conductor smaller than that required in paragraph 11.9 may be used if the bonding connection and conductor do not open when carrying twice the current equal to the rating of the circuit overcurrent device for 2 minutes, if such rating is 0—30 amperes, or for 4 minutes, if such rating is 31—60 amperes, and when subjected to the Short Circuit Tests, Section 37. A bonding conductor to a motor or other electrical component need not be larger than the size of the motor circuit conductors or the size of the conductor supplying the component. See paragraph 18.10.

11.12 Splices shall not be employed in wire conductors used to bond electrical enclosures, motor frames, or other electrical components.

11.13 If more than one size 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 overcurrent protection for the component bonded by the conductor. For example, if a motor is individually protected by an overcurrent device smaller than other overcurrent devices used with the heater, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor circuit.

11.14 Metal parts as described below need not comply with the requirement in paragraph 11.2.

A. Adhesive attached metal-foil markings, screws, handles, and the like, located on an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized.

B. Isolated metal parts, such as contactor magnet frames and armatures, small assembly screws, or the like, that are positively separated from wiring and uninsulated live parts.

C. Panels and covers that do not enclose uninsulated live parts if wiring is positively separated from the panel or cover so that it is not likely to become energized.

D. Panels and covers that are insulated from electrical components and wiring by an insulated barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.79 mm) thick and securely fastened in place.

ELECTRICAL COMPONENTS

12. Mounting of Components

12.1 A switch, a lampholder, an attachment-plug receptacle, or similar component shall be mounted securely and, except as noted in paragraphs 12.2 and 12.3, shall be prevented from turning.

12.2 The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

A. The switch is to be 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 the operation of the switch.

B. The means for mounting the switch is not subject to loosening as the result of its operation,

C. The spacings are not to be reduced below the minimum acceptable values if the switch rotates, and

D. The operation of the switch is to be by mechanical means rather than direct contact by persons.

12.3 A lampholder of a 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 minimum acceptable values.

12.4 The means for preventing the turning mentioned in paragraph 12.1 is to consist of more than friction between surfaces. A toothed lock washer which provides both spring take-up and mechanical interference is acceptable as the means for preventing a small stem-mounted switch or other small device having a single-hole mounting means from turning.

12.5 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 minimum acceptable values indicated in paragraphs 28.1—28.7.

12.6 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts as required by paragraph 12.5, but a lock washer as described in paragraph 12.4 is acceptable.

13. Heating Elements

13.1 A heating element shall be supported in its intended position under conditions of use.

13.2 In determining if a heating element complies with the requirement in paragraph 13.1, consideration is to be given to sagging, loosening, and other adverse conditions resulting from (1) continuous heating of the element or, (2) flexing of the element supports or related wiring due to alternate heating and cooling of the element.

14. Electrical Insulation

14.1 Insulating washers, bushings, or the like, that are integral parts of a heater, and bases or supports for the mounting of live parts shall be of a moisture resistant material which will not be affected adversely by the temperatures to which they will be subjected under conditions of actual use. Molded parts shall be so constructed that they will have the mechanical strength and rigidity to withstand the stresses of actual service.

14.2 Insulating material is to be judged with respect to its acceptability for the particular application. Materials such as mica and porcelain are acceptable for use as the sole support of live parts; and some other materials which are not acceptable for general use, such as magnesium oxide, are acceptable if used in conjunction with other acceptable insulating materials or if so located and protected that mechanical damage is prevented and the absorption of moisture is minimized. See paragraph 36.1.

14.3 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts. Polymeric materials may be used for the sole support of uninsulated live parts, if found to have mechanical strength and rigidity, dielectric voltage withstand, resistance to heat, flame propagation, arcing, creep, and moisture, and other properties required for the application without displaying a loss of these properties beyond the minimum acceptable level as a result of aging.

14.4 In the mounting or supporting of small, fragile insulating parts, screws or other fastenings shall not be tightened as to cause cracking or breaking of these parts with expansion and contraction.

15. Uninsulated Live Parts

15.1 The requirements of paragraphs 15.2—15.8 apply only to parts of high-voltage circuits.

15.2 Electrical parts shall be located or enclosed so as to reduce the risk of contact with uninsulated high-voltage live parts.

15.3 With reference to paragraph 15.2, the ducts and plenums installed in accordance with the installation instructions provided for the heater are considered to constitute part of the enclosure for open wire heating elements.

15.4 The criteria for judging a heater enclosure opening are given in the following items and the related figures:

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

1. A probe as illustrated in Figure 15.1 cannot be made to touch any uninsulated live part when inserted through the opening, and

2. A probe as illustrated in Figure 15.2 cannot be made to touch enamel insulated wire when inserted through the opening.

B. An opening which will permit entrance of a 3/4 inch diameter rod is acceptable under the conditions described in connection with Figure 15.3.

FIGURE 15.1
PROBE

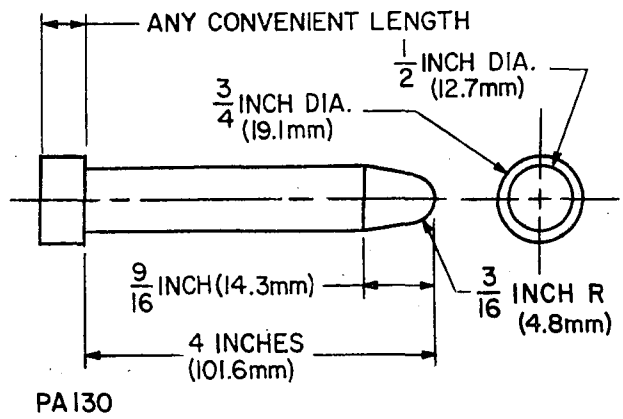
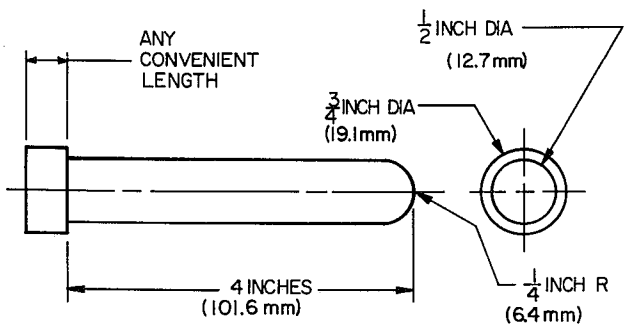


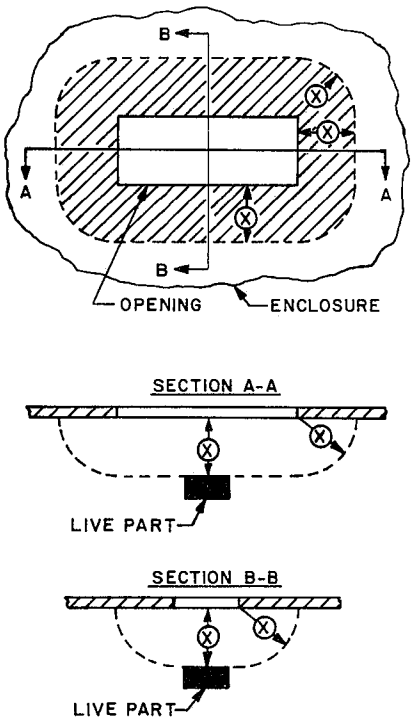
FIGURE 15.2
PROBE



PA140

FIGURE 15.3
OPENING IN ENCLOSURE

Proportions exaggerated for clarity



EC100

The opening is acceptable if, within the enclosure, there is no uninsulated high-voltage live part or film-coated wire (1) less than X distance from the perimeter of the opening, as well as (2) within the volume generated by projecting the perimeter X distance normal to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (101.6 mm). In evaluating an opening, any barrier located within the volume usually is ignored unless it intersects the boundaries of the volume in a continuous, closed line.

15.5 During the examination of a heater in connection with the requirements in paragraphs 15.1—15.4, (1) a part of the outer enclosure that may be removed or opened without the use of tools, (2) a part of the outer enclosure requiring removal by the user to allow access for making normal operating adjustments or changing air filters, and (3) an air filter are to be disregarded; that is, it will not be assumed that such parts reduce the risk of electric shock. A warning marking as specified in paragraph 43.5 is not considered to reduce the risk of electric shock.

Revised paragraph 15.5 effective October 18, 1988

15.6 A rubber or neoprene boot over the terminal of a motor capacitor that is accessible during user servicing (1) shall be no less than 1/32 inch (0.8 mm) thick, (2) shall resist thermal degradation, and (3) shall incorporate means to secure the boot in place, such as a molded lip that fits over the flange of the capacitor case.

15.7 Metal employed for a current-carrying part shall be recognized for the particular application. Plated iron or steel may be used for current-carrying parts whose temperature during intended operation is more than 100°C (212°F). Regardless of temperature attained, unplated iron or steel shall not be used but stainless steel and other corrosion resistant alloys may be used.

15.8 Ordinary iron or steel, if provided with an acceptable corrosion resistant coating, may be used for a current carrying part:

A. Within a motor or associated governor, and

B. In a control device such as a thermostat, if the part has been found suitable for use in ambient temperature in excess of 100°C (212°F).

16. Motors and Motor (Overload) Protection

16.1 A motor winding shall resist the absorption of moisture.

16.2 With reference to the requirement in paragraph 16.1, film-coated wire is not required to be additionally treated to prevent absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture absorptive materials shall be provided with impregnation or otherwise treated to prevent moisture absorption.

16.3 A fractional-horsepower motor, one having a frame diameter of 7 inches (178 mm) or less, see note a of Table 28.3, shall be protected by one of the following:

A. An integral thermal protector that provides running overload and locked rotor protection in accordance with Standard for Thermal Protectors for Motors, UL 547, or

Exception: A motor moving air only by means of a fan or blower directly attached to the motor shaft need not be provided with running overload protection.

B. An overcurrent protective device that in conjunction with the motor complies with the test requirements in Section 40, or

C. Impedance of the windings in accordance with paragraph 16.5.

16.4 For a multispeed motor that employs a separate overcurrent protective device to provide running protection, the protection is to be effective at all speeds at which the motor is intended to operate.

16.5 A motor with impedance protection that: (1) under conditions of use in the application, including such factors as elevated ambient temperatures and any restricted ventilation, complies with the requirements for impedance-protected motors, UL 519, and (2) does not generate smoke with the rotor of the motor locked under any required test condition for the equipment is considered to comply with the requirements specified in paragraph 16.3.

Exception: Compliance with item (2) is not required for equipment that is not intended to be duct connected.

16.6 An integral horsepower motor, one having a frame diameter more than 7 inches (178 mm), shall be protected by (1) an integral thermal protector that provides running overload and locked rotor protection in accordance with the Standard for Thermal Protectors for Motors, UL 547, or (2) a motor overload protective device rated or selected in accordance with the National Electrical Code, ANSI/NFPA 70—1984, except as specified in paragraph 16.7.

Paragraph 16.6 revised July 16, 1986

16.7 The overload protection of a single-speed, continuous duty blower motor having a marked rating over 1 horsepower (746 W output) need not be provided as part of a heater if all of the following conditions exist:

A. The motor is located where it is not affected by an external source of heat,

B. The motor is to be field-wired to a separate circuit that does not supply any other loads within the heater,

C. The motor overload protection is part of separate, field-provided motor control equipment that does not require wiring interconnection to the heater, except for the motor circuit (see paragraph 42.16), and

D. Energization of electric heating elements does not occur without motor operation or evidence of air flow.

16.8 A fuse may be used to provide the necessary overload protection if compliance with the requirements will be provided by the largest-ampere rated fuse that can be mounted in the fuseholder or if a noninterchangeable fuse is used. The fuse used to provide this protection may be of the supplementary type (need not be acceptable for branch circuit protection) provided the fuse has a short circuit rating acceptable for the circuit in which it is used. See Table 37.1. If a supplementary type fuse is used, the equipment shall be marked in accordance with the requirements in paragraph 43.18.

17. Capacitors

17.1 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 Currents, Table 37.1.

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 37.1 but not less than the current established by dividing the circuit voltage by the impedance of the other components.

18. Overcurrent Protection, General

18.1 A heater that employs resistance type heating elements and is rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

18.2 The overcurrent protective devices required by paragraph 18.1 shall be provided as an integral part of the heater or shall be provided by the heater manufacturer as a separate assembly, for independent mounting, for use with the heater. See paragraph 42.15.

18.3 The overcurrent protection mentioned in paragraphs 18.1, 18.2, 18.5—18.9, 18.11, and 18.13 shall be circuit breakers, cartridge fuses, or Type S plug fuses of a type and rating recognized as being acceptable for branch circuit protection for the circuit involved in accordance with the requirements of the National Electrical Code, ANSI/NFPA 70—1984.

Paragraph 18.3 revised July 16, 1986

18.4 The screw shell of a plug fuseholder shall be connected toward the load.

18.5 A motor circuit shall be protected against short circuit and ground fault conditions by an overcurrent protective device conforming with the National Electrical Code, ANSI/NFPA 70—1984. Such overcurrent protection shall be provided as part of the heater or as a separate assembly if, in accordance with paragraph 18.2, the overcurrent protection is provided by the heater manufacturer for the heater circuits. See paragraph 18.8.

Paragraph 18.5 revised July 16, 1986

18.6 Except as indicated in paragraphs 18.7—18.10, the acceptability of the motor-circuit short circuit and ground fault overcurrent protective device to provide the protection required in paragraph 18.5 shall be determined in accordance with the Short-Circuit Tests, Section 37.

18.7 Short-circuit tests need not be conducted on a motor overload protective device if the device is rated for the conditions specified in the Short-Circuit Tests, Section 37.

18.8 If each motor circuit is or will be provided with independent overcurrent protection complying with the National Electrical Code, ANSI/NFPA 70—1984, for the motor circuit involved, and if the motor overload protective device conforms with the requirements for such a device, the overload protective device is considered to comply with the requirements in paragraphs 18.5 and 18.6.

Paragraph 18.8 revised July 16, 1986

18.9 Short-circuit tests need not be conducted on a motor overload protective device to determine risk of fire if:

A. A thermally protected motor or a separately enclosed motor-overload protective device is within a cabinet 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 complies with the requirements of paragraphs 7.10—7.13.

However, if short-circuiting between live parts of different circuits may result, the test is not to be waived.

18.10 Short-circuit tests need not be conducted on conductors in the motor circuit if:

A. The conductors have an ampacity of not less than one-third the ampacity of the supply conductors as determined in accordance with paragraphs 8.8 and 8.9. Ampacities are to be determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70—1984, for the type of wire or cord employed, or for the wire or cord equivalent to appliance wiring material, or

B. The conductors, including those enclosed in raceways, are No. 18 AWG (0.82 mm^2) or larger and are not more than 4 feet (1.22 m) long and the circuit will be protected by a fuse or "HACR Type" circuit breaker that is rated 60 amperes or less as specified on the unit nameplate or that is provided as part of the unit and acceptable for branch-circuit protection.

C. The conductor is a jumper lead between controls and is not longer than 3 inches (76 mm), unless the conductor is located in a control panel.

Paragraph 18.10 revised July 16, 1986

18.11 Overcurrent protection at not more than 20 amperes shall be provided by an acceptable circuit breaker or fuses, as a part of the heater, (1) for each general-use duplex receptacle circuit, and (2) for each lampholder circuit, except as indicated in paragraph 18.12, independent of a heating element, unless the heater would be connected in accordance with the National Electrical Code, ANSI/NFPA 70—1984, to a branch circuit rated at 20 amperes or less. See paragraph 43.2.

Paragraph 18.11 revised July 16, 1986

18.12 A neon pilot lamp which is integral with the lampholder is not required to have overcurrent protection at 20 amperes or less.

18.13 Overcurrent protection at no more than 15 amperes shall be provided by an acceptable fuse or circuit breaker for each general-use single receptacle, unless the equipment would be connected in accordance with the National Electrical Code, ANSI/NFPA 70—1984, to a branch circuit rated at 15 amperes or less. See paragraph 43.2.

Paragraph 18.13 revised July 16, 1986

19. Overcurrent Protection, High-Voltage Control Circuit Conductors

General

19.1 For the purpose of these requirements, a "control circuit" is one that carries electric signals directing the performance of a controller which, in turn, governs power delivered to a motor or other load in the equipment. A control circuit does not carry main power current. Where a control-circuit is supplied through a transformer provided as part of the equipment, see Transformer Protection, Section 20, for additional requirements.

19.2 *Paragraph 19.2 deleted July 16, 1986*

Direct-Connected High-Voltage Control Circuits

19.3 For the purpose of this section, a "direct-connected high-voltage control circuit" is one that is supplied from a branch circuit separate from one supplying other loads within the equipment. It is not tapped from the load side of the overcurrent device(s) of the controlled circuit(s) within the equipment. See paragraph 43.21.

Tapped High-Voltage Control Circuits

19.4 For the purpose of this section, a "tapped high-voltage control circuit" is one which is tapped within the equipment from the load side of the overcurrent device(s) for the controlled load.

19.5 Tapped high-voltage control circuit conductors shall be provided with overcurrent protection. The rating of the overcurrent protective device(s) shall not exceed the applicable value specified in Table 19.1.

Exception No. 1: Nos. 18, 16, and 14 AWG (0.82, 1.3, and 2.1 mm^2, respectively) conductors that do not exceed 4 feet (1.2 m) in length between points of opposite polarity may be protected by fuses or "HACR Type" circuit breakers 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 the Short-Circuit Test, Section 37.

Exception No. 3: Leads that are 12 inches (305 mm) or less in length need not be provided with overcurrent protection.

Exception No. 4: Control-circuit conductors, supplied from the secondary of a single-phase transformer which is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device(s) located on the primary side of the transformer provided this protection (1) complies with requirements specified in Transformer Protection, Section 20 and (2) does not exceed the applicable value specified in Table 19.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Exception No. 5: A control circuit conductor 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—1984.

Revised paragraph 19.5 effective October 18, 1988

Overcurrent Protective Devices

19.6 Overcurrent protection for tapped high-voltage control circuit conductors, as required by paragraph 19.5, shall be provided as part of the equipment.

Exception: The overcurrent device(s) need not be provided as part of the equipment if, based on the marking rating(s) of the equipment, the rating of the branch circuit overcurrent protective device(s) does not exceed the values specified in Table 19.1.

19.7 A control circuit overcurrent protective device(s) shall (1) be provided for all ungrounded conductors, (2) be sized in accordance with requirements in paragraph 19.5, and (3) have a voltage rating not less than the circuit in which it is used. The device(s) shall be (1) a circuit breaker acceptable for branch circuit protection, or (2) a fuse acceptable for branch circuit protection, such as Class CC, G, H, J, K, L, R, or T cartridge fuses or Type S plug fuses.

Exception: If the control circuit is tapped from a circuit supplying other loads in the equipment, devices used for overcurrent protection may be of the supplementary type provided they have a short-circuit rating acceptable for the circuit in which they are used. See Table 37.1. If the supplementary type device used is a fuse, the equipment shall be marked in accordance with paragraph 43.18.

TABLE 19.1
OVERCURRENT PROTECTIVE DEVICE RATING FOR CONTROL CIRCUIT CONDUCTORS

Tapped Control-Circuit Conductor Size, AWG	Maximum Rating of Overcurrent Protective Device, Amperes			
	Conductor Contained in Control Equipment Enclosure		Conductors Extending Beyond Control Equipment Enclosure	
	Copper	Aluminum[a]	Copper	Aluminum[a]
18	25	—	7	—
16	40	—	10	—
14	100	—	45	—
12	120	100	60	45
10	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—1984.

[c]300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70—1984.

Revised Table 19.1 effective October 18, 1988

Replaces page 32A dated July 16, 1986

20. Transformer Protection

High-Voltage Transformers

General

20.1 A transformer (including an autotransformer), other than one as described in paragraphs 20.8 and 20.9 is considered a high-voltage transformer and shall (1) be provided with thermal overload protection in accordance with requirements in paragraphs 20.2, or (2) be protected by an overcurrent device in accordance with requirements in paragraph 20.4, or (3) comply with the requirements of the Burnout Test — High-Voltage Transformers, Section 39.

Paragraph 20.1 revised July 16, 1986

Thermal Protection

20.2 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 that permitted for the class of insulation employed in the windings. See Overload Test — High-Voltage Transformers, Section 38.

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 39.

Paragraph 20.2 revised January 30, 1988

20.3 Thermal cutoffs shall comply with the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020. Manual or automatic resetting thermal protectors shall have an endurance rating of not less than 6000 cycles and shall comply with the requirements pertaining to the calibration of temperature limiting controls specified in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873.

Overcurrent Protection

20.4 If a high-voltage transformer is protected by an overcurrent device, such protection shall comply with the requirements specified in paragraphs 20.5 and 20.6 and 20.10—20.12.

Paragraph 20.4 revised July 16, 1986

20.5 Except as noted in paragraph 20.6, a high-voltage transformer shall be protected by an overcurrent device(s) located in the primary circuit and rated or set as indicated in Table 20.1. See paragraph 20.10.

Exception: If the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70—1984.

Paragraph 20.5 revised July 16, 1986

TABLE 20.1
RATING OF OVERCURRENT DEVICE

Rated Primary Current, Amperes	Maximum Rating of Overcurrent Device, Percent of Transformer Primary Current Rating
Less than 2	300[a]
2 or more, less than 9	167
9 or more	125

[a] Does not apply to autotransformer. May be increased to 500 percent if transformer supplies a motor control circuit.

Table 20.1 added July 16, 1986

20.6 If the circuit supplying a transformer other than an autotransformer 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 at not more than 125 percent of the rated secondary current of the transformer. See paragraph 20.11.

Exception No. 1: If the rated secondary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used in the secondary circuit. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70—1984.

Exception No. 2: If the rated secondary current of the transformer is less than 9 amperes, the overcurrent device(s) in the secondary circuit may be rated or set at not more than 167 percent of the rated secondary current.

Paragraph 20.6 revised July 16, 1986

20.7 *Paragraph 20.7 deleted effective October 18, 1988*

Low-Voltage Transformers

20.8 Except as indicated in paragraph 20.9, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (National Electrical Code, ANSI/NFPA 70—1984, Class 1, power-limited circuit) shall be protected by an overcurrent device located in the primary circuit. The overcurrent device shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See paragraph 20.10.

Paragraph 20.8 revised July 16, 1986

20.9 A transformer that directly supplies a National Electrical Code, ANSI/NFPA 70—1984, Class 2 circuit (see paragraph 2.2) shall, in accordance with the Standard for Class 2 and Class 3 Transformers, UL 1585, either limit the output current (inherently limited transformer) or be equipped with an overcurrent device (not inherently limited transformer), and need not comply with the requirements in paragraph 20.8.

Paragraph 20.9 revised July 16, 1986

Overcurrent Protective Devices

20.10 Overcurrent protection in the primary circuit of a transformer, as described in paragraphs 20.5 and 20.8, need not be provided as part of the equipment if based on the marked rating(s) of the equipment, the rating of the branch circuit overcurrent protective device(s) does not exceed the applicable value specified in paragraph 20.5 or 20.8.

20.11 Overcurrent protection in the secondary circuit of a transformer, as required by paragraph 20.6, shall be provided as part of the equipment.

Paragraph 20.11 revised July 16, 1986

20.12 Required transformer overcurrent protective devices provided as part of the unit shall (1) be provided for all ungrounded conductors, (2) be sized in accordance with requirements in paragraphs 20.5—20.8, as applicable, and (3) have a voltage rating not less than the cicuit in which they are used. The device(s) shall be (a) a circuit breaker recognized as being acceptable for branch circuit protection or (b) fuses recognized as being acceptable for branch circuit protection, such as Class CC, G, H, J, K, L, R, or T cartridge fuses or Type S plug fuses.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the unit, fuses used for overcurrent protection may be of the supplementary type [a type other than indicated in item (b) of paragraph 20.12] provided the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 37.1. The unit shall be marked in accordance with requirements specified in paragraph 43.18.

21. Fan-Control and Thermal Back-Up Protection

Fan-Control

21.1 A contactor, time-delay relay, or similar device, such as a silicon controlled rectifier, that controls a fan or blower motor shall comply with the requirements for a fan control as given in the Standard for Limit Controls, UL 353.

21.2 The circuitry of a heater that includes a fan or blower motor shall be so arranged that no heating element circuit can be energized unless the motor circuit is also energized. This does not prohibit the use of a fan delay control which complies with the requirements for a fan control.

21.3 A heater that does not include a fan or blower motor but is intended to be used in conjunction with such motor, such as a duct heater, shall be provided with terminals or leads for field connection of an interlock circuit for such motor unless an air-flow interlock is provided as an integral part of the heater. The heater shall include the interlocking contacts or the power supply. It shall be so arranged that no heating element circuit can be energized unless the interlocking contacts are closed or the interlocking power supply energized.

Thermal Back-Up Protection

21.4 Except as indicated in paragraph 21.9, a heater shall be provided with one or more manually resettable or replaceable protective devices of the type indicated in paragraph 21.5 that will, with the contacts of the automatically reset limit control failed closed, limit the temperature rise at the points mentioned in paragraph 21.6 to no more than 75°C (135°F), except as noted in paragraph 21.7, during any of the tests described in paragraphs 51.4—51.7 (for a duct heater), or paragraphs 62.3—62.5 (for a furnace). See paragraphs 51.3 and 62.2.

21.5 The manually resettable or replaceable protective device(s) specified in paragraph 21.4 shall be functionally independent of the automatically reset limit control. The following types of controls comply with this requirement.

A. A thermal cutoff or nonresettable limit control connected to open a sufficient number of ungrounded conductors to comply with the specified temperature limits.

B. A manually resettable limit control that will open a sufficient number of ungrounded conductors to comply with the specified temperature limits.

C. A combination consisting of a normally open magnetic contactor and thermal cutoff, nonresettable limit control or manually resettable limit control. The thermal cutoff or limit control shall be connected in the coil circuit of the contactor. The combination:

1. Shall be integral with the heater, except as indicated in paragraph 26.11.

2. Shall open a sufficient number of ungrounded supply conductors in order to comply with the specified temperature limits.

3. Shall be independent of control by an automatic cycling device with the heater.

21.6 The temperature rise limit mentioned in paragraph 21.4 applies to:

A. The metal duct and the heater itself, on a heater suitable for zero spacing installation or on a heater for attic installation.

B. On the inside surface of the wooden test enclosure of any other heater.

21.7 The temperature rise mentioned in paragraph 21.4 shall not exceed 105°C (189°F) during the 30-minute period following the initial imposition of the test condition, except that the temperature rise following the functioning of one or more of the manually resettable limit controls, nonresettable limit controls, or thermal cutoffs may be no more than 150°C (270°F). At the end of the 30-minute period following the functioning of the first control or cutoff, the temperature rise shall not exceed 75°C (135°F).

21.8 The rate of closure for the restricted inlet test, paragraph 51.4 or 62.3, as required in paragraph 21.4 is to be such that the inlet duct is gradually and uniformly restricted until it is completely blocked at the end of 30 minutes.

21.9 The requirement in paragraph 21.4 does not apply to a heater, other than a duct heater, in which no part of the automatically resetting limit control circuit cycles under intended conditions. For example, a central heating furnace with an automatically resetting limit control(s) that directly controls the heating element(s) is not required to be provided with the back-up protection indicated in paragraph 21.4. However, a central heating furnace incorporating a contactor having its coil circuit controlled by both the automatically resetting limit control(s) and a temperature regulating control(s) is required to have back-up protection as indicated in paragraph 21.4.

22. Fuseholders and Circuit Breakers

22.1 A fuseholder or circuit breaker shall be rated for the particular application and shall not be accessible from outside the enclosure without opening a door or cover, except that the operating handle of a circuit breaker may project outside the enclosure. See also paragraph 5.13.

22.2 A fuseholder shall be designed, installed, or protected so that adjacent uninsulated high-voltage live parts, 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. A barrier of vulcanized fiber or similar material employed as a guard for uninsulated high-voltage live parts shall be not less than 1/32 inch (0.8 mm) in thickness. A screw shell shall be connected toward the load.

22.3 With reference to paragraph 22.2, a separation less than 4 inches (102 mm) from the insulating body of a fuse is considered to be adjacent, except as indicated in paragraph 6.3.

22.4 If a fuseholder is incorporated in the heater or a remote control assembly, the fuses shall be shipped with the heater or with the remote control assembly by the manufacturer, but need not be mounted in the fuseholder.

22.5 Circuit breakers used to protect circuits having more than one ungrounded conductor and no grounded neutral shall be of the multipole common trip type arranged to open all ungrounded conductors. The use of external handle ties does not in itself constitute a common trip mechanism.

Added paragraph 22.5 effective October 18, 1988

23. Thermal Cutoffs and Nonresettable Limit Controls

23.1 A thermal cutoff or nonresettable limit control shall be secured in place and so located that it will be accessible for replacement without damaging other connections or internal wiring. See paragraphs 23.4, 23.6, and 43.5.

23.2 A thermal cutoff or nonresettable limit control shall open the circuit in the intended manner without causing the short-circuiting of live parts and without causing live parts to become grounded to the enclosure when the heater is connected to a circuit of voltage in accordance with paragraph 31.8 and operated in an intended position to cause abnormal heating.

23.3 To determine if a thermal cutoff complies with the requirement in paragraph 23.2, the heater is to be operated with separate cutoffs five times as described in paragraph 23.2, and with any other thermally operated control devices in the heater short-circuited. If the thermal cutoff employs an external movable contact arm, the movable end of this arm is to be electrically connected toward the load (heating element). Each cutoff is required to perform acceptably. During the test, the enclosure is to be connected through a 3 ampere fuse to ground.

23.4 Replacement of a thermal cutoff or nonresettable limit control shall not necessitate:

A. Removal of the heater from its installation,

B. Disconnection of the field wiring system,

C. Stretching or similar displacement of the heater element wire, such as to cause permanent displacement or distortion that could affect the performance of the heater, and/or

D. Release of the heater-element wire from its attachment if this would result in displacement of the element wire.

23.5 Item A of paragraph 23.4 does not preclude the withdrawal of a removable heating element(s) to permit replacement of a thermal cutoff or nonresettable limit control.

23.6 Wiring connected to a thermal cutoff or nonresettable limit control shall be so secured that replacement of the thermal cutoff or nonresettable limit control will not result in displacement or disturbance of internal wiring other than leads to the cutoff or limit control itself or to a heating element assembly on which the cutoff or limit control is mounted.

24. Lampholders

24.1 A lampholder shall be so wired that the screw shell will be connected to a grounded circuit conductor.

24.2 Except as noted in paragraph 24.3, a lampholder shall be constructed and installed so that uninsulated live parts other than the screw shell will not be exposed to contact by persons removing or replacing lamps in service.

24.3 The requirement in paragraph 24.2 does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the heater or remote control assembly by means of tools. See paragraph 43.5.

25. Switches and Controllers

25.1 A switch or other control device shall have a current and voltage rating no less than that of the circuit (load) which it controls.

25.2 A switch shall be so located or protected that it will not be subjected to mechanical damage in intended use.

25.3 Except as indicated in paragraph 25.4, a switching device that interrupts the main power supply circuit to a heater or separate heater control assembly shall be such that, when open, the device will disconnect all ungrounded conductors of the power supply circuit if the switching device itself, or the pilot device that controls the switching device, has a marked ON or OFF position.

25.4 A switching device to be controlled by a thermostat which is not part of the heater or remote control assembly referenced on the heater nameplate is not required to disconnect all ungrounded conductors of the power supply circuit.

25.5 When a manual switch in a unit has a marked OFF position or the equivalent, there shall be no exposed live parts when the switch is in the OFF position and when the access panel(s) or cover(s) to the unit is opened.

Exception: This requirement does not apply to:

A. A switch in a unit which is clearly marked to indicate that a remote disconnect shall be opened before the access panel(s) or cover(s) is opened,

B. A switch which has its operating handle located behind a panel or cover which serves as the required enclosure for live parts, or

C. Supply wiring terminals integral to a switch or circuit breaker assembly in a remote control panel containing only fused or unfused switches or circuit breakers and neutral terminals.

25.6 A shield or barrier used to cover supply wiring terminals which may be live when the switch mentioned in paragraph 25.5 is in the OFF position, shall comply with paragraphs 10.10 and 10.11, and there shall be marking specifying that the shield or barrier be replaced after the supply connections have been made if removal is necessary for making supply connections. Such markings shall be readily visible adjacent to the terminals and shall not be located on the shield or barrier.

25.7 More than one switch may be used to comply with the requirement of paragraph 25.5 provided the manual switches are grouped and identified. A cover interlock switch, with terminals independently covered, may be used to disconnect some conductors, such as control circuit conductors from a supply separate from the main power supply.

26. Automatic Controls and Control Circuits

26.1 A control circuit shall comply with the requirements in paragraphs 10.1—10.11.

26.2 If an auxiliary control device, such as a thermostat or combination thermostat and control switch in a heater or remote control assembly has a marked ON or OFF position, or is marked with another wording or symbol, such as NO HEAT, COLD, O, or the like, that conveys the same meaning as the word OFF, it shall disconnect the element or elements it controls from all ungrounded conductors of the power supply circuit when placed in that position. See paragraphs 25.3 and 25.4.

26.3 The requirement in paragraph 26.2 applies to a thermostat in a remote control assembly that is referred to on the heater nameplate. See paragraph 42.15.

26.4 An auxiliary control is considered to be one that is intended primarily for regulating time, temperature, and the like, under conditions of intended operation, and not for protection against overload or excess temperature conditions resulting from abnormal operation.

26.5 If a thermostat in a heater or remote control assembly, or combination thermostat and control switch, has a marked position as described in paragraph 26.2 (other than a marked ON position), it shall not function as a thermostat; that is, it shall not respond to temperature changes to such extent as to open or close the circuit while the actuating member is in that position. See paragraph 26.6.

26.6 A thermostat that does not reclose (remains open) when cooled to a temperature of minus 35°C (minus 31°F) is acceptable with respect to the requirement in paragraph 26.5.

26.7 A limit control shall comply with the requirements given in the Standard for Limit Controls, UL 353.

26.8 A safety control or a temperature limiting control, one designed to reduce the risk of fire or electrical shock, shall be operative whenever the heater is connected to its power supply and shall interrupt a sufficient number of heating elements to prevent temperatures from exceeding applicable temperature limits.

26.9 A component, such as a pilot light, capacitor, or resistor, shall not be connected across the contact terminals of a safety control or a temperature limiting control.

26.10 A contactor or similar device, such as a silicon controlled rectifier, actuated by a limit control shall comply with the requirement for a limit control if it is a part of the limit-control circuit.

26.11 A contactor or similar device, such as a silicon controlled rectifier, required for use with a limit control shall be provided by the manufacturer of the heater, but need not be mounted on the heater. See paragraph 42.15.

27. Safety Devices

27.1 The terminals of a safety device within the enclosure of a heater shall be so located or further enclosed that they will be protected against accidental short-circuiting or damage.

27.2 The bulb, capillary tubing, or other sensing element of a temperature limiting control that is depended upon to prevent hazardous operation shall be so located or guarded as to be protected from mechanical damage during installation and use of the heater.

27.3 In connection with the requirement in paragraph 27.1, particular attention is to be paid to a heater that, when being installed, requires partial disassembly or permits rearrangement of internal parts.

SPACINGS

28. General

28.1 Except as noted in paragraphs 28.2 and 28.3, the spacings in a heater or remote control assembly shall be in accordance with Tables 28.1—28.4.

28.2 The spacings specified in Tables 28.2—28.4 do not apply to the inherent spacings of a component of a heater or remote control assembly. Such sacings are judged under the requirements for the component. However, the electrical clearance resulting from the assembly of the components into the complete heater or remote control assembly, including clearance to dead metal parts or enclosures, are to be those indicated in the tables.

28.3 At closed-in points only, such as the screw and washer construction of an insulated terminal mounted in metal, a spacing of no less than 3/64 inch (1.2 mm) is acceptable where the potential involved is 250 volts or less, and a spacing of no less than 1/4 inch (6.4 mm) is acceptable where the potential involved is 251—600 volts.

28.4 The spacings within a motor connected across a portion of a resistance element or in series with a reactor or an autotransformer shall be those specified for the full rated voltage of the heater.

28.5 Except as indicated in paragraph 28.6, an insulating lining or barrier of fiber or similar material employed where spacings would otherwise be less than the required values shall be no less than 1/32 inch (0.8 mm) in thickness, and shall be so located or of such material that it will not be adversely affected by arcing; except that fiber no less than 1/64 inch (0.4 mm) in thickness may be used in conjunction with an air spacing of no less than 50 percent of the spacing required for air alone.

28.6 Insulating material having a thickness less than that specified in paragraph 28.5 may be used if it has equivalent insulating, physical, and flammability properties.

28.7 The spacings indicated in Table 28.4 are applicable only to electrical components mounted external to the air handling compartment which may be subject to moisture due to condensation and are in a high-voltage circuit.

28.8 Unless protected from mechanical damage during assembly and intended functioning of the heater, a barrier of mica shall be 0.01 inch (0.25 mm) or more in thickness.

TABLE 28.1
MINIMUM ACCEPTABLE SPACINGS AT FIELD WIRING TERMINALS AND AT FUSEHOLDERS AND THERMAL CUTOFFS[a,b,d,e]

Parts Involved	Potential Involved, Volts	Through Air		Over the Surface	
		Inch	(mm)	Inch	(mm)
Between live parts of opposite polarity; and between a live part and a dead metal part, other than the enclosure, which may be grounded	0—250	1/4	(6.4)	3/8	(9.5)
	251—600	3/8	(9.5)	1/2[c]	(12.7)[c]
Between a live part and the enclosure	0—600	1/2	(12.7)	1/2	(12.7)

a These spacings do not apply to connecting straps or busses extending away from wiring terminals, from fuseholders or from thermal cutoffs. Such spacings are judged under Table 28.2 or 28.4.

b Applies to the sum of the spacings involved where an isolated dead part is interposed.

c A spacing of not less than 3/8 inch (9.5 mm) through air and over the surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

d These spacings apply with fuses installed in the fuseholders. The spacings given in Table 28.2 or 28.4 apply when fuses are being installed, one at a time.

e Spacings in a low-voltage circuit may be no less than 1/4 inch (6.4 mm).

TABLE 28.2
MINIMUM ACCEPTABLE SPACINGS THROUGH AIR OR OVER THE SURFACE AT POINTS OTHER THAN FIELD WIRING TERMINALS, FUSEHOLDERS, THERMAL CUTOFFS, OR INSIDE MOTORS[a]

Parts Involved	Potential Involved, Volts	Inch	(mm)
Between uninsulated live parts of opposite polarity; and between an uninsulated live part and a dead metal part, other than the enclosure, that either is exposed to contact by persons or may be grounded	0—250	1/16[d]	(1.6)[d]
	251—600	1/4[b,c]	(6.4)[b,c]
Between a live part and the enclosure	0—600	1/4[d]	(6.4)[d]

a If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum spacing is maintained under all operating conditions and under all normal conditions of handling.

b Enamel insulated wire is considered to be an uninsulated live part.

c A spacing of 1/16 inch (1.6 mm) is permissible at the heating element only, in a heater rated for 300 volts or less.

d No minimum spacing requirements apply to a low-voltage circuit unless a short circuit or ground may result in improper operation of the heater. In the latter case, the spacing between uninsulated live parts of opposite polarity, and between a rigidly mounted uninsulated live part and a dead metal part, other than an enclosure that is exposed to contact by persons or may be grounded, shall be no less than 1/32 inch (0.8 mm), and the spacing between the live part and the enclosure shall be no less than 1/8 inch (3.2 mm).

TABLE 28.3
MINIMUM ACCEPTABLE INTERNAL MOTOR SPACINGS AT OTHER THAN FIELD WIRING TERMNALS[f]

Potential at the Points Between Which the Spacings Are Measured	Parts Involved	Diameter of Motor Frame[a]	Through Air		Over the Surface	
			Inch	(mm)	Inch	(mm)
0—125 volts	Commutator or collector rings	7 inches (178 mm) or less	1/16	(1.6)	1/16	(1.6)
		More than 7 inches (178 mm)	1/8[b]	(3.2)[b]	3/16[b]	(4.8)[b]
	Elsewhere in the motor	7 inches (178 mm) or less	3/32[c]	(2.4)[c]	3/32[c]	(2.4)[c]
		More than 7 inches (178 mm)	1/8[b,d]	(3.2)[b,d]	1/4[b,d]	(6.4)[b,d]
126—250 volts	Commutator or collector rings	7 inches (178 mm) or less	1/16	(1.6)	1/16	(1.6)
		More than 7 inches (178 mm)	3/16[b]	(4.8)[b]	3/16[b]	(4.8)[b]
	Elsewhere in the motor	7 inches (178 mm) or less	3/32	(2.4)	3/32	(2.4)
		More than 7 inches (178 mm)	1/4[b,d]	(6.4)[b,d]	1/4[b,d]	(6.4)[b,d]
251—600 volts	Commutator or collector rings and live parts of the brush rigging	7 inches (178 mm) or less	1/4[e]	(6.4)[e]	1/4	(6.4)
		More than 7 inches (178 mm)	1/4	(6.4)	3/8	(9.5)
	Elsewhere in the motor	7 inches (178 mm) or less	1/4[d]	(6.4)[d]	1/4[d]	(6.4)[d]
		More than 7 inches (178 mm)	3/8[d]	(9.5)[d]	3/8[d]	(9.5)[d]

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

b
Spacings of no less than 3/32 inch (2.4 mm) are acceptable throughout a universal motor.

c
For a motor rated at 1/3 horsepower (249 watts) or less, these spacings may be no less than 1/16 inch (1.6 mm).

d
Enamel insulated wire is considered to be an uninsulated live part. However, a spacing of no less than 3/32 inch (2.4 mm) (over the surface and through air) is acceptable between enamel insulated wire (rigidly supported and held in place on a coil) and a dead metal part.

e
Spacings involving a collector ring may be no less than 1/8 inch (3.2 mm).

f
See paragraph 28.4.

TABLE 28.4
MINIMUM ACCEPTABLE SPACINGS[a], OTHER THAN AT FIELD WIRING, TERMINALS, OR INSIDE MOTORS, FOR DUCT HEATERS AND FURNACES FOR INSTALLATION WITH AIR CONDITIONERS AND/OR HEAT PUMPS

Parts Involved	Potential Involved Volts	Through Air		Over the Surface	
		Inch	(mm)	Inch	(mm)
Between live parts of opposite polarity; and between a live part and a dead-metal part, other than the enclosure, which may be grounded	0—250	1/4[b]	(6.4)[b]	3/8[c]	(9.5)[c]
	251—600	3/8	(9.5)	1/2	(12.7)
Between a live part and the enclosure	0—600	1/2[d]	(12.7)[d]	1/2[d]	(12.7)[d]

a See paragraph 28.7.

b May be not less than 1/8 inch (3.2 mm) provided that the load connected to the component is 2000 volt-amperes (VA) or less or is 150 volts or less.

c May be not less than 1/4 inch (6.4 mm) provided that the load connected to the component is 2000 VA or less or is 150 volts or less.

d For 0—250 volts, may be not less than 1/4 inch (6.4 mm) provided that the sum of all loads connected to or controlled by components within the enclosure is 2000 VA or less.

PERFORMANCE

General

29.1 A thermal cutoff or nonresettable limit control shall not function during any test performed with the automatically resetting limit control in the circuit.

30. Power Input

30.1 The power and/or current input to a heater shall not be more than 105 percent of its marked rating.

30.2 To determine if a heater complies with the requirement in paragraph 30.1, the input is to be measured with the heater at normal operating temperature under full-load conditions and while connected to a supply circuit of rated voltage in accordance with paragraph 31.8. If a heater employs a nonmetallic element (such as carbon), the input is to be determined when the element is new.

31. Temperature Test

31.1 A heater, when tested under the conditions described below, shall not attain a temperature at any point sufficiently high to constitute a risk of fire or to adversely affect any material employed in the heater, nor show temperature rises at specific points greater than those indicated in Table 31.2.

31.2 All values in Table 31.2 are based on an assumed ambient temperature of 25°C (77°F), but a test may be conducted at any ambient temperature within the range of 10—40°C (50—104°F). However, no observed temperature higher than 25°C plus the specified maximum rise is acceptable, if the operation of an automatic thermal control during the test limits the temperatures under observation.

31.3 Temperatures are to be measured by thermocouples consisting of Nos. 24—30 AWG (0.21—0.05 mm^2) wires, except that a coil temperature may be determined by the change of resistance method if the coil is inaccessible for mounting thermocouples. See paragraph 31.6. When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to employ thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

31.4 A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but no less than 5 minute intervals, indicate no change. The thermocouple wire is to comply with the requirements for special thermocouples as listed in the Table of Limits of Error of Thermocouples in ANSI MC96.1—1975.

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

31.6 Ordinarily a thermocouple is to be used for determining temperature of a coil or winding if it can be mounted, without removal of encapsulating compound or the like, (1) on the integrally applied insulation of a coil without a wrap, or (2) on the outer surface of a wrap that is no more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like, but not of thermal insulation. The change of resistance method is to be used if the thermocouple measurement cannot be conducted in accordance with the foregoing considerations. For a thermocouple-measured temperature of a motor coil, as mentioned in items 9 and 12 of Table 31.2, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

31.7 At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher by the following amount than the maximum indicated in Table 31.2, if the temperature rise of the coil measured by the resistance method is no greater than specified in Table 31.2:

Item in Table 31.2	Additional Temperature Rise	
	Degrees C	Degrees F
7 and 8 (A)	15	27
9 (A)	5	9
10 and 11 (A)	20	36
12 (A)	10	18

31.8 To determine if a heater complies with the requirement in paragraph 31.1, it is to be operated continuously until constant temperatures have been reached. The test voltage is to be as indicated in Table 31.1, except that, if the application of the indicated test voltage does not result in the measured wattage input to the heater being equal to or more than the marked wattage rating, the test voltage is to be increased until the measured wattage input equals the marked wattage rating.

TABLE 31.1
VOLTAGE FOR TEMPERATURE TEST[a]

Marked Voltage Rating	Test Potential in Volts
Value within one of the specified ranges	Highest value of corresponding specified ranges
Value not within one of the specified ranges	Rated voltage

[a] Specified range refers to any of the ranges of voltage mentioned in paragraph 42.1.

31.9 If a heater employs a motor, in addition to a heating element, the voltage applied to an integrally connected motor is to be the marked voltage rating of the heater in accordance with paragraph 42.1. A motor supplied from a separate circuit is to be operated at a voltage (depending upon the motor rating) as specified for an integrally connected motor.

TABLE 31.2
MAXIMUM ACCEPTABLE TEMPERATURE RISES

Materials and Component Parts	Degrees C	Degrees F
1. Furnace air filter	65	117
2. Any point within a wiring compartment in which field-installed conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with paragraph 43.9.	35	63
3. Any point on a test enclosure surface at designated clearances from the heater or attached duct and plenums and a surface of a heater or attached ducts and plenums at the point of contact with the test enclosure surface.	65	117
4. Fuses[a]	65	117
5. Fiber used as electrical insulation or as bushings	65	117
6. Wood or other combustible material which is a part of the heater	65	117
7. Class 105 insulated relay or solenoid or transformer winding[b]		
Thermocouple method	65	117
Resistance method	85	153
8. Class A insulation system on coil windings of a-c motors having a frame diameter (see note a to Table 28.3) of more than 7 inches (178 mm) and of d-c and universal motors[b]		
A. In open motors:		
Thermocouple method	65	117
Resistance method	75	135
B. In totally enclosed motors:		
Thermocouple method	70	126
Resistance method	80	144
9. Class A insulation system on coil windings of a-c motors (not including universal motors) having a frame diameter (see note a to Table 28.3) of 7 inches (178 mm) or less thermocouple or resistance method[b]:		
A. In open motors	75	135
B. In totally enclosed motors	80	144

TABLE 31.2 (Cont'd)
MAXIMUM ACCEPTABLE TEMPERATURE RISES

Materials and Component Parts	Degrees C	Degrees F
10. Class 130 (Class B) insulation system, except as indicated in items 11 and 12[b]		
Thermocouple method	85	153
Resistance method	105	189
11. Class B insulation system on coil windings of a-c motors having a frame diameter (see note a to Table 28.3) of more than 7 inches (178 mm) and of d-c and universal motors[b]:		
A. In open motors:		
Thermocouple method	85	153
Resistance method	95	171
B. In totally enclosed motors:		
Thermocouple method	90	162
Resistance method	100	180
12. Class B insulation system on coil windings of a-c motors (not including universal motors) having a frame diameter (see note a to Table 28.3) of 7 inches (178 mm) or less thermocouple or resistance method[b]		
A. In open motors	95	171
B. In totally enclosed motors	100	180
13. Transformer, relay, and solenoid windings		
Class 155 insulation;		
Class 2 transformers		
Thermocouple method	95	171
Resistance method	115	207
Power transformers, relays, and solenoids		
Thermocouple method	110	198
Resistance method	115	207
14. Transformer, relay, and solenoid windings		
Class 180 insulation;		
Class 2 transformers		
Thermocouple method	115	207
Resistance method	135	243
Power transformers, relays, and solenoids		
Thermocouple method	125	225
Resistance method	135	243

(Continued)

TABLE 31.2 (Cont'd)
MAXIMUM ACCEPTABLE TEMPERATURE RISES

Materials and Component Parts	Degrees C	Degrees F
15. Phenolic composition used as electrical insulation or as parts where deterioration will result in a risk of fire or electric shock[c]	125	225
16. Insulated wire or cord	25°C or 77°F less than its temperature rating[d]	
17. Sealing compound	40°C or 104°F less than its melting point	
18. Copper conductor, bare or insulated, without tinning, nickel coating, or silver plating, except as noted in item 19	175	315
19. Termination of copper conductor in a pressure terminal connector, unless both are tinned, nickel-coated, or silver-plated	125	225

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

b See paragraphs 31.6 and 31.7.

c The limitation on phenolic composition does not apply to a compound which has been investigated and found to have heat-resistant properties.

d Inside a heater, the temperature rise on a wire or cord may be greater than the specified maximum rise provided that the insulation on each individual conductor is protected by supplementary insulation (such as a braid, wrap, tape, or close-fitting tubing) which is acceptable for the temperature and type of insulation involved.

31.10 In conducting a test to determine if a heater complies with the temperature requirements, it is to be mounted or supported as in service and tested under conditions approximating those of intended operation, except as otherwise noted. Temperatures are to be taken on nearby surfaces, on the supporting surface, at points of support, and at other points as may be necessary, including wiring in and to the heater.

31.11 Unless it has been determined that it is likely to remain in position during the handling of the heater prior to and during installation and after the heater has been installed, external thermal insulation (such as mats of woven glass fiber or mineral wool) is to be removed from the heater before it is installed in or on the surfaces of the test enclosure.

31.12 For the temperature tests, the heater is to be connected with wires of the size or sizes no larger than determined by applying the requirements specified in paragraphs 8.9—8.20.

Paragraph 31.12 revised July 16, 1986

32. Abnormal Operation Test

32.1 If the conditions of intended operation are not representative also of abnormal conditions likely to occur in actual service, a heater shall not create a risk of fire or electric shock when operated continuously under such abnormal conditions. The applied voltage and method of mounting shall be in accordance with paragraphs 31.8—31.10.

Paragraph 32.1 revised July 16, 1986

33. Overvoltage and Undervoltage Test

33.1 Except as indicated in paragraph 33.2, an electromagnet, as employed on a relay or solenoid, in a low-voltage circuit, see paragraph 2.2, shall be able to withstand 10 percent above normal voltage without damage and shall operate successfully at that voltage and also at 15 percent below normal voltage when tested as described in paragraph 33.3 or 33.4.

33.2 A relay or solenoid that has been found to be acceptable for the voltage and operating conditions involved, including ambient temperature conditions, is not required to be tested in the heater to determine if it complies with the requirement in paragraph 33.1.

33.3 The primary of a low-voltage transformer provided as part of the equipment and supplying continuous-duty relays and solenoids is to be connected to a supply source, maintained at the indicated overvoltage until the coils of the relays and solenoids reach constant temperature. The potential is then reduced to the normal test voltage. Each relay and solenoid is to operate properly at this test voltage. The potential is maintained at the normal test voltage until the coils reach constant temperatures. The potential is then reduced to the indicated undervoltage condition. Each relay and solenoid is to operate properly under this test condition.

Paragraph 33.3 revised January 30, 1988

33.4 If the low-voltage transformer is not provided as part of the equipment, the normal test voltage is the voltage rating of the low-voltage circuit, and the overvoltage and undervoltage potentials applied to the relays or solenoids are 110 and 85 percent, respectively, of the voltage rating. A relay or solenoid which will not be subject to continuous operation is to be energized at the specified overvoltage and at the normal test voltage for the maximum time permitted by its duty cycle, or until it reaches constant temperature, whichever occurs first.

33.5 With reference to paragraphs 33.3 and 33.4, the test voltage applied for these tests is to be as indicated in Table 33.1.

TABLE 33.1
TEST VOLTAGES

Rated Voltage	Normal Test Voltage	Overvoltage	Undervoltage
110—120	120	132	102
200—208	208	229	177
220—240	240	264	204
254—277	277	305	235
440—480	480	528	408
550—600	600	660	510
Other	Rated	110 Percent Rated	85 Percent Rated

34. Overload Test

Motor Switches and Controllers

34.1 Unless so interlocked that it will never have to break the locked-rotor motor current, a switch or other device that controls a motor shall perform acceptably when subjected to 50 cycles of operation, making and breaking the locked-rotor current of the motor. The device shall be mechanically and electrically operable at the conclusion of the test, at which time the device shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description which will diminish the reliability of the device.

34.2 To determine if a switch or other control device will perform acceptably in the test, the heater is to be connected to a grounded supply circuit of rated frequency and of voltage in accordance with paragraph 31.8 with the rotor of the motor locked. During the test, exposed dead metal parts of the heater are to be connected to ground through a 3 ampere fuse, and the current-rupturing device, if single-pole, is to be located in an ungrounded conductor of the supply circuit. If the heater is intended for use on direct current, or on direct current as well as alternating current, the test is to be conducted with direct current and exposed dead metal parts are to be connected as to be positive with respect to a single-pole, current rupturing device. The device is to be operated at the rate of 10 cycles per minute, except that a different rate of operation may be employed if agreeable to all concerned. The performance is unacceptable if the fuse in the grounding connection opens during the test.

Solid-State Components

34.3 If a heater employs one or more rectifiers, transistors, or similar solid-state components, no adverse condition shall develop when any such component is open-circuited or short-circuited. If the heater employs a capacitor in combination with one or more of the above mentioned components, no adverse condition shall develop when the capacitor is short-circuited. Only one of the simulated fault conditions described above is to be imposed at one time. See paragraphs 34.4—34.8.

34.4 If an electron-tube rectifier is employed, all of its plate and cathode terminals are to be connected together. The test is to be repeated with only the cathode and heater terminals connected together if this condition was not represented by the first test.

34.5 If a semiconductor rectifier is employed, samples are to be tested with the rectifier terminals connected together. Additional samples are to be tested with the terminals of the electrolytic capacitor connected together.

34.6 Three complete tests are to be made under each of the conditions described in paragraphs 34.4 and 34.5, using new components in each test. The equipment to be tested is to be connected as indicated in paragraph 32.1.

34.7 If flame is emitted from the overall enclosure of the equipment or if a permanently conductive path is established between live parts and exposed dead metal parts the results of the test are not acceptable.

34.8 The tests described in paragraphs 34.3—34.6 may be waived if one or both of the following conditions exist:

A. There are 10,000 ohms or more of additional series impedance in a circuit in which the voltage is 125 or less.

B. There are 20,000 ohms or more of additional series impedance in a circuit in which the voltage is more than 125 but is no more than 250.

35. Dielectric Voltage-Withstand Test

35.1 A heater shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential between live parts and dead metal parts, with the heater at its maximum intended operation temperature. The test potential shall be 1000 volts for a heater rated at 250 volts or less, and 1000 volts plus twice rated voltage for a heater rated at more than 250 volts.

35.2 A transformer, the output voltage of which is essentially sinusoidal, that can be varied and can maintain the specified high potential voltage at the equipment during the duration of the test, is to be used to determine compliance with paragraph 35.1. The applied potential is to be increased gradually from zero to the required test value, and is to be held at that value for 1 minute.

36. Insulation Resistance

36.1 A heater employing (1) thermal or acoustic insulation, such as mineral wool, in contact with uninsulated live parts, or (2) electrical insulating material that is likely to be adversely affected by moisture under the conditions of intended use shall have an insulation resistance of no less than 50,000 ohms after exposure for 24 hours to moist air having a relative humidity of 85 ± 5 percent at a temperature of 32 ± 2°C (89.6 ± 3.6°F). See paragraph 14.2.

36.2 Ordinarily insulation resistance is to be measured by a voltmeter having an internal resistance of at least 30,000 ohms and using a 250 volt direct current circuit.

37. Short-Circuit Tests

37.1 Devices and conductors as referenced in paragraphs 11.7, 11.11, and 18.6 shall withstand short-circuit and ground-fault conditions when protected by (1) a device that is recognized for branch-circuit protection and located in the product, (2) a branch-circuit protective device of the type and maximum rating specified on the product nameplate, or (3) a fuse as specified in paragraph 37.3. Specifically, 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-voltage and low-voltage circuits.

37.2 For the purpose of these tests, (1) circuit breakers and fuses are not considered to be interchangeable, (2) fuses of the same rating are considered to be interchangeable, (3) "HACR Type" circuit breakers of the same rating are considered to be interchangeable, and (4) other types of circuit breakers are not considered to be interchangeable with each other or with "HACR Type" circuit breakers.

37.3 If a branch circuit protective device is not specified on the product nameplate, a fuse of the maximum rating permitted by the National Electrical Code, ANSI/NFPA 70—1984, to protect the circuit involved may be used. However, the rating is to be not less than 20 amperes for a voltage rating of 150 volts or less nor is it to be less than 15 amperes for a voltage rating of 151—600 volts. A test fuse rated at 15 or 20 amperes is to be of the time-delay type.

Paragraph 37.3 revised July 16, 1986

37.4 The device or conductor is to be connected in a circuit having a capacity based on the rated current and voltage of the product in accordance with Table 37.1. Each concurrent-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 alternating and the current capacity is to be measured without devices or conductors in the circuit. The power factor is to be 0.9—1.0 unless a lower power factor is agreeable to all concerned.

TABLE 37.1
SHORT-CIRCUIT TEST CURRENTS

Product Ratings, Amperes				
Single Phase				
110—120 V	200—208 V	220—240 V	254—277 V	Circuit Capacity Amperes
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
3 Phase				
200—208 V	220—240 V	440—480 V	550—600 V	
2.12 or less	2.0 or less	—	—	200
2.13— 3.7	2.1— 3.5	1.8 or less	1.4 or less	1000
3.8 — 9.5	3.6— 9.0	—	—	2000
9.6 —23.3	9.1—22.0	—	—	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000
Direct Current				
0 to 250 V, dc—0 to 648 VA				200

Table 37.1 revised January 30, 1988

37.5 Three samples of each component under test are to be subjected to each test condition and a new protective device is to be used for each test. Consideration is to be given to both short-circuit and ground-fault conditions.

38. Overload Test — High-Voltage Transformers

38.1 This test applies to a high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type. See paragraph 20.2.

38.2 Temperatures measured on the surface of the windings of a thermally protected high-voltage transformer shall not exceed the insulation temperature rating when the transformer is tested as indicated in paragraphs 38.3 and 38.4. 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.

38.3 A variable resistance load is to be connected to the output terminals and the transformer operated continuously at the normal test voltage indicated in Table 33.1. 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 test ambient temperature 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.

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

38.5 The transformer shall comply with the Dielectric Voltage-Withstand Test, Section 35, following the test specified in paragraphs 38.3 and 38.4.

Replaces page 47 dated July 15, 1986

39. Burnout Test — High-Voltage Transformers

39.1 There shall be no emission of flame or molten metal from the unit enclosure and no emission of smoke into an air handling compartment when a high-voltage transformer is tested as described in paragraphs 39.2 and 39.3.

Exception: This test does not apply to a high-voltage transformer that is provided with thermal overload protection of other than the nonrenewable thermal cutoff type (see paragraph 20.2) or that is protected by an overcurrent device in accordance with requirements in paragraph 20.4.

39.2 Three samples of the transformer are to be tested at the normal test voltage specified in Table 33.1 and at rated frequency with the enclosure grounded. The test ambient temperature is to be 77°F (25°C) and operation is to be continued until constant temperatures are indicated by a thermocouple on the transformer enclosure unless burnout occurs earlier.

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

A. A resistance load to provide 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 to provide 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 coils of relays, solenoids, and the like, a resistance load to provide a current equal to the sum of such loads with the armature of the largest blocked open.

Exception: The test may be conducted with the output terminals short-circuited if this results in less than three times rated secondary current.

40. Motor Overload Tests

General

40.1 A motor protected by an overcurrent device in accordance with item B of paragraph 16.3 shall not burn out, nor shall there be other evidence of a risk of fire when tested in accordance with paragraphs 40.2—40.6.

40.2 The motor and protective device combination is to be connected to a supply circuit of normal test voltage as indicated in Table 33.1. Temperatures are to be measured by thermocouples on the surface of coils of the motor.

40.3 The motor and protective device combination is to be tested in the ambient encountered in operation, as determined during the applicable Normal Temperature Test.

Exception No. 1: A motor that encounters an ambient higher than normal room ambient, 25—26°C (77—79°F), during the applicable Normal Temperature Test may be tested in a lower ambient. However, the maximum allowable temperatures specified in paragraphs 40.4 and 40.5 are then to be reduced by the difference between the ambient encountered in intended operation and the test ambient.

Exception No. 2: An ambient compensated protective device may be tested in any ambient from 25—50°C (77—122°F).

Running Overload

40.4 When a motor is operating under the maximum load that it can carry without causing the protective device to function, the winding temperature shall not exceed 140°C (284°F) for a Class A insulated motor or 165°C (329°F) for a Class B insulated motor.

Exception: A motor moving air only by means of a fan or blower directly attached to the motor shaft need not comply with this requirement.

Locked Rotor

40.5 When the rotor of a motor is locked, the winding temperature for a Class A insulated motor shall not exceed 200°C (392°F) during the first hour of operation and 175°C (347°F) thereafter. After the first hour of operation, the average temperature; that is, the average of (1) the arithmetic mean of the maximum temperatures and (2) the arithmetic mean of the minimum temperatures; shall not exceed 150°C (302°F). For a Class B insulated motor, the corresponding temperatures shall not exceed 225°C (437°F) for the first hour, 200°C after the first hour, and 175°C for the average temperature.

40.6 The locked rotor test on a manually reset device is to be continued for four operations of the protective device, with the device being reset as quickly as possible after it is opened. For an automatically reset device, the locked rotor test is to be continued for 72 hours unless the equipment includes other controls — such as a timer — that will demonstrably limit the duration of the operation to a shorter interval.

MANUFACTURING AND PRODUCTION TESTS

41. Production Line Dielectric Voltage-Withstand Tests

41.1 The manufacturer shall conduct a dielectric voltage withstand test on each heater. A 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 specified. For the test, the heater may be in a heated or unheated condition.

A. For heaters rated 250 volts or less:

1. 1000 volts ac or

2. 1414 volts dc.

B. For heaters rated more than 250 volts:

1. 1000 volts ac plus twice rated voltage or

2. 1414 volts ac plus 2.83 times the rated voltage.

41.2 For heaters employing low-voltage circuits, 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 which is applied between the high-voltage live parts and dead metal parts will simultaneously be applied between high-voltage live parts and low-voltage circuits.

41.3 If the heater 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 sample selected at random from each day's production is to be tested to determine compliance with paragraph 41.1, but the circuitry may be rearranged for the test to reduce the risk of component damage while retaining representative dielectric stress of the circuit.

41.4 The test equipment used to determine compliance with paragraph 41.1 having alternating current output shall include a transformer having an essentially sinusoidal output. All test equipment shall also include an audible or visual indication of breakdown. In the event of breakdown, manual reset of an external switch is required or an automatic reject of the unit under test shall result.

41.5 If the output of the test equipment transformer is less than 500 volt-amperes the equipment shall include a voltmeter in the output circuit to directly indicate the test potential. If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential may be indicated by a voltmeter in the primary circuit or in a tertiary winding circuit, by a selector switch marked to indicate the test potential, or by a marking in a visible location to indicate the test potential on equipment having a single test-potential output. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as a power-on lamp, to indicate that the manual reset switch has been reset following a tripout.

MARKING

42. Nameplate

42.1 A heater shall be rated in amperes, volt-amperes, or watts (see paragraph 42.3) and also in volts, and may be rated for alternating current only. The rating shall include the number of phases and the frequency, if necessary because of motors, relay coils, or other control devices. The voltage rating shall be any appropriate single voltage or voltage range, such as 100—120, 200—208, 220—240, 254—277, 440—480, or 550—600.

42.2 Except as indicated in paragraph 42.3, if the connected load at one or more terminals or leads differs from that at the remaining terminals or leads, because of unbalanced loads, the marking shall include the rated current in amperes acceptably identified for each terminal or lead.

42.3 The marked current rating for each terminal or lead, as specified in paragraph 42.2, may be omitted, provided (1) the current at any terminal or lead does not exceed the rated current, or (for a heater rated in watts) the current computed on the basis of a balanced load by more than 5 percent, and (2) the size of the power-supply conductors is acceptable for the maximum unbalanced load in accordance with paragraph 8.9.

42.4 A heater that includes a motor load of more than 1/8 horsepower (93.3 W output) shall have a dual rating with each segment of the rating appropriately identified. One segment of the rating shall be that of the motor load in amperes and horsepower. The other segment shall be the rating of the total load other than the motor load (heater load, lighting load, and the like), and it may be in amperes or in watts or kilowatts.

42.5 Except as indicated in paragraph 42.6, the nameplate marking of a heater that includes a motor shall include the minimum supply circuit ampacity and the maximum current rating of the supply circuit protective device. The marking of the supply circuit device rating shall specify the supply circuit fuse size, except as indicated in paragraphs 42.9 and 42.10. See also paragraph 42.8. The supply circuit ampacity and the protective device rating shall be determined in accordance with the National Electrical Code, ANSI/NFPA 70—1984.

Paragraph 42.5 revised January 30, 1988

42.6 The markings specified by paragraph 42.5 are not required under any of the following conditions:

A. The motor is intended to be connected to a branch circuit supply separate from the branch circuit supplying the heating elements.

B. The motor is rated DC or single phase AC, the input is less than 0.5 ampere under the conditions described in paragraph 30.2, and the motor load is not separately identified on the equipment nameplate.

C. The heater is intended for connection to a 15 ampere branch circuit and is marked with this limitation, as indicated in paragraph 43.2.

D. The heater is to be supplied from a remote control assembly and the markings specified by paragraph 42.5 are to be on the remote control assembly. See paragraphs 18.2 and 42.15.

Revised paragraph 42.6 effective October 18, 1988

42.7 The nameplate marking of a heater or remote control assembly, in which any field wiring terminals or leads are sized in accordance with paragraph 8.16, shall include the minimum supply conductor size for those terminals or leads.

42.8 The marking indicated in paragraph 42.5 may additionally specify a maximum "HACR Type" circuit breaker size if the required short-circuit tests have been conducted in accordance with paragraph 37.1 using an "HACR Type" circuit breaker.

42.9 If, for each motor circuit, the heater incorporates short-circuit and ground-fault protective devices complying with the requirements of the National Electrical Code, ANSI/NFPA 70—1984, for the circuit protected, the marking indicated in paragraph 42.5 may specify a maximum fuse and circuit breaker size(s) or may refer to the maximum rating of an overcurrent device, without specifying a circuit breaker or fuse.

Paragraph 42.9 revised July 16, 1986

42.10 The marking indicated in paragraph 42.5 may specify both a maximum fuse and circuit breaker size(s), or may refer to the maximum rating of an overcurrent protective device, without specifying a circuit breaker or fuse, if the unit complies with item A or with all of items B, C, and D, as specified below.

A. The internal motor circuit involved is protected by (1) a circuit breaker, provided as part of the equipment, that has been determined by short-circuit tests on the circuit breaker in combination with the motor circuit wiring and components to provide short-circuit and ground-fault protection for the motor circuit wiring and components, or (2) a fuse, provided as part of the equipment, of a type and rating acceptable to provide short-circuit and ground-fault protection for the motor circuit wiring and components.

B. Each motor overload-protective device can be considered to comply with the requirements of the short-circuit test. See paragraph 42.11.

C. The marked maximum rating of the overcurrent protective device does not exceed 225 percent of the full-load current rating of any motor controller protected against short circuits and ground faults by that overcurrent device.

D. The marked maximum rating of the overcurrent protective device does not exceed 180 percent of the ampacity of motor-circuit conductors protected against short circuits and ground faults by that overcurrent-protective device. Ampacities of conductors are determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70—1984, for the type of wire or cord equivalent to appliance wiring material.

Exception: The ampacity consideration is not applicable to motor-circuit conductors if:

1. The conductors are short jumper leads between controls, not longer than 3 inches (76 mm), or the conductors are located in a control panel; or

2. Each conductor is connected in a circuit with fixed impedance in each side of the conductor so that high fault current is not likely to occur in it, for example, a lead from a motor running capacitor to the start winding of a permanent-split-capacitor motor.

Paragraph 42.10 revised July 16, 1986

42.11 Compliance with item B of paragraph 42.10 may be established by one of the following means:

A. The internal motor circuit involved is protected by an overcurrent-protective device, provided as part of the equipment, of a type and rating providing short-circuit and ground-fault protection for the motor circuit involved.

B. A short-circuit test on the motor overload-protective device is not required. For example, a short-circuit test is not required if the motor overload-protective device is located at the center point of the wye-connected 3-phase motor, or is located inside a hermetic-compressor enclosure or equivalent, so that the protective device is not subject to high fault currents.

C. The motor overload-protective device has been subjected to a short-circuit test using a fuse of such rating that the circuit impedance during the test is the same or less than could be anticipated using a circuit breaker rated not more than the marked maximum rating of the overcurrent-protective device, and (1) results of the tests are such that the motor overload-protective device opens the circuit without the risk of fire or electric shock, and (2) the fuse does not open during the test.

42.12 A heater shall be legibly and permanently marked where plainly visible after installation of the heater with:

A. The manufacturer's name, trade name, or trademark or other descriptive marking by which the organization responsible for the heater may be identified;

B. A distinctive catalog number or the equivalent;

C. The electrical ratings in accordance with paragraphs 42.1 and 42.4 of each circuit to which a supply connection is made; and

D. The date or other dating period of manufacture not exceeding any three consecutive months.

Exception: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code:

A. Does not repeat in less than 20 years, and

B. Does not require reference to the production records of the manufacturer to determine when the heater was manufactured.

42.13 The electrical rating shall be completely indicated in the marking, and reference to a wiring diagram for one or more items of the rating is not acceptable in lieu of including the rating in the marking except as indicated in paragraph 42.14.

42.14 For a heater requiring multiple supply sources, the ratings of the individual circuits of the heater other than the markings required by paragraphs 42.4, 42.5, and 42.7, may be shown on a wiring diagram permanently attached to the heater, and need not be indicated on the nameplate, which need show only the total rating.

42.15 If required overcurrent-protective devices, contactors, or the like are provided in a separate assembly, see paragraphs 18.2, 21.3, and 26.11, the heater shall be marked to indicate that it is to be used only with this separate assembly.

Paragraph 42.15 revised July 16, 1986

42.16 Heaters requiring field-provided motor overload protection under the provisions of paragraph 16.7 shall have markings readily visible during and after installation stating this fact and indicating that the motor overload protective devices shall be rated or selected in compliance with the applicable installation code as specified by the authority having jurisdiction.

42.17 If a manufacturer produces or assembles heaters at more than one factory, each finished heater shall have a distinctive marking to identify it as the product of a particular factory.

42.18 A remote control assembly that is not intended only for use with specific electric space heating equipment shall be marked "Short Circuit Current Rating _____ RMS Symmetrical Amperes." The rating in the blank shall be the lowest such rating of any of the components used in the panel if all components are so rated, or may be established by tests of the assembly as specified in Short-Circuit Tests, Section 37.

Paragraph 42.18 added July 16, 1986

42.19 All required nameplate markings shall be permanent and shall be located on a part that cannot be removed without the use of tools.

Added paragraph 42.19 effective October 18, 1988

42.20 Ordinary usage, handling, storage, and the like, of the heater shall be considered in the determination of permanence of marking. Etched, molded, or die-stamped markings are generally considered to be permanent. Paint-stenciled or ink-stamped types of markings are considered to be permanent if they remain legible after scraping ten times across the printed area with a force of approximately 2 pounds (8.9 N) using the edge of a 5/64 inch (2.0 mm) thick steel blade held at a right angle to the surface and after rubbing the printed area with thumb or finger pressure back and fourth ten times. In addition, paint-stenciled or ink-stamped markings on exterior enclosure surfaces are to be rubbed several times with a damp cloth to ensure that the ink or paint is not water soluble. Marking plates secured by adhesive shall be investigated and shall comply with the Standard for Marking and Labeling Systems, UL 969.

Added paragraph 42.20 effective October 18, 1988

43. Supplementary

43.1 If more than one disconnect switch may be required to disconnect all power, other than NEC Class 2, within a control assembly or compartment, the assembly or compartment shall be marked as follows, or with an equivalent wording: CAUTION — Hazard Of Electric Shock — More Than One Disconnect Switch May Be Required To De-energize The Equipment For Servicing. The marking shall be in letters not less than 1/8 inch (3.2 mm) in height and shall be of a permanent type located on the outside of the control assembly or compartment, such as on the cover, or on a stationary (fixed, nonremovable) part inside the control assembly or compartment. The warning marking placed inside the cover or on the connection diagram attached to the inside of a cover shall not be acceptable.

43.2 A heater intended for use on a 15 or 20 ampere circuit, as indicated in paragraph 8.13, shall be marked: Use Only On _____ Ampere Branch Circuit. The blank shall contain the number 15 or 20 as appropriate.

43.3 Each individual heating element or unit that is part of a heater and is replaceable in the field shall be marked with its electrical ratings in amperes or watts and also in volts.

43.4 A heater whose acceptable performance depends upon its proper location or position shall be marked (such as top or bottom) to indicate the way in which it is to be installed or used, unless such position is obvious from the external appearance of the heater.

43.5 If it is intended that the heater be disassembled by means of a tool for cleaning or similar servicing by the user (including replacement of a thermal cutoff or nonresettable limit control), and if such disassembly involves the exposure of persons to accidental contact with any normally enclosed or protected live part, the heater shall be marked with a warning that such servicing should be done only while the heater is disconnected from the supply circuit. See also paragraph 15.5.

43.6 If the servicing or replacement of a component of a heater in the field requires the removal or disconnection of any safety device, a caution marking shall appear on or adjacent to that device, calling attention to the fact that it should be repositioned in the intended location. The manufacturer's instructions provided with the heater shall call specific attention to this feature.

43.7 If, in accordance with paragraph 10.6, the barriers required by item C or D of paragraph 10.4 are not provided, the heater shall be marked to indicate that wiring rated for use in a National Electrical Code, ANSI/NFPA 70—1984 — Class 1 system shall be used for the field installed conductors.

Paragraph 43.7 revised July 16, 1986

†*Additional page*

43.8 If compliance of a heater with any of the requirements in this standard depends upon the functioning of a thermal cutoff or nonresettable limit control:

A. The thermal cutoff or nonresettable limit control shall be marked with the name or identifying symbol of its manufacturer or private labeler, and its designation,

B. The heater shall be marked with a statement that a replacement thermal cutoff or nonresettable limit control should be as indicated in item A, and this marking shall be located where visible during such replacement, and

C. A thermal cutoff which can be readily resoldered after operation shall be provided with a marking warning against resoldering. This marking shall be on a thermal cutoff or immediately adjacent to it. The following marking or equivalent on the thermal cutoff is acceptable:

WARNING — Do Not Resolder. Fire May Result.

The following marking or equivalent, visible in the area of the thermal cutoff(s), is acceptable:

WARNING — Do Not Resolder Thermal Cutoff After Operation. Fire May Result.

43.9 A unit shall be marked to indicate the temperature rating of the field wiring that is to be used in accordance with Table 43.1. Except as noted in paragraph 43.11, if any point within a wiring compartment of a heater, in which field installed conductors are intended to be connected, including such conductors themselves, attains a temperature rise more than that indicated in item 2 of Table 31.2 during the Temperature Tests, Section 31, the marking shall also include the conductor size in accordance with paragraph 43.10. The conductor size may also be included in a marking indicating 60°C wire if it is specified in accordance with paragraph 43.10. The marking shall be legible and so located that it will be visible during and after installation of the supply wiring connection. See also paragraphs 43.10A and 43.10B.

Revised paragraph 43.9 effective October 18, 1988

43.10 The conductor size mentioned in paragraph 43.9 shall not be smaller than any of the following:

A. The conductor size used in the Temperature Test, Section 31, or

B. The 75°C wire size based on the ampacities given in Table 310-16 of the National Electrical Code, ANSI/NFPA 70—1984 if 75 or 90°C wire is specified, or

C. The 60°C wire size based on the ampacities given in the Table 310-16 of the National Electrical Code, ANSI/NFPA 70—1984 if 60°C wire is specified.

If the unit is marked in accordance with item B of paragraph 43.13, the conductor sizes shall be included for both copper and aluminum.

Revised paragraph 43.10 effective October 18, 1988

43.10A If conductor sizes are included in the marking specified in paragraph 43.9, and:

A. If all the conductors are to be of the same size, the marking is to be, "For Supply Connections Use No. ____ AWG Or Larger Wires Suitable For At Least ____°C (____°F)" or an equivalent statement.

B. If conductors of more than one size are to be used because of unbalanced loads, multiple power supplies, or other reason, the marking is to be, For Supply Connections, Use Wires Suitable For At Least ____°C (____°F). See Wiring Diagram For Wire Size," or an equivalent statement.

Paragraph 43.10 revised and relocated as paragraph 43.10A effective October 18, 1988

43.10B If conductor sizes are not included in the marking specified in paragraph 43.9, the marking shall be "Use 60°C Wire" or an equivalent statement.

Added paragraph 43.10B effective October 18, 1988

TABLE 43.1
TEMPERATURE FOR MARKING

Temperature Rise Attained in a Wiring Compartment During Test		Temperature Marking	
°C	°F	°C	°F
35 maximum	63 maximum	60	140
36—50	64—90	75	167
51—65	91—117	90	194

Revised Table 43.1 effective October 18, 1988

43.11 If the field wiring connection area is so located that it is obvious that the field wiring can be located and maintained away from parts of the heater operating at a temperature rise more than 35°C (63°F), a marking, visible during and after installation of the field wiring connections, may be used to indicate the area in which the field wiring and splices are to be located after the splice is accomplished.

43.12 A thermally protected motor shall be marked "Thermally Protected." An impedance protected motor shall be marked "Impedance Protected."

43.13 A product with field wiring terminals or with wire connectors for field wiring including those referenced in item A of paragraph 8.12 shall be marked as follows:

A. If the product is not intended for field connection with aluminum wire — "Use Copper Conductors Only."

B. If the product is intended for field connection with either copper or aluminum wire — "Use Copper Or Aluminum Conductors," "Use Copper Or Copper-Clad Aluminum Conductors" or "Use Copper, Copper-Clad Aluminum, Or Aluminum Conductors."

In either case, an equivalent appropriate statement may be used in the marking. The marking shall be independent of any marking on the terminal connectors and shall be visible during installation of the product and also when the terminals are exposed for inspection after the unit has been installed. The marking may be combined with the markings specified in paragraphs 43.9 and 43.10.

Paragraph 43.13 revised July 16, 1986

43.14 A unit or remote control assembly with leads for spliced connections to an external high-voltage circuit which employs reusable wire connectors on those leads which will not be acceptable for splicing every combination of factory-provided and field-provided conductors shall be marked as indicated in paragraph 43.13, if it will then comply; or the unit or remote control assembly shall include a marking to the effect that the above described wire connectors are to be discarded and are not to be employed in making the field wiring connections. This marking is to be in the field wiring area and visible during installation and inspection.

43.15 Wiring instructions provided with the heater shall not conflict with the requirement in paragraph 10.13.

43.16 Where the output (one or more connections) of a Class 2 transformer provided as part of the heater is to be connected to a heating-cooling thermostat, the wiring diagram and/or instructions shall indicate by a wiring diagram or statement that isolation shall be maintained from an external Class 2 output in the cooling circuit. The statement, "Use Thermostat With Isolating Contacts To Prevent Interconnection Of Class 2 Outputs," or the equivalent, will be considered to comply with this requirement. See paragraphs 10.12 and 10.13.

43.17 A replacement marking shall be provided for a replaceable fuse provided as a part of a heater or remote control assembly. This marking shall specify the rating of the fuse in amperes and it shall be visible when the cover or door of the fuse compartment is opened.

43.18 If a supplementary type fuse is provided in accordance with paragraph 16.8 or the exception to paragraph 19.7 or 20.12, the marking specified in paragraph 43.17 shall also include the fuse manufacturer's or private labeler's name, catalog designation, and fuse voltage rating.

43.19 If a Class G fuse is provided; or if a fuseholder will accept a Class H fuse, but a different class of fuse was used during the temperature test on the heating equipment; the marking specified in paragraph 43.17 shall also include the fuse class.

43.20 A product not provided with an equipment-grounding terminal or lead, as permitted by paragraph 8.23, shall be marked "If This Product Is Supplied By A Wiring System That, In Accordance With The National Electrical Code, Requires The Installation Of An Equipment-Grounding Conductor Or Conductors, A Terminal Or Terminals For Connection Thereof Must Be Installed," or with an equivalent statement. This marking shall be located in the wiring compartment where the power supply conductors will be connected, and shall give pertinent information, such as where the terminal or terminals should be mounted, how they should be mounted, and the like.

43.21 If a unit employs a direct-connected high-voltage control circuit (see paragraph 19.3), it shall be marked with the maximum size of overcurrent device(s) for the control circuit. The rating of overcurrent device (1) shall be based on the ampacity of the control circuit conductors, as determined from ampacity tables contained in the National Electrical Code, ANSI/NFPA 70—1984 for No. 14 AWG or larger conductors and (2) shall not exceed 7 amperes for No. 18 AWG conductors or 10 amperes for No. 16 AWG conductors. The marking shall appear on the wiring diagram, adjacent to the field wiring terminals, or on the unit nameplate. See paragraph 43.22.

Revised paragraph 43.21 effective October 18, 1988

43.22 With reference to paragraph 43.21, the type of overcurrent protective device shall also be specified in the marking if required in order to comply with the requirement in paragraph 42.5.

43.23 If a unit is designed for field cut openings in accordance with paragraph 5.22A, the enclosure shall be marked to (1) specify this information and (2) clearly indicate the surface areas in which such openings are to be made. If such a unit is designed based on Exception No. 2 to paragraph 5.22A, the marking shall also include instructions for removing the necessary parts prior to the cutting or drilling operation. These markings shall be located in the area in which field wiring connections are intended to be made, but not where it will be obliterated as a result of the intended cutting or drilling operation.

Paragraph 43.23 added July 16, 1986

43.24 If provisions are made for a switching device in the unit to control an external load, such as a contactor coil or a blower motor, the unit shall be marked with the maximum ratings of the external load. If provisions are made for the connection of an external high-voltage switching device, such as a thermostat or blower interlock, to control loads within the unit, the unit shall be marked with the minimum required ratings of the switching device. These markings shall be located in the area in which (1) field wiring connections to the external load or switching device are to be made or (2) on the wiring diagram attached to the unit.

Paragraph 43.24 added July 16, 1986

DUCT HEATERS

CONSTRUCTION

44. General

44.1 Requirements under this heading are supplementary to those given in Sections 1—43.

44.2 These requirements apply to relays and other auxiliary control devices that may be provided as part of a duct heater to make it usable with other heating or cooling equipment, and are intended to take into account the effects of operating the duct heater in conjunction with or in proximity to such equipment.

44.3 A duct heater is a self-contained heater designed to be installed in the field in the air stream of a ducted system, external to the air-moving unit. It is designed to be installed in a duct where an adequate flow of air from a separate, interlocked fan or blower system is provided. Such a heater may be located in the main supply duct of an air heating system, or in one of the branch ducts. Two or more duct heaters may be installed in a group (in proximity to one another in the duct) if tests indicate acceptable results when the heaters are installed in accordance with the manufacturer's instructions.

44.4 A duct heater intended to be employed in conjunction with another source of heat is judged on the basis of its compliance with the requirements in this standard, and further examination and tests to determine whether or not the combination is acceptable.

44.5 A duct heater rated 50 kilowatts or less shall be tested for installation with zero spacing between the duct and combustible surfaces. A duct heater rated more than 50 kilowatts may necessitate that such spacings be larger than zero. See paragraph 52.2.

45. Instructions

45.1 Instructions for the installation and operation of a duct heater shall be provided. The instructions shall include such of the following items as are essential for intended operation:

A. A complete electrical diagram of the heater system, except as indicated in paragraph 45.2, showing the connections of the power supply, the necessary temperature rating of the field wiring, if higher than 60°C (140°F), the blower and all other temperature and other controls, including indication as to the manner in which the duct heater must be connected externally to be properly interlocked with the blower motor, if the blower motor control is not actually a part of the duct heater assembly, unless the duct heater is provided with an integral airflow switch.

B. Illustrations of essential features, showing the relation of components.

C. The method of mounting heaters individually or in groups in the duct. In the absence of any specific restrictions, it is to be presumed that heater frames may safely be in contact with combustible material and that the maximum number of heaters may be mounted in close proximity to one another in the duct.

D. The direction and the minimum velocity of the air in the duct and the maximum temperature of the inlet air for any specific arrangement of heaters. If the heater is the same size (cross-sectional area) as the duct, the velocity of the air may be specified as either linear feet (m) per minute or cubic feet (m^3) per minute; but if the heater can be employed in a larger duct, the velocity shall be specified in linear feet (m) per minute. See paragraph 45.3.

E. Specific instructions regarding any items which require particular care on the part of contractors or workmen.

F. Specific instructions regarding duct configuration, such as changes in size, turns or elbows, and the use of air filters, humidifiers, and the like, in relation to distance from the heater.

G. Any instructions for the user necessary to ensure the operation of the system as intended.

H. Detailed instructions regarding all features of installation and operation of the system as intended.

I. An indication that the minimum air flow requirements shall be met at any point over the face of the heater.

45.2 In a multistage heater in which two or more stages are identical, the wiring diagram in item A of paragraph 45.1 may show only one such stage, if it includes a statement giving the pertinent information about the stages not included in the diagram.

45.3 Because filters clog during intended use of the duct heater, the specified minimum air velocity in the manufacturer's instructions in item D of paragraph 45.1 shall be at least 11 percent higher than the minimum air velocity measured during the Limit-Control Cutout Test, Section 49.

46. Moisture

46.1 A duct heater through which air from a humidifier may pass, shall be so designed that water from the humidifier will be prevented from entering the control compartment or affecting any electrical equipment or wiring. See also paragraph 9.10 and Section 36.

47. Limit Controls

47.1 A duct heater shall incorporate one or more, as determined by applying paragraph 47.2, factory-installed, thermally operated automatic reset limit controls. Operation of the limit control(s) shall de-energize a sufficient number of heating elements to reduce temperature rises to values no more than those indicated in Table 31.2. See paragraph 48.13.

47.2 The number of automatic reset limit controls provided in a duct heater, or in several duct heaters mechanically fastened together to form a larger unit, shall be the larger of the values determined by applying items A and B below:

A. One control for each equal size module. The number of modules is equal to the product of X and Y. See Table 47.1 and paragraphs 47.4 and 47.5.

B. One control for the first 150 kilowatts or less of the rating of the heater, plus an additional control for each additional 150 kilowatts or less.

TABLE 47.1
X AND Y

Depth				Length			
Inches				Feet			
More Than	No More Than	(mm)	X	More Than	No More Than	(Meters)	Y
0	40	(0—1016)	1	0	10	(0—3.05)	1
40	80	(1016—2032)	2	10	20	(3.05—6.10)	2
80	120	(2032—3048)	3	20	30	(6.10—9.15)	3
120	160	(3048—4572)	4				
160	200	(4572—5080)	5				
200	240	(5080—6096)	6				

47.3 The position of the sensing element of each control, relative to the heating element or elements to which it is primarily intended to respond, is to be identical in each module.

47.4 With reference to Table 47.1 unless otherwise defined by the required markings, depth and length signify, respectively, the shorter and the longer dimensions of the rectangular assembly of the heating element proper in a direction perpendicular to the air flow during operation.

47.5 If the depth of the heater is greater than 240 inches (6096 mm) and/or length greater than 30 feet (9.15 m), the values of X and Y are determined from the following formulas, except that if the resulting quatient is not an integer, the next higher integer is to be used for value of X and/or Y. The terms in parentheses are to be used for metric values.

$$X = \frac{\text{Inches (mm)}}{40\ (1016)} \qquad Y = \frac{\text{Feet (m)}}{20\ (3.05)}$$

Paragraph 47.5 revised January 30, 1988

PERFORMANCE

48. General

48.1 In the selection of one or more test samples to represent a line of duct heaters, consideration is to be given to the volume of the heater, the size of the duct opening, and the wattage density of the unit (total W per square foot or per square m of duct-heater face area). If the manufacturer's instructions cover the multiple installation of duct heaters in various configurations, such as stacked vertically, lined up horizontally, or arranged in tandem, tests of multiple units may also be necessary.

Supply Connections

48.2 All tests are to be conducted with the heater or heaters supplied from a circuit of rated frequency and of voltage in accordance with paragraph 31.8. All components of the system are to be connected in accordance with the instructions mentioned in paragraph 45.1. If the instructions specify a downflow system or any other system not contemplated in these requirements, appropriate modification of the test procedure may be necessary.

Air Flow

48.3 If different values of air flow are specified for different combinations (numbers) of heaters that may be used in the main supply duct of the system, Normal Tests, Section 50, are to be conducted for each group of heaters using the minimum specified air flow for that group; but, in the Abnormal Tests, Section 51, only the minimum and maximum numbers of heaters are to be used. If a single value of air flow is specified for the system, only the maximum number of heaters for that air flow need be tested.

Paragraph 48.3 revised January 30, 1988

Inlet Air

48.4 Except as indicated in paragraph 48.5, the temperature of the inlet air to a heater or group of heaters under test is to be maintained at 25 ± 2°C (77 ± 4°F), except when the inlet air is the outlet air from another heater or group of heaters, in which case the inlet air temperature should be no less than the temperature of the outlet air of the other heater or heaters with which it is to be used. The inlet air should then be 38°C (100°F) minimum. In any case, both inlet and outlet air temperatures are to be observed and recorded, and the thermocouples employed are to be so located that they will not be affected directly by radiation from the heater elements.

48.5 The inlet air to a duct heater being tested for use with heat pumps is to be maintained at 25 ± 2°C (77 ± 4°F) for all of the applicable tests in paragraphs 51.4—51.7. All of these tests are then to be repeated with the inlet air to the duct heater increased to 38°C (100°F) minimum.

48.6 Air velocity may be measured by any recognized means; but if it is possible to measure the outlet air velocity only, the inlet air velocity is to be computed from the outlet air velocity.

48.7 The inlet air velocity may be computed by means of the formula:

$$V = \frac{PvK}{A\,(T_2 - T_1)}$$

where:

	Factor	USA Customary Units	Metric Units
V =	inlet air velocity	feet per minute	meters per second
P =	power input	kilowatts	kilowatts
v =	specific volume of air	cubic feet per pound mass	cubic meters per kilogram mass
K =	constant	132 (T_1 and T_2 in degrees C) 237 (T_1 and T_2 in degrees F)	1 (T_1 and T_2 in degrees C)
A =	duct cross-sectional area	square feet	square meters
T_1 =	inlet air temperature	as applicable	degrees C
T_2 =	outlet air temperature	as applicable	degrees C

Paragraph 48.7 revised January 30, 1988

Outlet Air

48.8 On the outlet side of the heater or heaters, the main supply duct is to terminate at and discharge into an attached outlet duct of the same cross-sectional area. The outlet duct is to extend away from and at right angles to the main supply duct for a distance of 36 inches (914 mm) or more, measured to the inside corner of the connected ducts. The inside surface of the outlet duct nearer the heater assembly is to be 18—24 inches (457—610 mm) from the nearest heater, unless some other distance is specified in the instructions. A grid consisting of nine thermocouples of identical length wired in parallel is to be installed in the outlet duct to measure the temperature of the outlet air. The thermocouples are to be located in a plane perpendicular to the axis of the duct, and (1) for a rectangular duct — each located at the center of an equal sized rectangular area with the areas arranged in three rows to cover the entire cross section, or (2) for a round duct — one located at the center and the others equally spaced along the circumference of a concentric circle having a radius of two-thirds of the duct radius. The grid is to be located no more than 6 inches (152 mm) downstream from the location nearest to the heater at which no thermocouple will be affected directly by radiation from the heating element, and not less than 6 inches from the outlet end of the outlet duct.

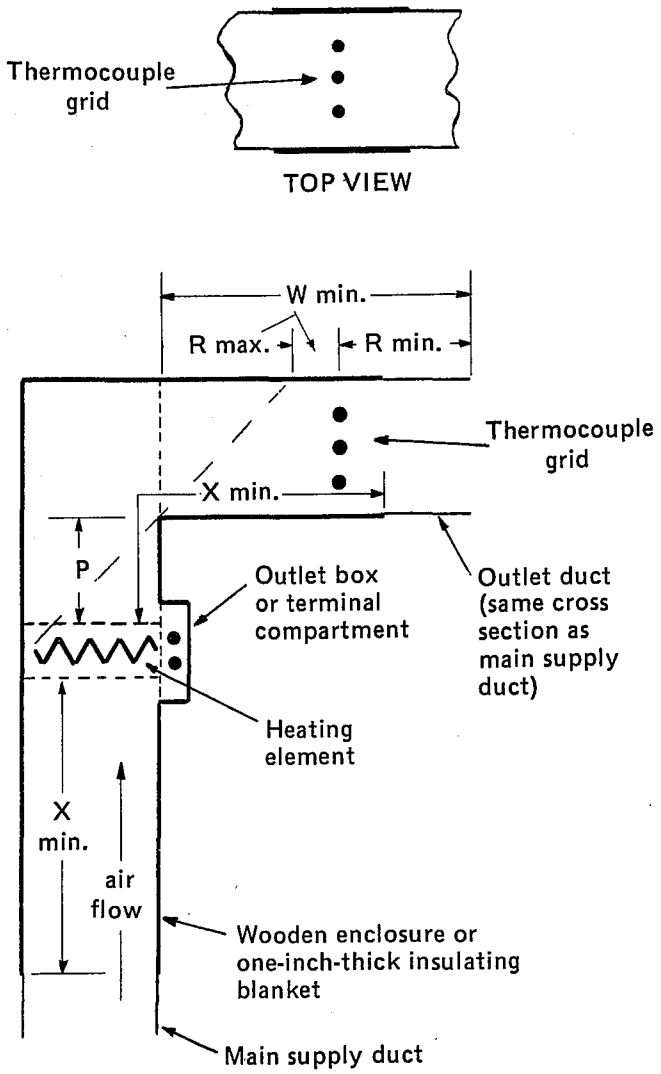
Test Enclosure

48.9 Except as noted in paragraph 48.12, a wooden test enclosure, see Figure 48.1, is to be employed to enclose the main supply, and outlet ducts, and is to extend at least 4 feet (1.2 m) on either side of the heater or heaters in the main supply duct. The enclosure is to be made of 3/4 inch (19 mm) plywood or boards having a nominal thickness of 1 inch. The inside surfaces are to be painted flat black, and all joints are to be sealed.

48.10 The enclosure is to house completely and be in direct contact with the main supply duct and the outlet duct, except that for a duct heater rated at more than 50 kilowatts, a definite clearance between the enclosure and combustible material may be specified by the manufacturer. If such a clearance is specified, that spacing is to be maintained between the heated surfaces of the equipment and the wooden enclosure. The terminal box or control compartment is to be enclosed by the wooden enclosure unless the installation instructions and the manufacturer's marking specify installation of the duct heater without the terminal box or control compartment being enclosed by adjacent surfaces.

48.11 If no clearance is specified, temperatures on the metal surfaces of the equipment, measured by means of thermocouples soldered to the metal, are to be observed and recorded. If a clearance is specified, temperatures on the inside surfaces of the wooden enclosure are to be observed and recorded.

FIGURE 48.1
ENCLOSURE FOR DUCT HEATERS[a]



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Dimensions

Code	Inch	Millimeters
P	21 ± 3	533 ± 76
R	6	152
W	36	914
X	48	1219

[a] This represents a side view of a vertical installation in which the air flow is up, and a plan view of a horizontal installation in which the air flow is horizontal.

48.12 As an alternative to the use of the previously mentioned wooden enclosure and, when no clearance is specified, an insulating blanket 1 inch (25 mm) thick and having a density no less than 1 pound per cubic foot (16 kg/m^3) may be wrapped closely around the outlet duct and the main supply duct and also the heater if the heater is of the exposed (flange) type.

Paragraph 48.12 revised January 30, 1988

Temperature

48.13 A duct heater shall be subjected to all the tests indicated in paragraphs 49.1—51.7. In each test the observed temperature rise above the temperature of the inlet air at any designated point shall be no more than the limits indicated in those paragraphs, and during the tests indicated in paragraphs 50.1—51.7, the temperature rise on any particular material shall be no higher than the specific rise given in Table 31.2, except that an additional 30°C (54°F) temperature rise is permissible during the first hour only of an abnormal test, see paragraphs 51.4—51.7. All tests shall be continued until the temperatures under observation become stabilized, except that if a manual reset limit control functions during an Abnormal Test, Section 51, the maximum temperature is to be observed without resetting the control.

48.14 The 1-hour interval mentioned in paragraph 48.13 begins with the initial operation of the first limit control to function in each abnormal test and is not to be repeated during that abnormal test.

49. Limit Control Cutout Test

49.1 A limit control, at the maximum setting allowed by its fixed stop shall prevent a duct heater system from delivering outlet air at a temperature higher than 93°C (200°F). The functioning of a manually resettable or nonresettable limit control or thermal cutoff during the test is not acceptable.

49.2 An automatic-reset limit control is to be adjusted to the maximum setting allowed by its fixed stop and to the maximum indicated differential setting. An adjustable manually resettable temperature control is to be set to the minimum allowable setting.

Replaces page 59 dated July 16, 1986

49.3 The velocity of the air in the duct is to be adjusted to a value 10 percent less than the specified minimum value in the manufacturer's instructions, see paragraph 45.3. The heater or heaters are to be energized and operation is to be continued until the temperature of the outlet air becomes stabilized. Then, with no other adjustment of the system, the inlet duct is to be slowly and uniformly restricted in such manner that the temperature of the outlet air increases approximately 1.1°C (2°F) per minute, but not faster, until the limit control operates to open the circuit to the heating elements, at which time the temperature of the outlet air is to be observed and recorded. See paragraph 49.4.

49.4 If the heater is not fully de-energized by operation of the limit control, the test is to be continued by further restricting the inlet air until the maximum outlet air temperature is determined.

50. Normal Tests

Continuous Operation

50.1 When a duct heater is operated under maximum conditions of intended use, the observed temperature rise at any point and on any material shall be no more than the value indicated in Table 31.2, except as indicated in paragraph 50.2.

50.2 The acceptance of temperature rises not more than those given in Table 31.2 is based on an inlet air condition of 25°C (77°F), as stated in paragraph 31.2. If a duct heater is intended to be used as a supplementary heat source with inlet air at temperatures higher than the above mentioned ambient condition, the maximum temperature rises should not exceed those specified in Table 31.2 minus the difference between the maximum specified inlet air temperature and 25°C.

50.3 The limit control or controls may be shunted out during the test, and the inlet is then to be slowly and uniformly restricted until the outlet air temperature is 3°C (5.4°F) lower than the outlet air temperature measured when the first limit control cuts out during the Limit Control Cutout Test, Section 49. The test is to be continued until the temperatures at all specified points have become stabilized.

Nuisance Tripping

50.4 At the conclusion of the continuous operation test, both the heater and the air-handling unit are to be de-energized simultaneously. Thermal cutoff(s) or nonresettable limit control(s) shall not operate thereafter.

Fan-Delay Control

50.5 During the intended operation of a duct heater provided with a fan-delay control and intended for installation in a horizontal duct, starting with the heater at room temperature, the fan control shall operate to prevent the air in the inlet duct from attaining a temperature higher than 90°C (194°F).

50.6 The operation (timing) of a fan-delay control shall be such that it will not cause tripping of the thermal limit control during the starting cycle of a duct heater.

50.7 A duct having a cross section the same as the air inlet opening in the heater is to be attached to the air inlet and extended vertically by means of a 90 degree elbow for 6 feet (1.8 m) above the top of the inlet opening. The limit control and the fan control are to be set for maximum temperature and minimum differential. During the test, the fan is to be completely removed from the system, and the end of the test will be determined by the operation of the fan control.

50.8 The temperature of the air in the vertical section of the duct is to be measured by three individual thermocouples in a horizontal plane 2 feet (610 mm) below the upper end of the duct. None of the three thermocouples is to indicate a temperature higher than 90°C (194°F) prior to the operation of the fan control.

51. Abnormal Tests

General

51.1 For each Abnormal Test, the heater or heaters shall be operated as intended until temperatures become stabilized before the abnormal condition is imposed.

51.2 A duct heater, when subjected to each of the following Abnormal Tests, shall comply with the requirements in paragraphs 29.1, 48.13, and 48.14.

51.3 In connection with the tests covered in paragraphs 50.4—51.7, all limit controls and resettable thermal cutoffs are to be adjusted to the maximum setting allowed by their fixed stops and to the minimum indicated differential setting. During the tests to determine the acceptability of the back-up safety control means, the automatic resetting limit control is to be shunted out of the circuit for all tests except for the preliminary limit control cutout test, see paragraphs 21.4 and 49.1.

Restricted Inlet

51.4 The test is to be conducted under the same conditions as in the continuous operation test, paragraphs 50.1—50.3, except that the limit control is not to be shunted out, and is to be continued until the temperature of the outlet air becomes stabilized. The inlet duct is then to be slowly and uniformly restricted until operation of the heater is interrupted by the functioning of the thermal limit control.

51.5 Except as indicated in paragraph 21.8, the rate of restriction from the condition of the continuous operation test is to be sufficient to cause the outlet air temperature to increase approximately 1.1°C (2°F) per minute, but not faster. The system is to be permitted to function without any further adjustment until temperatures become stabilized, following which the inlet duct is to be further restricted until the resulting temperatures are the maximum that occur with any amount of restriction.

Fan Failure

51.6 The system is to be allowed to resume stabilized operating temperatures as in the continuous operation test, after which the blower is to be stopped and operation continued with the limit control functioning to interrupt the heating element circuit. The system is to be permitted to function without any further adjustment until temperatures become stabilized.

Blocked Outlet

51.7 The duct heater is again to be allowed to resume stabilized operating temperatures as in the continuous operation test with the fan operating. The outlet duct is then to be blocked completely and operation continued without any further adjustment until temperatures become stabilized.

MARKINGS

52. General

52.1 The supplementary markings of a duct heater shall include, in addition to the items mentioned in (Marking) Supplementary, Section 43, a specific wiring diagram for the heater including the information mentioned in item A of paragraph 45.1; an indication, if required, of the direction of the air flow through the heater; and a reference to instructions relating to inlet air temperatures, velocities, and the like.

Paragraph 52.1 revised July 16, 1986

52.2 If spacings between combustible material and the duct in which a duct heater is installed must be no less than a specified distance to prevent attainment of excessive temperatures on that material (see paragraph 31.1), the heater shall bear a warning marking on the nameplate to convey this information. See paragraph 44.5.

Revised paragraph 52.2 effective October 18, 1988

52.3 The spacings mentioned in paragraph 52.2 shall be given in integral inches, that is, not inclusive of fractions of an inch.

CENTRAL HEATING FURNACES

CONSTRUCTION

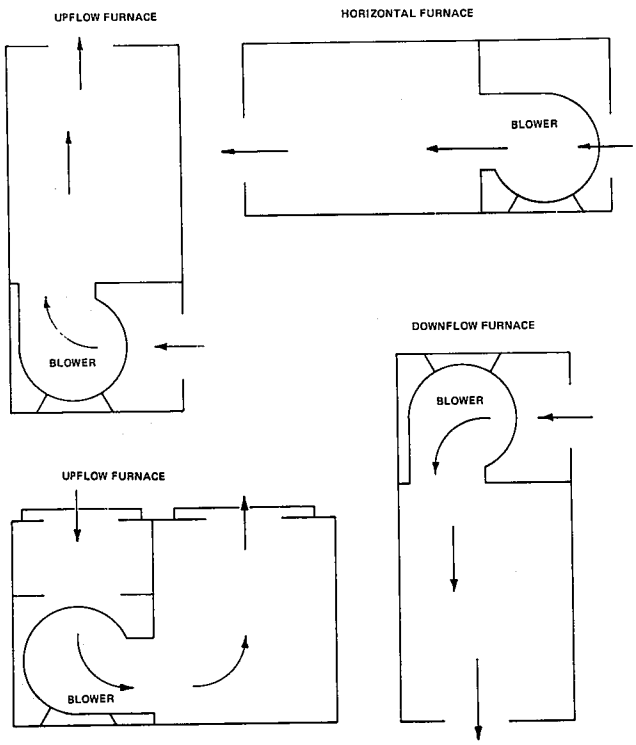
53. General

53.1 Requirements under this heading apply to central heating furnaces (to be referred to as furnaces) and are supplementary to those given in Sections 1—43. These requirements do not cover air-cooling equipment, electronic filters, nor comparable accessories, usually optional, that may be available as parts of a complete central-furnace or air-conditioning system.

53.2 A furnace consists essentially of an electric heating element or elements with or without a motor-driven fan or blower, provided with appropriate operating and safety controls, and housed within a sheet metal enclosure designed to be connected to a duct system for the transmission of heated air to designated spaces.

53.3 A furnace of the gravity type depends primarily on the density of heated air for its circulation as intended, but may have a booster fan that does not materially restrict the free flow of air when inoperative. In a furnace of the forced air type, a fan or blower is the primary means of circulating the air; and such a furnace is commonly designated also as of the upflow, downflow, or horizontal type depending upon the intended, essential direction of the air flow and the relative location of the air-discharge outlet. See Figure 53.1. A forced air furnace is likewise designated as an attic type if its design is such that it is intended for installation in an attic or comparable normally unoccupied location.

FIGURE 53.1
TYPES OF FORCED-AIR CENTRAL FURNACE[a]



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a The arrows indicate the direction of air flow.

54. Instructions

54.1 Instructions for the installation and operation of a furnace shall be provided. The instructions shall include the following items:

A. A complete electrical diagram of the furnace heating system, showing the connections of the power supply, the blower, any electrically operated accessories that are employed, and all temperature and other controls.

B. Illustrations of essential features, showing the relation of component parts and accessories, including any separate furnace mounting base. See paragraph 55.11.

C. An indication of the minimum installation clearances required to be maintained between combustible material and the furnace, plenum, and connected warm air duct in order to reduce the risk of fire. Clearances for a furnace for use in other than mobile homes shall be given in integral inches, that is, not inclusive of fractions of an inch.

D. Specific instructions regarding any items which require particular care on the part of contractors or workmen.

E. The general method of installing the supply plenum and ducts and the return air duct or other return air means. See paragraph 58.12.

F. An indication that applicable installation codes may limit the furnace to installation only in a single story residence if there is no provision for a return air duct, or if the instructions indicate that a return air duct need not be used.

G. If the furnace is intended only for connection of an outlet duct or plenum having a round cross section, an indication of the minimum size of right angle bend to be connected to the outlet opening.

Paragraph 54.1 revised July 16, 1986

55. Assembly

55.1 A furnace designed for installation in a mobile home shall have provision for permanent mounting. See paragraph 4.2.

55.2 If a furnace is not furnished as a complete unit, separate sections or parts that are designed to be united at the point of installation shall be as few as practicable and shall be capable of being assembled together as intended without further processing. For any intended installation, it shall not be necessary to alter or remove any baffle, insulation, or radiation shield provided with the furnace, if such alteration or removal would result in a construction not complying with the requirements of this standard.

55.3 If a furnace is so designed that it can be installed in the field with inlet air ducts attached in any of several positions, that is, upflow, or horizontal left or right, a complete enclosure shall be provided except for the opening required at the position where the duct is attached.

55.4 The requirement in paragraph 55.3 will necessitate provision of either removable panels that can be moved to obtain the opening at the desired location or provision of an inlet area with complete enclosure that can be cut, as required, to permit attachment of the inlet air duct. See paragraph 54.1.

55.5 A furnace through which air from a cooling coil or humidifier may pass shall be so designed that water will be prevented from entering the furnace or affecting any electrical equipment or wiring; and interior surfaces of the furnace with which the air stream may come in contact shall be resistant to corrosion. See Table 28.4 and paragraph 28.7.

55.6 If a furnace has provision for installation of a cooling coil, field or factory installed, a condensate pan shall be provided as part of the furnace or cooling coil. Such a pan shall be so designed and located that overflow due to a blocked drain will not wet uninsulated live parts or enamel insulated wire.

55.7 A furnace shall have provision for the connection of inlet air and outlet air ducts, except that a furnace having installation instructions including the indication specified in item F of paragraph 54.1 need not have provision for the connection of an inlet air duct.

55.8 With reference to paragraph 55.7, duct flanges provided for an opening are acceptable; or openings without flanges or marked opening locations are acceptable provided drilling or cutting into the cabinet, or using screws, will not damage components or wiring within the enclosure. In general, a distance of 6 inches (152 mm) from the opening is considered adequate to prevent damage due to drilling or cutting.

55.9 An integral plenum of a furnace intended for alcove or closet installation shall have only one outlet air opening unless any additional opening is furnished with means for closing it completely.

55.10 A furnace with an inlet or outlet duct that penetrates the building structure that supports the furnace shall be provided with a mounting base of noncombustible material so designed that, after the furnace is installed, there will be no open passages through the supporting structure that would permit flame or hot gases from a fire originating in the space below the supporting structure to travel to the space above that structure. If the furnace is intended to be installed on a supporting structure of combustible material, the base shall be so designed that the requisite clearance will be maintained between the supporting structure and the furnace, plenum, and attached duct. Spacers necessary to provide required clearances shall be attached to the furnace mounting base and shall extend not less than 3 inches (76 mm) below the upper surface of the supporting structure, except that, in a furnace designed for use only in a mobile home, the distance shall be not less than 3/4 inch (19 mm).

55.11 The furnace mounting base mentioned in paragraph 55.10 may be furnished as a separate member or members, and need not be shipped with the furnace if not needed for every intended installation. See paragraph 63.5.

55.12 The surface of the furnace mounting base in contact with the floor shall have no projections. Recessed flathead screws or rivets shall be used.

56. Limit Controls

56.1 A furnace shall incorporate a thermally operated automatic resetting limit control (factory installed) that, when a temperature higher than a predetermined limit is attained, will de-energize a sufficient number of heating elements to reduce temperature rises to values no more than those indicated in Table 31.2. The limit control shall comply with the requirements in paragraph 26.7. See also Fan-Control and Thermal Back-Up Protection, Section 21.

57. Air Filters

57.1 An air filter shall be recognized for the purpose.

PERFORMANCE

58. General

Supply Connections

58.1 All tests are to be conducted with the furnace and any accompanying electrical accessories that are intended to function with the operation of the furnace supplied from a circuit of rated voltage and frequency, see paragraphs 31.8 and 31.9, and with all electrical components connected in accordance with the instructions mentioned in paragraph 54.1.

Types of Installations

58.2 Temperature tests may be conducted for open, closet, or alcove installations, on combustible or noncombustible floors; see Test Enclosures, Section 59. These tests may also evaluate the suitability of the furnace for installation in attics, see paragraph 58.29, or in mobile homes. A furnace intended for mobile home use is tested only for (1) alcove or closet installation, and (2) for installation on a combustible floor.

Assembly, Leveling, and Adjustable Features

58.3 All tests are to be conducted with the furnace completely assembled, see paragraph 55.3, and with all components mechanically connected in accordance with the instructions. If a furnace is intended to employ one or more air filters, all filters are to be in place and are to be of the largest size that the furnace will accommodate.

58.4 All tests are to be conducted with the furnace level. Detachable leveling means are to be removed, and any leveling means that are not detachable are to be so adjusted that the base of the furnace will be the minimum distance from the floor.

58.5 If a furnace employs a fan or blower whose speed can be varied and is intended to be set only by the installer, all tests are to be conducted with the fan speed adjusted to give approximately the rated air delivery. See paragraph 58.6.

58.6 The Limit Control Cutout Test, Section 60, is to be performed with the fan speed adjusted to the highest setting indicated by the installation instructions, and is to be repeated at the lowest setting. This includes adjustment of any adjustable pulley in accordance with the installation instructions. At each such setting the furnace shall comply with the requirement in paragraph 60.1.

58.7 If a furnace employs an adjustable component that is intended to be regulated by the user, and if its setting could affect temperature test results, all tests are to be conducted with the component adjustment most likely to produce maximum temperatures or develop faulty performance.

Static Pressure

58.8 The static pressure in the outlet plenum, with reference to external atmospheric pressure, is to be in accordance with paragraphs 60.3, 61.2, and 61.5, with the initial static pressure values specified in Tables 58.1 and 58.2 in accordance with paragraph 58.9. Static pressure is to be observed by means of an inclined tube manometer gauge reading in inches or mm of water column, having an accuracy of $\pm$ 0.0025 inch (0.06 mm) and capable of being read directly to 0.005 inch (0.13 mm).

TABLE 58.1
STATIC PRESSURE FOR FURNACE NOT EQUIPPED WITH AIR-CONDITIONING EVAPORATOR COIL

Input to Furnace in Kilowatts	Static Pressure in Plenum in Inches (mm) of Water Column[a]
15 or less	0.12 (3.05)
15.1—20	0.15 (3.81)
20.1—40	0.20 (5.08)
Over 40	0.25 (6.35)

[a]For a furnace not employing an air filter, add 0.08 inch (2.03 mm) to the applicable pressure in the table. A greater static pressure is to be maintained during the tests if so recommended by the manufacturer of the furnace.

Table 58.1 revised January 30, 1988

TABLE 58.2
STATIC PRESSURE FOR FURNACE EQUIPPED WITH AIR-CONDITIONING EVAPORATOR COIL[a]

Standard Cooling Rating		External Resistances	
Thousands of Btu/Hr.	Thousands of Watts	Inches of Water	Millimeters of Water
42 or less	12.3 or less	0.15	3.81
43—70	12.6—20.5	0.20	5.08
71—105	20.8—30.8	0.25	6.35
106—140	31.1—41.0	0.30	7.62
141—210	41.3—61.5	0.35	8.89
211—280	61.8—82.1	0.40	10.16
281—350	82.3—103	0.45	11.43

a
For a furnace not employing an air filter add 0.08 inch (2.03 mm) to the applicable pressure in the table. If the static pressure recommended by the manufacturer is higher than the applicable value in the table, the static pressure recommended by the manufacturer is to be used.

58.9 The furnace is to be tested at the static pressure indicated in Table 58.1 if it is not equipped with an air-conditioning evaporator coil, and at the static pressure indicated in Table 58.2 if it is equipped with such a coil. If the evaporator coil is an optional component, the furnace is to be tested at the static pressure indicated in Table 58.1 without the coil installed and also at the static pressure indicated in Table 58.2 with the coil installed.

58.10 A hole 0.040 inch (1.02 mm) in diameter is to be drilled through the wall of the plenum; and the inner surface of the wall adjacent to the hole is to be smooth and free from irregularities. A metal tube having an internal diameter of 3/16 inch (4.8 mm) or larger is to be centered over the hole and soldered to the outside surface of the plenum. Connection of this tube to the manometer gauge is to be made by rubber tubing or the equivalent.

Inlet Air

58.11 All tests are to be conducted with the temperature of the inlet air maintained as closely as possible at 25°C (77°F), except that the temperature may be as high as 40°C (104°F). See paragraphs 60.3, 61.2, 61.3, and 61.6.

58.12 If the air inlet opening is not built into a furnace cabinet, its location and minimum area or dimensions are to be as specified in the instructions. The cross-sectional area and shape of the connected inlet duct are to be the same as those of the inlet opening in the furnace, and the duct is to be extended 12 inches (305 mm) or more beyond the test enclosure. A modified inlet duct for the fan-delay-control test of a horizontal furnace is described in paragraph 61.9.

58.13 In a gravity type furnace, the area of the air inlet opening, or openings, is to be equal to the area of the air outlet opening, or openings. If there are two air inlet openings, they are to be of the same size and shape.

58.14 The temperature of the inlet air is to be measured by means of a thermocouple so shielded that it will not be affected directly by radiation from the heating elements. The thermocouple is to be centrally located at the furnace inlet opening.

Replaces page 65 dated July 15, 1986

Outlet Air

58.15 If the outlet plenum is not an integral part of the furnace, a metal plenum is to be provided for the temperature tests and is to be connected to the furnace in the intended manner. The cross-sectional area and shape of the plenum are to be the same as those of the air outlet opening in the furnace. If the furnace is intended only for connection to an outlet duct or plenum having a round cross section, the ductwork connected to the air outlet opening is to be the minimum size indicated in the instructions; see item G of paragraph 54.1. For furnaces intended for connection to rectangular ducts, the surface of the ductwork facing the air outlet opening is to be located in accordance with paragraphs 58.16—58.19.

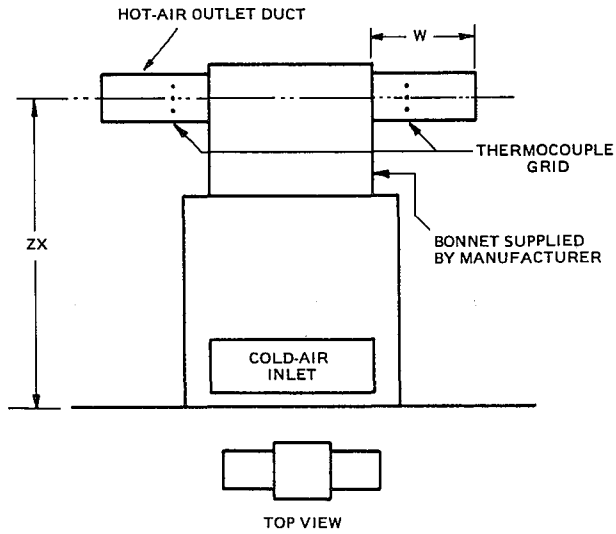
58.16 For a forced air horizontal furnace, the surface facing the outlet air opening is to be spaced from the furnace casing a distance not more than the square root of the opening area.

58.17 For a forced air upflow furnace, the surface facing the outlet air opening is to be spaced from the furnace casing a distance not more than the square root of the opening area except that the height of the plenum is not to exceed a value which will result in less than the manufacturer's specified overhead clearance between the upper surface of the plenum and the test enclosure ceiling located in accordance with paragraph 59.3, 59.7, or 59.8.

58.18 For a forced air downflow furnace, the plenum surface facing the outlet air opening is to be spaced from that opening (1) 12 inches (305 mm) plus the square root of the outlet opening area for a furnace not intended for use in a mobile home, or (2) 1 inch (25.4 mm) plus the square root of that area for a mobile home furnace. However, in either case, the spacing may be increased if necessary to obtain the required clearance from the upper surface of the outlet duct. The plenum surface facing the outlet air opening may be spaced from that opening less than indicated in this paragraph if agreeable to all concerned in order to employ one size plenum for horizontal, and/or upflow, and downflow installation.

58.19 For a gravity type furnace, the height of a separate vertical outlet plenum is to be such that the center line of connected horizontal warm air ducts will be 8 feet (2.4 m) above the floor, as indicated in Figure 58.1.

FIGURE 58.1
PLAN OF DUCTS FOR GRAVITY FURNACE



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Dimensions

Code	Inch	Millimeter
W	36	915
ZX	96	2438

58.20 An air outlet duct connected to the outlet plenum is to be extended 12 inches (305 mm) or more beyond the test enclosure, and arranged to discharge away from the air inlet to the furnace and away from the air inlet (in the door) to the test enclosure for a closet installation.

58.21 The opening in a test enclosure through which an outlet duct passes is to have the clearance space filled with insulating material and sealed.

58.22 A gravity type furnace is to be provided with two horizontal air outlet ducts, each 3 feet (0.9 m) in length, and having the same cross-sectional shape. The cross-sectional area of each duct in square inches (m^2 x 1550) is to be 15 times the furnace input in kilowatts.

58.23 The temperature of the outlet air in an outlet duct is to be measured by means of a grid consisting of nine thermocouples of identical length and wired in parallel. The thermocouples are to be located in a plane perpendicular to the axis of the duct, and (1) for a rectangular duct — each located at the center of an equally sized rectangular area with the areas arranged in three rows to cover the entire cross section, or (2) for a round duct — one located at the center and the others equally spaced along the circumference of a concentric circle having a radius of two-thirds of the duct radius.

58.24 In a forced air furnace, the grid is to be located not more than 6 inches (152 mm) downstream from the location nearest the plenum where no thermocouple will be affected directly by radiation from the heating elements, and not less than 6 inches (152 mm) from the outlet end of the duct.

58.25 In a gravity type furnace, the grid is to be located 12—24 inches (305—610 mm) from the outlet end of the duct and is to be further shielded if necessary to prevent any thermocouple from being affected directly by radiation from the heating elements.

Temperature

58.26 A furnace shall be subjected to all of the tests indicated in paragraphs 61.1—62.5. The observed temperature rise at any designated point and on any particular material shall be no more than the rise given in Table 31.2; except that (1) an additional 30°C (54°F) rise is permissible during the first hour of an abnormal test, and (2) a temperature rise of 115°C (207°F) on Class A insulation in a motor is permissible during the abnormal tests, paragraphs 62.3—62.5. All tests shall be continued until the temperature under observation becomes stabilized; except that, if a manual reset limit control functions during an abnormal test, the maximum temperature is to be observed without resetting the control.

58.27 The 1-hour interval mentioned in paragraph 58.25 begins with the initial operation of the limit control in each abnormal test.

58.28 In connection with each abnormal test, paragraphs 62.3—62.5, the furnace shall be operated as intended until temperatures become stabilized before the abnormal condition is imposed.

58.29 The temperature at a point on the external surface of an attic furnace except on the bottom, is to be determined by means of a thermocouple attached to the metal surface by soldering or brazing and covered with a pad of fire and heat resistive insulating material 6 inches square by 0.4 inch thick (152 mm square by 10.2 mm thick). This measurement is not necessary on furnaces which have been tested for horizontal installation with zero clearances to all surfaces of the furnace casing.

59. Test Enclosures

Open Installations

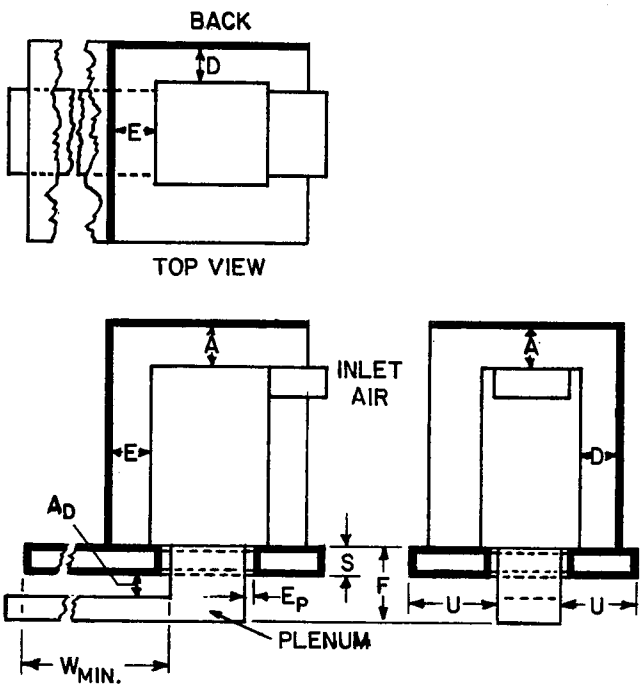
59.1 All tests of a furnace intended for open installation, for example, for installation other than in an alcove, closet, or attic, are to be conducted with the furnace installed in a partial enclosure as in paragraph 59.2 and illustrated in Figures 59.1 and 59.2.

59.2 If one side of the furnace is likely to attain higher temperatures than the other, the warmer side is to be adjacent to one of the side walls of the test enclosure. The various clearances between the furnace and the enclosure are to be as specified in the instructions, see item C of paragraph 54.1, and in the marking on the furnace, see paragraph 63.2.

59.3 The partial enclosure is to consist of two adjoining vertical walls at right angles to each other and a horizontal ceiling, all of 3/4 inch (19 mm) plywood or of boards having a nominal thickness of 1 inch (25 mm). All interior surfaces of the enclosure are to be painted flat black, and all joints are to be tight or sealed. The dimensions of the walls are to be such that they will provide a support for the ceiling at whatever height is necessitated by the specified test conditions or clearances, and will extend 3 feet (0.9 m) beyond the side and front of the furnace. The dimensions of the rectangular ceiling are to be the respective lengths of the two side walls.

59.4 If the furnace is intended to be installed on a noncombustible floor, the floor of the partial enclosure is to be of noncombustible material, such as stone, brick, or concrete. If the furnace is intended to be installed on a combustible floor, the floor of the partial enclosure is to consist of softwood boards or plywood as described in paragraph 59.3.

FIGURE 59.1
ENCLOSURE — DOWNFLOW FURNACE;
OPEN INSTALLATION — COMBUSTIBLE FLOOR



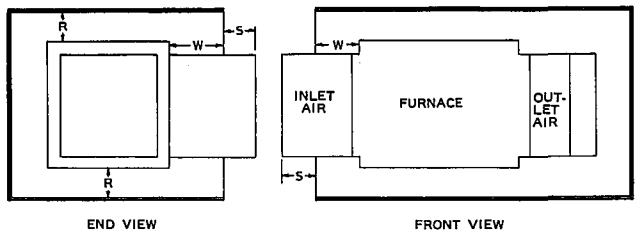
A — Clearance from the top of the furnace casing to the enclosure.
A_D — Clearance to the enclosure from the horizontal warm air duct within 3 feet (915 mm) of the furnace.
D — Clearance from the back of the furnace to the enclosure.
E — Clearance from the side of the furnace to the enclosure.
E_P — Clearance from the side of the supply plenum to the enclosure.
F — Plenum dimension. See paragraphs 58.15 and 58.18.

Dimensions

Code	Inch	Millimeters
S	12	305
U	24	610
W	36	915

Figure 59.1 revised July 16, 1986

FIGURE 59.2
ENCLOSURE FOR HORIZONTAL FURNACE —
OPEN INSTALLATION



CD 25-4

Dimensions

Code	Inch	Millimeters
R	6	152
S	12	305
W	36	915

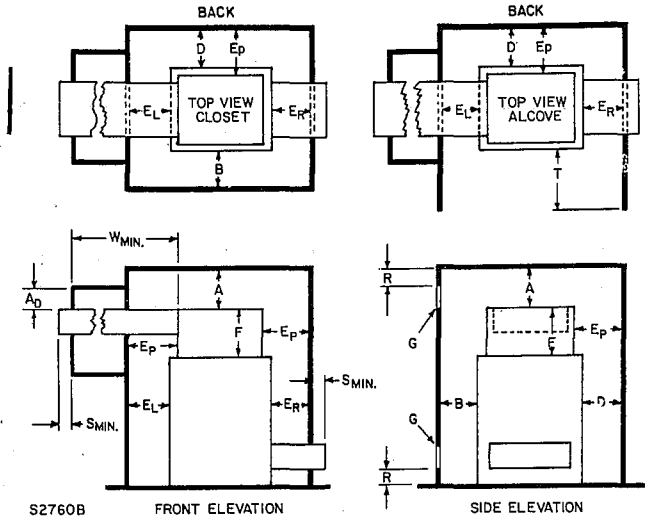
59.5 For a downflow furnace intended to be installed on a combustible floor, see Figure 59.1, a horizontal, simulated ceiling of the same material as the test enclosure is to be so located that its lower surface is 12 inches (305 mm) below the upper surface of the floor of the test enclosure. The clearance between the outlet duct and this ceiling is to be as specified. The ceiling is to extend at least 3 feet (0.92 m) beyond the plenum, and not less than 2 feet (0.6 m) beyond each side of the duct.

Paragraph 59.5 revised July 16, 1986

Closet or Alcove Installations

59.6 All tests of a furnace intended for installation in a closet or alcove are to be conducted with the furnace, plenum, and ducts installed in an enclosure as described in paragraphs 59.7—59.12 and illustrated in Figures 59.3—59.6. The various clearances between the furnace and the attached ductwork and the test enclosure are to be as specified in the instructions, see item C of paragraph 54.1, and in the markings on the furnace, see paragraph 63.2.

FIGURE 59.3
ENCLOSURE FOR ALCOVE OR CLOSET
INSTALLATION — UPFLOW FURNACE



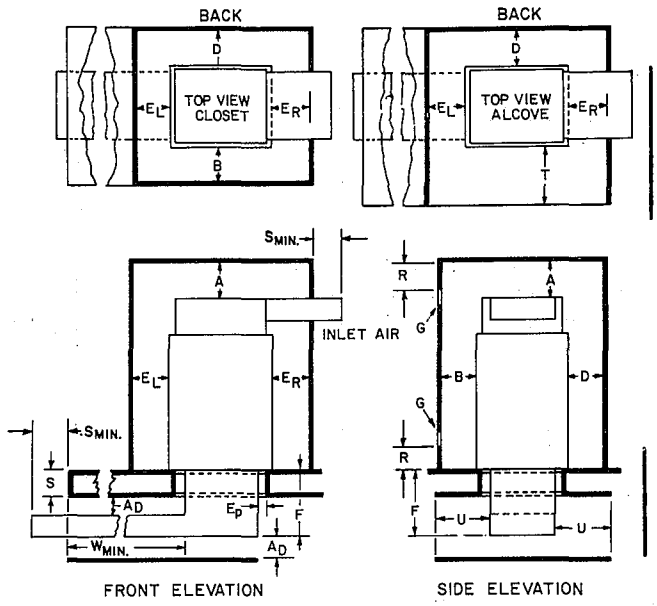
- A — Clearance from the top of the furnace casing or plenum to the enclosure.
- A_D — Clearance to the enclosure from the horizontal warm air duct. See paragraph 59.9A.
- B — Clearance from the front of the furnace to the enclosure.
- D — Clearance from the back of the furnace to the enclosure.
- E_L — Clearance from the left side of the furnace to the enclosure.
- E_R — Clearance from the right side of the furnace to the enclosure.
- E_P — Clearance to the enclosure form any side of the outlet plenum.
- F — Plenum dimension. See paragraphs 58.15 and 58.17.
- G — Ventilating openings.

Dimensions

Code	Inches	Millimeters
R	6	152
S	12	305
T	18	456
W	36	915

Figure 59.3 revised January 30, 1988

FIGURE 59.4
ENCLOSURE FOR ALCOVE OR CLOSET
INSTALLATION — DOWNFLOW RESIDENTIAL FURNACE



- A — Clearance from the top of the furnace casing or plenum to the enclosure.
- A_D — Clearance to the enclosure from the horizontal warm air duct. See paragraph 59.9A.
- B — Clearance from the front of the furnace to the enclosure.
- D — Clearance from the back of the furnace to the enclosure.
- E_L — Clearance from the left side of the furnace to the enclosure.
- E_R — Clearance from the right side of the furnace to the enclosure.
- E_P — Clearance to the enclosure form any side of the outlet plenum.
- F — Plenum dimension. See paragraphs 58.15 and 58.17.
- G — Ventilating openings.

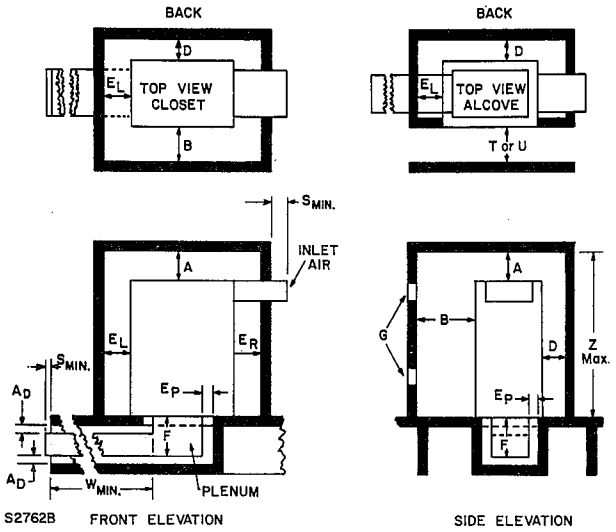
Dimensions

Code	Inches	Millimeters
R	6	152
S	12	305
T	18	456
U	24	610
W	36	915

Figure 59.4 revised January 30, 1988

Replaces page 69 dated July 16, 1986

FIGURE 59.5
ENCLOSURE FOR ALCOVE OR CLOSET INSTALLATION — DOWNFLOW MOBILE-HOME FURNACE



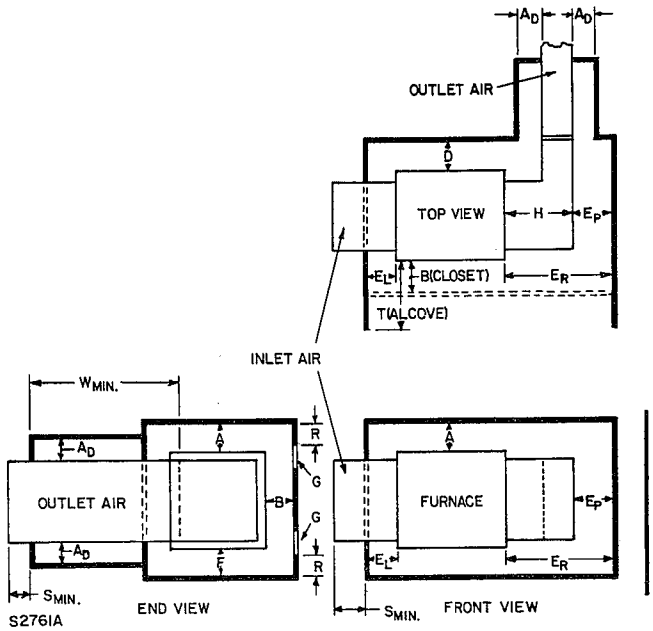
- A — Clearance from the top of the furnace casing or plenum.
- A_D — Clearance from horizontal warm air duct of furnace designed for connection of ducts. See paragraph 59.9A. If not specified, furnace is not designed for ducts.
- B — Clearance from front of furnace.
- D — Clearance from back of furnace.
- E_L — Clearance from left side of furnace.
- E_R — Clearance from right side of furnace.
- E_P — Clearance from any side of supply plenum and warm air duct within 3 feet (915 mm) of furnace. The dimension is specified only for a furnace to be equipped with an external plenum for connection to a duct system; its omission, and A_D is specified, indicates a furnace equipped with an integral plenum, and if the furnace is otherwise installed, clearances specified are not valid.
- F — Plenum dimension. See paragraphs 58.15 and 58.18.
- G — Ventilating openings.

Dimensions

Code	Inches	Millimeters
S	12	305
T	18	456
U	24	610
W	36	915
Z	84	2134

Figure 59.5 revised January 30, 1988

FIGURE 59.6
ENCLOSURE FOR ALCOVE OR CLOSET INSTALLATION — HORIZONTAL FURNACE



- A — Clearance from the top of the furnace casing or plenum to the enclosure.
- A_D — Clearance to the enclosure from the horizontal warm air duct. See paragraph 59.9A.
- B — Clearance from the front of the furnace to the enclosure.
- D — Clearance from the back of the furnace to the enclosure.
- E_L — Clearance from the left side of the furnace to the enclosure.
- E_R — Clearance from the right side of the furnace to the enclosure.
- E_P — Clearance from any side of the supply plenum to the enclosure.
- F — Clearance from the bottom of a suspended furnace to the enclosure.
- G — Ventilating Openings.
- H — See paragraph 58.15.

Dimensions

Code	Inches	Millimeters
R	6	152
S	12	305
T	18	456
W	36	915

Figure 59.6 revised July 16, 1986

Replaces page 70 dated July 16, 1986

59.7 The enclosure is to consist of a vertical back wall, two adjoining vertical side walls parallel to each other and at right angles to the back wall, and a horizontal ceiling, all of softwood, plywood or boards, as described in paragraph 59.3. All inside surfaces of the enclosure are to be painted flat black, and all joints are to be tight or sealed. The height of the ceiling, which is to be supported by the side walls, is to be 7 feet (2.1 m) for a mobile home furnace and 7-1/2 feet (2.3 m) for any other furnace, unless a lower ceiling is necessary to provide the specified clearance to the top of the furnace or plenum, or a higher ceiling is permitted in accordance with paragraph 59.8. The dimensions of the rectangular ceiling are to be the respective lengths of the back and side walls.

†*Additional page*

59.8 If the furnace is marked in accordance with paragraph 63.6, the height of the ceiling may be increased to no more than the marked minimum ceiling height.

59.9 If the furnace is intended only for connection to an outlet duct or plenum having a round cross section and clearances are specified in the instructions, the test enclosure for these parts is to consist of sheet metal cylinders having the inside surfaces painted flat black and having the exterior wrapped with an insulating blanket as specified in paragraph 59.12. The cylinders are to be mounted concentrically with the ductwork to provide the specified clearances.

Paragraph 59.9 revised January 30, 1988

59.9A The test enclosure is to extend around the outlet duct at least 3 feet (0.92 m) beyond the plenum. If the specified duct clearance is greater than zero, the enclosure is to be constructed to maintain (1) this clearance for a distance of 3 feet from the plenum, and (2) zero clearance for at least an additional 1 foot (0.3 m).

Exception: If the clearance markings specified in paragraph 63.2 include a specific distance of less than 3 feet, the test enclosure is to be constructed to maintain that clearance for the specified distance, but the other minimum dimensions for the enclosure are still applicable.

Paragraph 59.9A added July 16, 1986

59.10 For an alcove installation, a supplementary vertical wall of the same size and material as the back wall is to be placed opposite the open end of the enclosure. For a mobile home furnace, this wall is to be located at a distance of 1-1/2 or 2 feet (0.46 or 0.6 m), as specified, and the side walls of the enclosure are to terminate flush with the front of the furnace. For all other furnaces this wall is to be located at a distance of 2, 3, or 4 feet (0.6, 0.9, or 1.2 m) from the front of the furnace, as specified, and the side walls of the enclosure are to extend 1-1/2 feet (0.46 m) beyond the front of the furnace.

59.11 For a closet installation, a door of the same size and material as the back wall is to be attached to the front edges of the side walls of the enclosure. Ventilating openings in the door are to be provided only if specified in the installation instructions.

59.12 As an alternative to the use of the previously mentioned wooden enclosure and when zero clearance is specified, an insulating blanket 1 inch (25.4 mm) thick and having a density no less than 1 pound per cubic foot (16 kg/m^3) may be wrapped closely around the furnace casing, plenum, or outlet duct.

Paragraph 59.12 revised July 16, 1986

59.13 If the furnace is intended to be installed on a combustible floor, the floor of the test enclosure is to be in accordance with paragraph 59.4, and if the furnace is of the downflow type, the test enclosure is to include the ceiling described in paragraph 59.5.

60. Limit Control Cutout Test

60.1 A limit control, at the maximum setting allowed by its fixed stop, shall prevent a furnace from delivering outlet air at a temperature higher than 93°C (200°F), except that the maximum limit is 121°C (250°F) in the case of a gravity-type furnace or a forced air upflow furnace tested for open installation as defined in NFPA Standards 90A and 90B, see paragraph 1.4. To preclude nuisance tripping, the functioning of an auxiliary limit control or a supplementary thermal control during the test shall not be acceptable.

60.2 An automatic-reset type limit control is to be adjusted to the maximum setting allowed by its fixed stop. An adjustable auxiliary limit control is to be set to the minimum allowable setting.

60.3 For this test, the temperature of the inlet air is to be regulated as closely as possible to 25°C (77°F), but not less than 23°C (73.4°F). The furnace is to be placed in operation with no inlet duct restriction except for an air filter, if provided in the assembly. The outlet duct is to be restricted to establish the static pressure specified in Table 58.1 or 58.2, whichever applies, and operation is to be continued until all surface and air temperatures become stabilized. Then, with no other readjustment of the system, the inlet duct is to be slowly and uniformly restricted until the first limit control operates to open the circuit to the heating elements, at which time the temperature of the inlet and outlet air is to be observed and recorded. The rate of restriction from the condition of the static pressure specified in Table 58.1 or 58.2 is to be sufficient to cause the outlet-air temperature to increase at approximately 1.1°C (2°F) per minute, but not faster. If more than 10 minutes is required until the first limit control opens, the specified rate of restriction need only apply to the final 10 minute period prior to functioning of that limit control. If more than one limit control is provided, the inlet duct is to be further restricted at the same rate until the duct is fully blocked or until all limit controls are open, whichever condition occurs first. Outlet air temperature shall not exceed the values specified in paragraph 60.1 at any time during the test.

61. Normal Tests

Continuity of Operation

61.1 Except as indicated in paragraph 61.3, the limit control of a furnace shall not function when the furnace is operated under conditions of intended use and in accordance with paragraph 61.2.

61.2 For this test, temperature of the inlet air is to be regulated as closely as possible to 25°C (77°F), but not less than 23°C (73.4°F). The furnace is to be placed in operation with no inlet duct restriction except for an air filter if provided in the assembly. The outlet duct is to be restricted to maintain the static pressure specified in Table 58.1 or 58.2.

61.3 If the temperature of the inlet air (T_1) is higher than 25°C (77°F), the limit control may function during this test, in which case the temperature of the outlet air (T_2) is to be measured when the limit control functions. The limit control is then to be shunted out and the test continued, with no change in the temperature of the inlet air, until the temperature of the outlet air (T_3) becomes stabilized. The result is acceptable if T_3 minus T_2 is not greater than the difference between T_1 and 25°C.

Normal Temperature

61.4 When a furnace is operated under maximum conditions of intended use, the observed temperature rise at any designated point and on any particular material shall not be higher than the specified rise given in Table 31.2.

61.5 During this test, the limit control is to be short-circuited. The inlet and outlet ducts are to be restricted so as to maintain the static pressure specified in Table 58.1 or 58.2 and an outlet air temperature in accordance with paragraph 61.6.

61.6 The difference between the inlet and outlet air temperatures during the test is to be 3°C (5.4°F) less than the difference measured at the time of operation of the first limit control during the Limit Control Cutout Test, Section 60.

Fan-Delay Control

61.7 During intended operation of a horizontal or downflow furnace provided with a fan-delay control, starting with the furnace at room temperature, the fan control shall operate to prevent the air in the inlet duct from attaining a temperature higher than 90°C (194°F), and to prevent an air filter, if provided, from attaining a temperature higher than that specified in Table 31.2.

61.8 The operation with reference to timing of a fan-delay control shall be such that it will not cause tripping of any thermal limit control during the starting cycle of a furnace.

61.9 For a downflow furnace, a duct having a cross section the same as the air inlet opening in the furnace is to be attached to the air inlet and extended vertically, by means of a 90-degree elbow if the furnace has only a side air inlet opening, for a distance of 7-1/2 feet (2.3 m) above the floor of the test structure. For a horizontal furnace a duct having a cross section the same as the air inlet opening in the furnace is to be attached to the air inlet and extended vertically by means of a 90-degree elbow for a distance of 6 feet (1.8 m) above the top of the inlet opening. The thermal limit control and the fan control, if adjustable, are to be set for maximum temperature and minimum differential.

61.10 The temperature of the air in the vertical section of the duct is to be measured as described in paragraph 50.8.

62. Abnormal Tests

General

62.1 A furnace, when subjected to each of the abnormal tests, shall comply with the requirements in paragraphs 58.26 and 58.28.

62.2 In connection with the tests covered in paragraphs 62.3—62.5, the limit control and any auxiliary limit control are to be adjusted to the maximum setting allowed by their fixed stops and to the minimum indicated differential setting.

Restricted Inlet

62.3 This test is to be conducted under the same conditions as in the continuity of operation test, paragraphs 61.1—61.3, and is to be continued until the temperature of the outlet air becomes stabilized. The inlet duct is then to be slowly and uniformly restricted until operation of the heating elements is interrupted by the functioning of the limit control. The rate of restriction from the condition of the continuity of operation test is to be sufficient to cause the outlet air temperature to increase approximately 0.6°C (1°F) per minute, but not faster. The furnace is to be permitted to function without any further adjustment until temperatures become stabilized, following which the inlet duct is to be further restricted until the resulting temperatures are the maximum which occur with any amount of restriction.

Fan Failure

62.4 The furnace is to be allowed to resume temperatures as in the continuity of operation test, after which the fan drive motor is to be de-energized and operation continued with the limit control functioning to interrupt the heating element circuit. The system is to be permitted to function without any further adjustment until temperatures become stabilized.

Blocked Outlet

62.5 The furnace is again to be allowed to resume normal temperatures as in the continuity of operation test, with the fan operating. The air outlet duct is then to be blocked completely and operation continued until the limit control functions to interrupt the heating element circuit. The system is to be permitted to function without any further adjustment until temperatures become stabilized.

MARKINGS

63. General

Nameplate

63.1 A furnace intended for use in a mobile home shall have a nominal nameplate rating of 120/240 volts, 3-wire, single phase with grounded neutral; or 120 volts, single phase; or 240 volts, single phase.

Revised paragraph 63.1 effective October 18, 1988

63.2 *Paragraph 63.2 revised and relocated as paragraph 63.4A July 16, 1986*

63.2A The nameplate marking of a central furnace shall include the minimum clearance required, including zero clearance, from combustible surfaces in accordance with item C of paragraph 54.1. Unless the furnace is intended for mobile home use, the spacings shall be given in integral inches, that is, not inclusive of fractions of an inch.

Paragraph 63.4 revised and relocated as paragraph 63.2A effective October 18, 1988

63.3 *Paragraph 63.3 relocated as paragraph 63.5A July 16, 1986*

63.3A A separate furnace mounting base, as mentioned in paragraph 55.11, shall be marked with the manufacturer's or private labeler's name or identifying symbol, and the catalog number or equivalent.

Paragraph 63.5 relocated as paragraph 63.3A effective October 18, 1988

63.4 *Paragraph 63.4 revised and relocated as paragraph 63.2A effective October 18, 1988*

Supplementary

63.4A In addition to the items mentioned in Supplementary, Section 43, the marking of a central furnace shall include the outlet air temperature limit; a reference to the instructions, see Section 54; a specific wiring diagram for the furnace; and the external static pressure at which the furnace was tested.

Paragraph 63.2 revised and relocated as paragraph 63.4A July 16, 1986

63.5 *Paragraph 63.5 relocated as paragraph 63.3A effective October 18, 1988*

63.5A If an air filter is provided with the furnace, the marking shall include a statement that a replacement filter should be of the same type that was originally supplied. Any other essential user information necessary to ensure operation of the system as intended shall be included in the marking.

Paragraph 63.3 relocated as paragraph 63.5A July 16, 1986

63.6 A furnace which is not suitable for installation under a ceiling height of 7 feet (2.1 m) or less for mobile homes, or 7-1/2 feet (2.3 m) or less for all other furnaces, shall be marked: "For Installation Only Where Ceiling Height Is At Least _____," or the equivalent.

63.7 A furnace intended for use with a field-installed evaporator coil shall be marked to identify the intended coil or coils. If the furnace cabinet includes a cavity for an evaporator coil, but the furnace performance has not been evaluated with such a coil, the furnace shall be marked to indicate that an evaporator coil is not to be installed in the cavity.

OUTDOOR USE EQUIPMENT

CONSTRUCTION

64. General

64.1 Electric central space heating equipment intended for installation where it may be exposed to the weather shall comply with the applicable requirements of the preceding sections and shall, in addition, comply with the requirements of Sections 65—72.

65. Enclosure

General

65.1 An enclosure or enclosures shall be so constructed as to prevent the wetting of live parts as indicated below, and protect the system against the risk of electric shock due to weather exposure.

65.2 To determine compliance with the requirement of paragraph 65.1, a complete assembly, with supply conduit connections, without pipe thread compounds, is to be subjected to the Rain Test, Section 69.

65.3 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 a risk of electric shock due to weather exposure or a risk of personal injury due to moving parts.

65.4 Hinges and other attachments shall be resistant to corrosion.

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

65.6 Sheet steel cabinets and enclosures shall have a thickness of not less than 0.032 inch (0.81 mm) if uncoated and not less than 0.034 inch (0.86 mm) if zinc coated, except as indicated in paragraph 65.7.

65.7 An enclosure having a thickness less than that specified in paragraph 65.6 is acceptable if it complies with Table 5.1 and is protected by an outer cabinet. Sheet steel cabinets and enclosures employing panels consisting of more than one sheet of lesser thickness than specified in paragraph 65.6 may be used if equivalent in all respects, including mechanical strength and corrosion resistance to a single sheet of steel of the thicknesses stated in paragraph 65.6.

Corrosion Protection

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

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

Type of Cabinet and Enclosure	No. 16 MSG or GSG and Heavier as Specified[a] by Paragraph	Lighter Than No. 16 MSG or GSG as Specified[a] by Paragraph
Outer cabinets which protect motors, wiring, or enclosed current-carrying parts	65.11	65.12
Inside enclosures which protect current-carrying parts other than motors	65.11	65.12
Outer cabinets which are the sole enclosure of current-carrying parts	65.12	65.12

[a] See Table 5.1 for specified minimum thickness.

†*Additional page*

65.10 Paragraph 65.9 is not applicable to a metal part, such as a decorative grille, which is not required for conformance with this standard.

65.11 To comply with paragraph 65.9 referenced to this paragraph, one of the following coatings shall be used:

A. Hot-dipped mill galvanized sheet steel conforming with the coating Designation G60 or A60 in Table I of Specifications for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, ASTM A525—78, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM specification. 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 Tests for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90—69(1978). An A60 (alloyed) coating shall also comply with paragraph 65.14.

B. A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0086 mm), the thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 71. An annealed coating shall also comply with paragraph 65.14.

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

65.12 To comply with paragraph 65.9 referenced to this paragraph, one of the following coatings shall be used:

A. Hot-dipped mill galvanized sheet steel conforming with the coating Designation G90 in Table I of ASTM A525—78, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM specification. 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—69(1978).

B. A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm), the thickness of the coating shall be established by the Metallic Coating Thickness test, Section 71. An annealed coating shall also comply with paragraph 65.14.

C. A cadmium coating not less than 0.001 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 71.

D. A zinc coating conforming with item A or B of paragraph 65.11 with one coat of outdoor paint as specified in item C of paragraph 65.11 on each surface.

E. A cadmium coating not less than 0.00075 inch (0.0191 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 inch (0.013 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 71, and the paint shall be as specified in item C of paragraph 65.11.

Paragraph 65.12 revised January 30, 1988

**Replaces page 75 dated July 16, 1986*

65.13 With reference to paragraph 65.9, 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 item A of paragraph 65.11 or 65.12, as applicable, indicate they provide equivalent protection. Among the factors which are taken into consideration when judging the equivalency of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light and water.

65.14 A hot-dipped mill galvanized A60 (alloyed) coating, or an annealed zinc coating which is bent or similarly formed after annealing which is not otherwise required to be painted shall be additionally 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.

65.15 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 paragraph 65.14.

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

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

66. Field Wiring Connections

66.1 Conduit openings or knockouts shall be provided for all field wiring connections and shall be not less than 7/8 inch (22.2 mm) in diameter. Threaded openings shall be provided unless: (1) they are located wholly below the lowest uninsulated live part within the enclosure, or (2) their location prevents drainage into the enclosure along the outside surface of a field supplied wireway. Threaded holes for conduit shall be provided with a conduit end stop unless the thread is tapered.

67. Internal Wiring

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

67.2 The use of moisture resistant wiring material, such as Type RW, RHW, TW, THW, XHHW, MTW, or THWN enclosed in rigid or flexible metal conduit or electrical metallic tubing, or moisture resistant nonmetallic sheathed cable for the wiring between electrical component enclosures is considered acceptable. Other wiring materials, except those limited to use in dry locations, installed in either rigid conduit or electrical metallic tubing with rain-tight fittings or in liquid-tight flexible metal conduit with acceptable fittings are acceptable. The use of flexible cords or appliance wiring material as described in paragraphs 9.4—9.9 and 9.17, is also acceptable. A bushing is to be nonabsorptive.

67.3 The wiring assembly shall be so constructed and located as to exclude water from electrical enclosures in accordance with paragraph 65.2.

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

68. Electrical Insulating Material

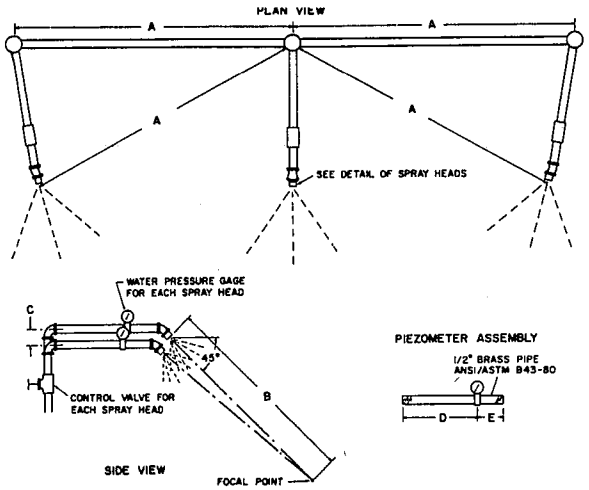
68.1 Nonabsorptive electrical insulation shall be used in electrical components. Untreated fiber and asbestos, are examples of materials that shall not be used, while vulcanized fiber on electrical components is acceptable if the components are not wetted as a result of the Rain Test, Section 69.

PERFORMANCE

69. Rain Test

69.1 Equipment designed for outdoor use shall be subjected to the rain test. Following the test, the device shall have an insulation resistance of not less than 50,000 ohms measured between live parts and dead metal parts, and shall withstand the Dielectric Voltage Withstand Test, Section 35. The assembly shall also comply with paragraph 69.6 after the test.

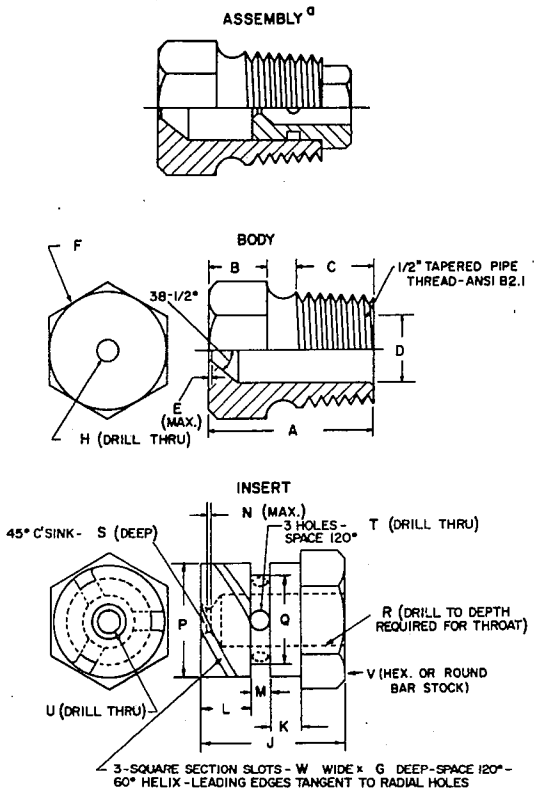
FIGURE 69.1
RAIN-TEST SPRAY-HEAD PIPING



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

RT100A

FIGURE 69.2
RAIN-TEST SPRAY HEAD



69.2 The test is to be conducted under the intended conditions of use most likely to cause entrance of water into or on the electrical components. If may be necessary to operate the equipment under various modes of operation or to de-energize it if more adverse conditions could result therefrom. In any case, each exposure is to be for 1 hour. If more than one exposure is required, the equipment is to be reconditioned, if necessary, prior to the second and each subsequent exposure so that the results of the test will not be adversely affected by prior exposures.

69.3 Field wiring connections to the equipment are to be made to represent the intended method of field wiring. Normally, openings at which conduit is to be terminated will be sealed, but openings for the entry of a conductor or conductors of a low-voltage circuit, as described in paragraph 2.2, are not sealed. See paragraph 8.6.

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.

RT100B

69.4 The dielectric voltage-withstand test is to be conducted and the insulation resistance is to be measured following each exposure.

69.5 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 69.1. Spray heads are to be constructed in accordance with the details shown in Figure 69.2. The water pressure for all tests is to be maintained at 5 psig (34.5 kPa) at each spray head. The spray is to be directed towards the top and side of the assembly which is to be centrally located within the spray pattern. The top of the assembly is to be at least 3 feet (0.91 m) below the plane of the lower spray-head outlet.

69.6 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 on the basis of the insulation resistance and by the dielectric voltage-withstand test provided the motors are within the cabinet and are shielded from openings in the top of the cabinet.

B. Water may enter an enclosure above the lowest live electrical part provided the point of entrance is not in proximity to live electrical parts and live parts are not to be wetted during the rain test.

70. Gaskets

70.1 Neoprene or rubber compounds (except foamed materials) used for gaskets to seal electrical enclosures, shall have physical properties as indicated in Table 70.1 before and after accelerated aging under the conditions indicated in Table 70.2.

70.2 Foamed neoprene or rubber compounds forming gaskets to seal electrical enclosures shall be subjected to accelerated aging at the conditions indicated in Table 70.2. The compounds shall not harden or otherwise deteriorate to a degree which will impair their sealing properties.

70.3 Thermoplastic materials forming gaskets to seal electrical enclosures shall be subjected to accelerated aging under the conditions indicated in Table 70.2. Thermoplastic materials shall not deform or melt, or otherwise deteriorate to a degree which will impair their sealing properties. Solid polyvinyl-chloride gasket materials shall have physical properties as indicated in Table 70.1 before and after the accelerated aging.

70.4 Gaskets of materials other than those mentioned in paragraphs 70.1—70.3, shall be nonabsorptive and shall provide equivalent resistance to aging and temperature.

70.5 The temperatures indicated in Table 70.2, correspond to the maximum temperature rise measured on the gasket during the normal temperature test conducted on the heater.

TABLE 70.1
PHYSICAL PROPERTIES FOR GASKETS

Physical Property	Neoprene or Rubber Compound		Polyvinyl Chloride Materials	
	Before Test	After Test	Before Test	After Test
Recovery — Maximum set when 1-inch (25.4-mm) gage marks are stretched to 2-1/2 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 (25.4 mm) gage marks at break.	250 percent, 1—3-1/2 inches (25.4—88.9 mm)	65 percent of original	250 percent, 1—3-1/2 inches	75 percent of original
Tensile Strength — Minimum force at breaking point.	850 psi (5.9 MPa)	75 percent of original	1200 psi (8.3 MPa)	90 percent of original

TABLE 70.2
ACCELERATED AGING CONDITIONS

Measured Temperature Rise °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 circulating 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 circulating oven at 100°C (212°F)
55	99	Rubber, Neoprene, or Thermoplastic	7 days in an air circulating oven at 113°C (235.4°F)
65	117	Rubber or Neoprene	10 days in an air circulating oven at 121°C (249.8°F)
65	117	Thermoplastic	7 days at 121°C (249.8°F) or 60 days at 97°C (206.6°F) in an air circulating oven
80	144	Rubber, Neoprene, or Thermoplastic	7 days in an air circulating oven at 136°C (276.8°F)

71. Metallic Coating Thickness Test

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

71.2 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 about 0.025 milliliters each. To preserve an effectively constant level, a small glass tube is inserted in 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.

71.3 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 21.1 to 32.2°C (70 to 90°F).

71.4 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 suitable 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.

71.5 The sample to be tested is to be supported from 0.7 to 1 inch (17.8 to 25.4 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested should be inclined about 45 degrees from horizontal.

71.6 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.

71.7 Each sample of a test lot is to be subjected to the 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.

71.8 To calculate the thickness of the coating being tested, select from Table 71.1 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 paragraph 71.6.

TABLE 71.1
COATING THICKNESS FACTORS

Temperature, Degrees F (C)	Thickness Factors, 0.00001 Inches (0.0003 mm) Per Second	
	Cadmium Platings	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

72. General

72.1 A a nameplate on an outdoor use heater shall be of corrosion resistant material.

72.2 Among the factors to be considered in judging the acceptability of a nameplate on an outdoor use heater are its degree of adhesion, resistance to defacement, and legibility after being exposed to appropriate aging and immersion tests.

72.3 A heater that has been found to be acceptable for outdoor use shall be legibly marked with the words "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
Standard for Safety —	
Attachment Plugs and Receptacles, Electrical	UL 498
Building Materials, Test for Surface Burning Characteristics of	UL 723
Circuit Breakers, Molded-Case, and Circuit-Breaker Enclosures	UL 489
Conduit, Electrical, Flexible Metal	UL 1
Conduit, Electrical, Liquid-Tight Flexible Steel	UL 360
Conduit, Electrical, Rigid Metal	UL 6
Conduit, Intermediate Metal	UL 1242
Conduit, Schedule 40 and 80 Rigid PVC	UL 651
Conduit, Type EB and A Rigid PVC, and HDPE Conduit	UL 651A
Controls, Limit	UL 353
Cord Sets and Power-Supply Cords	UL 817
Filter Units, Air, High Efficiency, Particulate,	UL 586
Filter Units, Air, Test Performance of	UL 900
Flexible Cord and Fixture Wire	UL 62
Fuseholders	UL 512
Fuses for Supplementary Overcurrent Protection	UL 198G
Fuses, Class H	UL 198B
Fuses, High-Interrupting-Capacity Class K	UL 198D
Fuses, Class R	UL 198E
Fuses, Class T	UL 198H
Fuses, High-Interrupting-Capacity Current-Limiting Types	UL 198C
Fuses, Plug	UL 198F
Grounding and Bonding Equipment, Electrical	UL 467
Industrial Control Equipment, Electric	UL 508
Lampholders, Edison-Base	UL 496
Motors, Electric	UL 1004
Motors, Impedance-Protected	UL 519
Nonmetallic-Sheathed Cables	UL 719
Outlet Boxes, Metallic, Electrical	UL 514A
Outlet Boxes, Flush-Device Boxes and Covers, Nonmetallic	UL 514C
Panelboards, Electric	UL 67
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, Electrical	UL 796
Protectors for Electric Motors, Thermal	UL 547
Refrigerant-Containing Components and Accessories, Nonelectrical	UL 207

APPENDIX A (Cont'd)

Title of Standard	UL Standard Designation
Standard for Safety —	
Switches, Clock-Operated	UL 917
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
Tape, Insulating	UL 510
Temperature-Indicating and -Regulating Equipment, Electrical	UL 873
Terminal Blocks, Electrical	UL 1059
Terminals, Electrical Quick-Connect	UL 310
Thermal Cutoffs for Use in Electrical Appliances and Components	UL 1020
Transformers, Class 2 and Class 3	UL 1585
Tubing, Electrical Metallic	UL 797
Tubing, Extruded Insulating	UL 224
Valves, Electrically-Operated	UL 429
Wire Connectors and Soldering Lugs for Use with Copper Conductors	UL 486A
Wire Connectors for Use with Aluminum Conductors	UL 486B
Wires and Cables, Machine-Tool	UL 1063
Wires and Cables, Rubber-Insulated	UL 44
Wires and Cables, Thermoplastic-Insulated	UL 83
Wires and Cables with Varnished-Cloth Insulation	UL 133
Wires with Asbestos or Asbestos and Varnished Cloth or Tape Insulation	UL 115