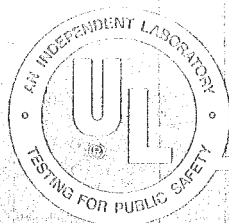


UL 1096

STANDARD *for* SAFETY

ELECTRIC CENTRAL AIR HEATING EQUIPMENT



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January 30, 1988

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:

Page	Date
1	January 30, 1988
2, 3	July 16, 1986
4—6	July 15, 1986
7	January 30, 1988
8, 8A	July 16, 1986
9—11	July 15, 1986
12	July 16, 1986
13—15	July 15, 1986
16	July 16, 1986
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18A	July 16, 1986
19, 20	January 30, 1988
20A, 21	July 16, 1986
22—27	July 15, 1986
28	January 30, 1988

(Continued on overleaf)

(36)

Page	Date
29—32	July 16, 1986
32A, 33	January 30, 1988
34	July 16, 1986
35	July 15, 1986
36, 36A	July 16, 1986
37—43	July 15, 1986
44	January 30, 1988
45	July 15, 1986
46	July 16, 1986
47	January 30, 1988
48, 49	July 15, 1986
50	January 30, 1988
51	July 16, 1986
52	January 30, 1988
52A	July 16, 1986
53, 54	January 30, 1988
55	July 16, 1986
56	July 15, 1986
57—59	January 30, 1988
60	July 15, 1986
61, 62	July 16, 1986
63, 64	July 15, 1986
65	January 30, 1988
66, 67	July 15, 1986
68	July 16, 1986
69, 70, 70A, 71	January 30, 1988
72	July 15, 1986
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1

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UL 1096

STANDARD FOR ELECTRIC CENTRAL AIR HEATING EQUIPMENT

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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
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TABLE OF CONTENTS

Foreword	4
All Equipment	5
General	5
1. Scope	5
2. General	5
3. Components	5
Construction	5
4. General	5
5. Enclosure	6
6. Protection of Service Personnel	12
7. Materials in Air-Handling Compartments	14
8. Field Wiring Connections	16
9. Internal Wiring	21
10. Separation of Circuits	23
11. Bonding for Grounding	24
Electrical Components	26
12. Mounting of Components	26
13. Heating Elements	26
14. Electrical Insulation	27
15. Uninsulated Live Parts	27
16. Motors and Motor (Overload) Protection	28
17. Capacitors	29
18. Overcurrent Protection, General	30
19. Overcurrent Protection, High-Voltage Control Circuit Conductors	31
20. Transformer Protection	33
21. Fan-Control and Thermal Back-Up Protection	34
22. Fuseholders and Circuit Breakers	35
23. Thermal Cutoffs and Nonresettable Limit Controls	36
24. Lampholders	36
25. Switches and Controllers	36A
26. Automatic Controls and Control Circuits	37
27. Safety Devices	38
Spacings	38
28. General	38
Performance	41
29. General	41
30. Power Input	41
31. Temperature Test	41
32. Abnormal Operation Test	44
33. Overvoltage and Undervoltage Test	44
34. Overload Test	45
35. Dielectric Voltage-Withstand Test	46
36. Insulation Resistance	46
37. Short-Circuit Tests	46
38. Overload Test — High-Voltage Transformers	47
39. Burnout Test — High-Voltage Transformers	48
40. Motor Overload Tests	48
Manufacturing and Production Tests	49
41. Production Line Dielectric Voltage-Withstand Tests	49

**Replaces page 2 dated July 15, 1986*

Marking.....	50
42. Nameplate	50
43. Supplementary	52A
Duct Heaters	55
Construction	55
44. General	55
45. Instructions.....	56
46. Moisture	56
47. Limit Controls	56
Performance	57
48. General	57
49. Limit Control Cutout Test	59
50. Normal Tests	60
51. Abnormal Tests	60
Markings	61
52. General	61
Central Heating Furnaces	61
Construction	61
53. General	61
54. Instructions.....	62
55. Assembly	62
56. Limit Controls	64
57. Air Filters	64
Performance	64
58. General	64
59. Test Enclosures	67
60. Limit Control Cutout Test	71
61. Normal Tests	72
62. Abnormal Tests	73
Markings	73
63. General	73
Outdoor Use Equipment.....	74
Construction	74
64. General	74
65. Enclosure	74
66. Field Wiring Connections	76
67. Internal Wiring	76
68. Electrical Insulating Material	76
Performance	76
69. Rain Test	76
70. Gaskets	78
71. Metallic Coating Thickness Test.....	79
Marking.....	80
72. General	80
Appendix A	A1
Standards for Components.....	A1

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 mm²).

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.

**Replaces page 7 dated July 16, 1986*

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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, con-

duit 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 sub-assembly 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		Minimum Thickness In Inches (mm) AWG	
Maximum Width ^b In Inches (cm)	Maximum Length ^c In Inches (cm)	Maximum Width ^b In Inches (cm)	Maximum Length In Inches (cm)		
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

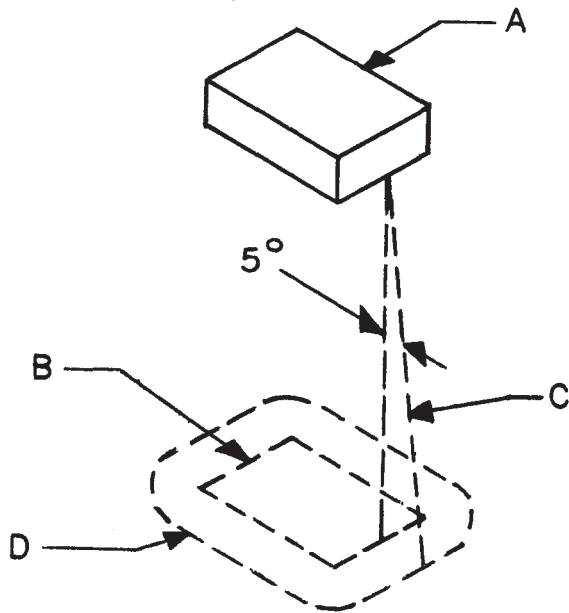
3. The motor is provided with a thermal protector (a protective device that is sensitive to both temperature and current) that will prevent the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load under which the motor will run without causing the protector to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



EB 120A

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

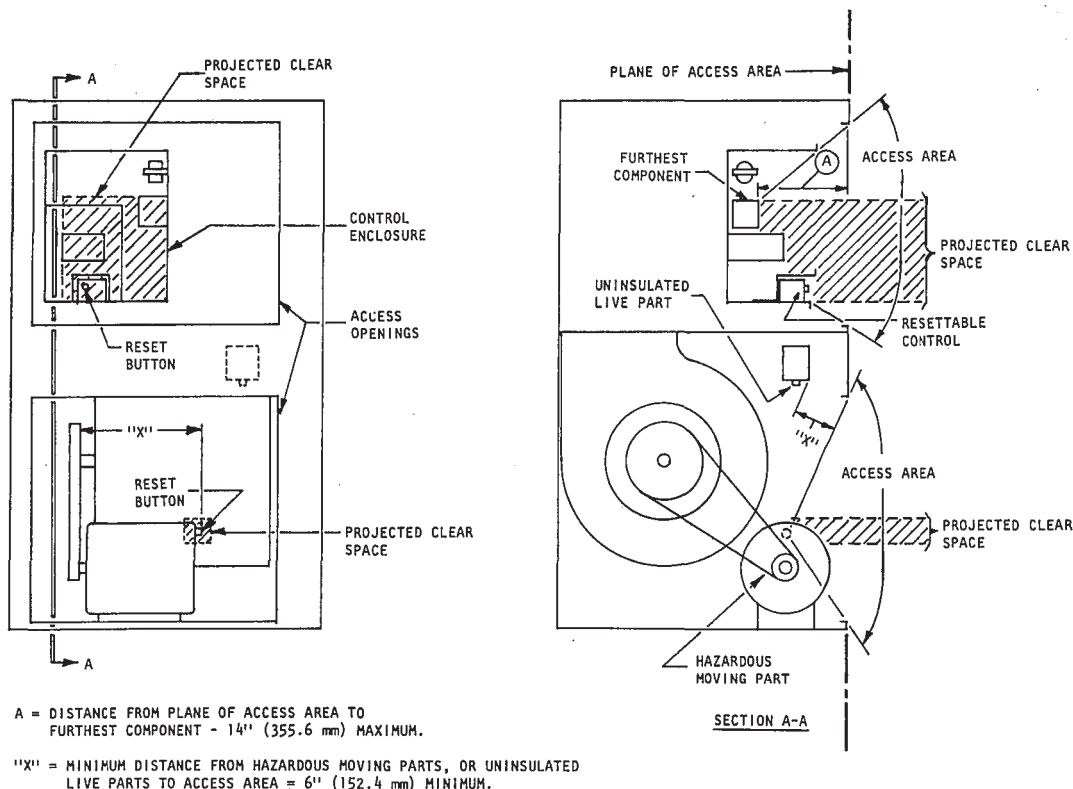
is considered to be bounded on the sides by the projection of the perimeter of the access opening of the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

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



EA 105

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 m²).

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 m²). 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 $1\text{-}1/2$ 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.

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TABLE 8.1
TRADE SIZE OF CONDUIT IN INCHES^{a,b}

Wire Size	Number of Wires				
	2	3	4	5	6
AWG (mm²)					
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.

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 mm²) 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 mm²) copper conductor and shall also be adequate for connection of a No. 8 AWG (8.4 mm²) 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

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

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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 mm²) 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 mm²) 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 mm²) 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

**Replaces page 18 dated July 16, 1986*

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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 mm²) 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 mm²) or No. 18 AWG (0.82 mm²) 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 mm²), 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 mm²) 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 mm²). 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 mm²) 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*

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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 mm²) conductor and a No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 16 AWG (1.3 mm²) or No. 18 AWG (0.82 mm²) 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 mm²) 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 mm²), 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.

**Replaces page 20 dated July 16, 1986*

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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.

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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 mm²), 3/64 inch (1.2 mm) thick for No. 8 AWG (8.4 mm²), and 4/64 inch (1.6 mm) thick for No. 6—2 AWG (13.3—33.6 mm²) 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 mm²), 5/64 inch (1.93 mm) for No. 14—10 AWG (2.1—5.3 mm²), 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.

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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.