

UL 1996

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Electric Duct Heaters

Underwriters Laboratories Inc. (UL)

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UL Standard for Safety for Electric Duct Heaters, UL 1996

Third Edition, Dated November 12, 2004

Revisions: This Standard contains revisions through and including December 1, 2006.

SUMMARY OF TOPICS

This revision to ANSI/UL 1996 is being issued to add a requirement that necessitates the breaking of all ungrounded conductors on contacts that serve the electric duct heater.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective date with the corresponding item.

Future Effective Date References

June 1, 2009 Paragraph 24.3.18

The new requirements are substantially in accordance with UL's Proposal(s) on this subject dated May

12, 2006 and September 29, 2006.

The revisions dated December 1, 2006 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard.

Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at:
<http://ulstandardsinfo.net.ul.com/ulforeword.html>

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-3	December 1, 2006
4	November 12, 2004
5-6	March 10, 2006
7-36	November 12, 2004
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Standard for Electric Duct Heaters

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Third Edition

November 12, 2004

The most recent designation of ANSI/UL 1996 as an American National Standard (ANSI) occurred on November 28, 2006. The ANSI approval for this standard does not include the cover page, transmittal pages, or the title page.

This ANSI/UL Standard for Safety, which consists of the Third Edition with revisions through December 1, 2006, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover fixed electric duct heaters, 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, ANSI/NFPA 70.

1.2 These requirements do not cover fan-coil units, central heating furnaces, 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 Duct heaters intended for use in a hazardous location are 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 Duct heaters designed to be connected to air-duct systems are intended for installation in accordance with the Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A, and the Standard for the Installation of Warm Air Heating and Air Conditioning Systems, NFPA 90B.

1.5 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.

1.6 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.

1.7 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.

2 General

2.1 General

2.1.1 A low voltage circuit is one that has an ac potential of not more than 30 volts alternating current (42.4 peak), and power of 100 VA or less; or 30 V dc supplied by a primary battery; or supplied by a Class 2 transformer; or supplied by a combination of a transformer and fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer. A circuit that is derived from a circuit that exceeds 30 V by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current is not considered to be a low voltage circuit.

2.1.2 A high-voltage circuit is one having characteristics in excess of those of an low-voltage circuit.

2.1.3 Duct heaters intended for installation within 4 ft (1.22 m) of heating or cooling equipment shall be evaluated for the combination use in accordance with the requirements in the standard. See 46.1.8.

2.2 Terminology

2.2.1 Unless otherwise indicated, all voltage and current values mentioned in this standard are rms.

2.3 Units of measurement

2.3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.4 Undated references

2.4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

3.2 A component is not required to comply with a specific requirement that:

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

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

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

4 Instructions

4.1 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 4.2, showing the connections of the power supply, the necessary temperature rating of the field wiring, when higher than 75°C (167°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, when 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 shall safely be in contact with combustible material and that the maximum number of heaters shall 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. When the heater is the same size (cross-sectional area) as the duct, the velocity of the air shall be specified as either linear feet (m) per minute or cubic feet (m³) per minute; but when the heater can be employed in a larger duct, the velocity shall be specified in linear feet (m) per minute. See 4.3.
- e) Specific instructions regarding any items which require particular care on the part of contractors or workmen.
- f) Specific instructions regarding duct direction (horizontal, vertical upflow or downflow) 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 required 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 airflow requirements shall be met at any point over the face of the heater.

4.2 In a multistage heater in which two or more stages are identical, the wiring diagram in 4.1 (a) may show only one such stage, when it includes a statement giving the pertinent information about the stages not included in the diagram.

4.3 Because filters clog during intended use of the duct heater, the specified minimum air velocity in the manufacturer's instructions in 4.1 (d) shall be at least 11 percent higher than the minimum air velocity measured during the Limit-Control Cutout Test, Section 31.

CONSTRUCTION

5 Enclosures

5.1 Enclosures for duct heaters shall be so formed and assembled that, they have the strength and rigidity to resist abuse during shipment, installation, or use without increasing their fire and accident hazards due to a total or partial collapse that could result in a reduction of spacings, a loosening or displacement of parts, or any other defect.

5.2 Enclosures for individual electrical components and wiring, outer enclosures, and combinations of the two, shall be considered in determining compliance with the requirements of 5.1.

5.3 Among the factors to be used in determining the acceptability of an enclosure are:

- a) Physical strength,
- b) Resistance to impact,
- c) Moisture-absorptive properties,
- d) Flammability,
- e) Resistance to corrosion, and
- f) Resistance to distortion or melting caused by the temperatures that is possible under conditions of anticipated use or by electrical disturbances within.
- g) Intended installation within ducts and plenums.

5.4 Nonmetallic enclosures or parts thereof shall be considered to comply with 5.3 (d) and (f), when:

- a) They comply with the flammability test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C; and
- b) They have temperature ratings not less than the maximum temperatures to which exposure during normal operation is possible.

5.5 A sheet metal enclosure shall be evaluated with respect to its size, shape, metal thickness, and use in a particular application. Sheet steel having a thickness of less than 0.026 inch (0.66 mm) when uncoated or 0.029 inch (0.74 mm) when galvanized, or nonferrous sheet metal having a thickness of less than 0.036 inch (0.91 mm) is not acceptable, except for relatively small areas or for surfaces that are curved or corrugated, or otherwise reinforced such as by angles, channels, flanges, or ribs.

5.6 The enclosure of a unit shall be provided with means for mounting in the intended manner. Any special fittings necessary for intended mounting shall be shipped with the unit.

5.7 An electrical part within the outer cabinet need not be individually enclosed when the assembly complies with all of the following:

- a) The construction and location of the part do not permit the emission of flame or molten metal through openings in the outer cabinet, or it can be shown that malfunction of the component does not result in a risk of fire.
- b) There are no openings in the bottom of the compartment in which the part is located that permit molten metal or the equivalent to drop onto flammable material. See 17.8 for units for outdoor installation.
- c) The part is not near flammable material other than electrical insulation.
- d) Sheet metal thickness of the outer cabinet is in compliance with Section 6.
- e) The part is not located in an air-handling compartment.
- f) The part is not subject to unintended contact by persons, as specified in Section 7.
- g) There are no openings in the top surface of the outer cabinet that permit objects to fall on or near uninsulated live parts.

Exception: Electric resistance heating elements and other similar components that does not emit smoke or components protected to prevent emission of smoke into the air-handling compartment need not be individually enclosed.

5.8 To determine when a product complies with 5.7, all of its intended mounting positions are to be considered.

6 Thickness of Sheet Metal Enclosures for Uninsulated Live Parts

6.1 Sheet metal used in making enclosures shall have a thickness of not less than that specified in Tables 6.1 and 6.2, except as permitted by 6.4.

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

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness 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)	Not limited	6.25 (15.9)	Not limited	0.020	(0.51)	0.023	(0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	(24)		(24)	
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026	(0.66)	0.029	(0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)	(22)		(22)	
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032	(0.81)	0.034	(0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)	(20)		(20)	
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042	(1.07)	0.045	(1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)	(18)		(18)	
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053	(1.35)	0.056	(1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)	(16)		(16)	
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060	(1.52)	0.063	(1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)	(15)		(15)	
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067	(1.70)	0.070	(1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)	(14)		(14)	
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080	(2.03)	0.084	(2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)	(13)		(13)	
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093	(2.36)	0.097	(2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)	(12)		(12)	
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108	(2.74)	0.111	(2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)	(11)		(11)	
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123	(3.12)	0.126	(3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)	(10)		(10)	

^a A supporting frame is a structure of angle or channel of a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments which are applied via the enclosure surface when it is deflected. Construction considered to have equivalent reinforcing shall be accomplished by designs that produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) Single sheet with single-formed flanges (formed edges);
- 2) A single sheet that is corrugated or ribbed; and
- 3) An enclosure surface loosely attached to a frame with, for example, spring clips.

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

^c For panels that 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.

Table 6.2
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

Without supporting Frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width ^b , Inches (cm)	Maximum length ^c , Inches (cm)	Maximum width ^b , Inches (cm)	Maximum length, Inches (cm)	Inch (mm)	(AWG)
3.0 (7.6)	Not limited	7.0 (17.8)	Not limited	0.023	(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 (63.4)	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 support frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments which are applied via the enclosure surface when it is deflected. Construction considered to have equivalent reinforcing shall be accomplished by designs that produce a structure as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) Single sheet with single-formed flanges (formed edges);
- 2) A single sheet that is corrugated or ribbed; and
- 3) An enclosure surface loosely attached to a frame with, for example, spring clips.

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

^c For panels that 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.

6.2 The minimum thickness of metal for cast enclosures shall comply with Table 6.3.

Table 6.3
Minimum thickness of cast metal enclosures for live parts

Method of fabrication	Minimum thickness, inch (mm)					
	Plain walls			Around conduit holes		
	Maximum area ^a 24 inch ² (154.9 cm ²) maximum length 6 inch (152.4 mm)	Area over 24 inch ² (154.9 cm ²) maximum length 6 inch (152.4 mm)				
Die-Cast	1/16	(1.6) ^{b, c}	3/32	(2.4)	1/4	(6.3)
Other	1/8	(3.2)	1/8	(3.2)	1/4	(6.3)
^a Area and length limitations may be complied with by subdividing larger areas by means of suitable reinforcing ribs.						
^b Is reduced to 1/32 inch (0.8 mm) when:						
1) The enclosure will not be used as a splice box; and						
2) The voltage rating of the complete device is such that the voltage between any two conductors is not more than 250 volts dc or single-phase ac.						
^c Is reduced to 0.028 inch (0.7 mm) minimum thickness for enclosures housing only low-voltage circuits.						

6.3 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

- a) 0.014 inch (0.35 mm) when steel, or 0.019 inch (0.48 mm) when nonferrous metal, for a hole having a 1/4 inch (6.4 mm) maximum dimension; and
- b) 0.027 inch (0.68 mm) when steel, or 0.032 inch (0.81 mm) when nonferrous metal, for a hole having a 1-3/8 inch (34.9 mm) maximum dimension. A closure for a larger hole shall have a thickness no less than that required for the enclosure of the device, or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

6.4 With reference to 6.1, the thickness of an enclosure shall be two gauge sizes less than indicated in Tables 6.1 and 6.2, if the electrical components are located at least 2-1/2 inch (64 mm) from the surface, and 4 gauge sizes less when the components are located at least 5 inches (128 mm) from the surface. The thickness shall be not less than No. 24 MSG or GSG (steel), or 18 AWG (aluminum, copper, or brass), unless a lesser thickness is in accordance with Tables 6.1 and 6.2. An example of 2 gauge sizes less is No. 18 MSG instead of No. 16 MSG; an example of 4 gauge sizes less is No. 20 MSG instead of No. 16 MSG.

7 Openings in Enclosures

7.1 Uninsulated live parts excluding film-coated wire, of high-voltage circuits, shall be located, guarded, or enclosed so as to prevent unintended contact by persons reaching through openings in the enclosure, or by persons adjusting controls, or performing other intended service and maintenance operations.

7.2 Openings in enclosures, including perforations, louvers, and openings protected by means of screening, expanded metal, or perforated covers, shall be of such size or shape as to prevent the passage of a probe, illustrated in Figure 7.1, from contacting uninsulated live parts. The configuration of the probe shall be changed (articulated) after insertion. See 7.4 for film-coated wire.

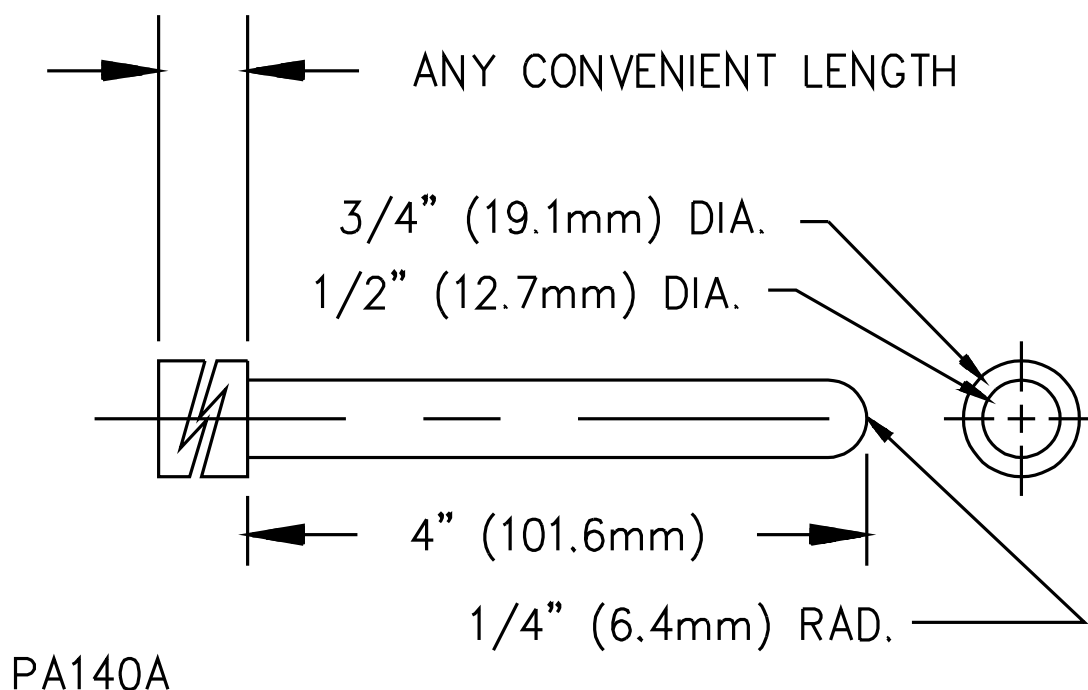
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7.3 During the examination of a unit or part thereof, in connection with the requirements in 7.1, parts of the enclosure, such as covers, panels, and grilles are to be removed unless tools are required for their removal. A warning marking, such as specified in 46.1.3 (i) is disregarded in establishing compliance with these requirements.

7.4 A probe as illustrated in Figure 7.2 shall not touch film-coated wire when inserted through the opening.

Figure 7.2
Probe
(For film-coated wire)



8 Enclosures, Doors, and Covers

8.1 Doors and covers that give access to uninsulated live high-voltage parts shall be secured firmly in place, and shall require the use of a tool or key to open them or shall be provided with an interlocking mechanism; except that components having covers that comply with their respective standards do not require additional enclosures.

8.2 An interlocking mechanism complies with the requirements of 8.1 when it:

- a) Secures the cover in the closed position when engaged; and
- b) Is engaged before parts in a high-voltage circuit are energized.

9 Accessibility of Parts

9.1 Sufficient and reasonable accessibility shall be afforded to all parts that require normal servicing or adjustment (adjustment of controls) when the equipment is installed as intended. Covers or access panels giving access to such parts that are required to be removed for routine maintenance shall not expose uninsulated live parts.

9.2 The assembly shall be arranged so that any overcurrent protective device that is replaced or reset as required is accessible without removal of parts other than the service covers or panels.

9.3 Except as specified in 9.4, the door or cover of an enclosure shall be hinged, sliding type, pivoted, or the equivalent, and not intended for removal, when it gives access to fuses.

Exception: When more than one door or cover is opened to provide access, only one of these needs to comply with this requirement.

9.4 A cover as specified in 9.3 is not required when fuses only of the following types are enclosed:

- a) Fuses connected in low-voltage circuits;
- b) Extractor type fuses that have their own enclosures;
- c) Control circuit fuses provided that the control circuit loads (other than fixed loads, such as pilot lamps) are housed in the same enclosure as the fuses; or
- d) Supplementary type fuses rated 2 amperes or less used in small, auxiliary resistance heater circuits having a maximum rating of 100 watts.

9.5 The reset button or lever of manual resettable devices (for example, the operating handle of a circuit breaker, the adjusting screw or knob of an adjustable temperature control) may be accessible without the use of a tool, providing that the resetting of the device does not result in exposure to uninsulated live high-voltage parts.

9.6 A cover as specified in 9.3 shall not depend solely upon screws or other similar means to hold it closed, but shall be provided with an automatic latch or the equivalent. A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that holds the door in place and requires some effort on the user's part to open complies for holding the door closed. A cover interlocking mechanism, as described in 8.2, and provided as the sole means for securing the cover or panel, complies.

10 Assembly

10.1 A duct heater shall have provision for the intended connection of ducts, either in the form of duct flanges, openings without flanges, or locations marked for openings, providing that drilling or cutting into the cabinet, or the use of screws, will not damage electrical components and wiring. A distance of 6 inch (152 mm) separating the opening from all components and wiring is considered to prevent damage due to drilling or cutting. Protection shall be provided by equivalent means.

11 Outdoor Use Equipment

11.1 General

11.1.1 Sheet steel cabinets and enclosures of units intended for outdoor use shall be protected against corrosion as specified in Table 11.1, or by other metallic or nonmetallic coatings that have been shown to give equivalent protection. Nonferrous cabinets and enclosures are not required to employ special corrosion protection. The thickness of the material is to be judged on the basis of its strength and rigidity.

Table 11.1
Corrosion protection

Type of cabinet and enclosure	1.35 mm (0.053 in) uncoated and 1.42 mm (0.056 in) coated and greater as specified by	Less than 1.35 mm (0.053 in) uncoated and 1.42 mm (0.056 in) coated as specified by
Outer cabinets that protect motors, wiring, or enclosed current-carrying parts	11.1.2	11.1.3
Inside enclosures that protect current-carrying parts other than motors	11.1.2	11.1.3
Outer cabinets that are the sole enclosure of current-carrying parts	11.1.3	11.1.3

11.1.2 Where Table 11.1 references 11.1.2, a cabinet or enclosure intended for outdoor use shall be provided with one of the following coatings:

- a) Hot dipped mill galvanized sheet steel conforming with the coating designation G60 or A60 in Table 1 of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) for Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653 or in Table 1 of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) for Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process (Metric), ASTM A653M, with not less than 40% of the zinc on any side, as determined by the minimum single spot test requirement in this ASTM designation. The weight of zinc coating shall be determined by any recognized method; however, where results are in question, the weight of coating shall be established in accordance with the Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90.
- b) A zinc coating, other than that provided on hot dipped mill galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.01041 mm (0.00041 in), and to a minimum thickness of 0.00864 mm (0.00034 in).
- c) Two coats of outdoor paint on both surfaces. The suitability of the paint shall be determined by consideration of its composition.

11.1.3 Where Table 11.1 references 11.1.3, a cabinet or enclosure intended for outdoor use shall be provided with one of the following coatings:

- a) Hot dipped mill galvanized sheet steel having the coating designation G90 in Table 1 of ASTM designation A653 or A653M, with not less than 40% of the zinc on any side as determined by the minimum single spot test requirement in these ASTM designations. The weight of zinc coating shall be determined by any recognized method; however, where results are in question, the weight of coating shall be established in accordance with the test method of ASTM designation A90.
- b) A zinc coating, other than that provided on hot dipped mill galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.01549 mm (0.00061 in), and to a minimum thickness of 0.01372 mm (0.00054 in).
- c) A zinc coating complying with 11.1.2 (a) or (b), plus one coat of outdoor paint as specified in 11.1.2 (c) on each surface.

11.1.4 With reference to 11.1.1, other finishes, including paints, special metallic finishes, and combinations of the two is accepted when comparisons with galvanized sheet steel (without annealing, wiping, or other surface treatment) that complies with 11.1.2 (a) or 11.1.3 (a), as applicable, indicate they provide equivalent protection.

11.1.5 Metals shall not be used in combinations such as to cause galvanic action that adversely affects cabinets or enclosures.

11.2 Enclosures

11.2.1 The outer cabinet of the equipment intended for outdoor use shall be so constructed as to prevent the wetting of uninsulated live parts (hazardous voltage or extra-low-voltage safety circuits), and shall protect the system against risk of shock due to exposure to rain (see Rain Test, Section 41). When of steel, it shall be not less than 0.78 mm (0.0307 in) thick, and shall be protected against corrosion as required by Section 11. Enclosures made of other metal shall have mechanical strength and rigidity at least equivalent to that of steel, 0.78 mm (0.0307 in) thick.

11.2.2 An enclosure that is formed of metal which is thinner than specified in 11.2.1, and which complies with Tables 6.1 and 6.2, whichever applies, is acceptable when it is protected by an outer cabinet. A sheet steel cabinet or enclosures employing panels consisting of more than one sheet, each sheet thinner than specified in 11.2.1, shall be used when equivalent in all respects, including mechanical strength and corrosion resistance, to a single sheet of steel of the thickness specified in 11.2.1.

11.2.3 Service covers and access panels that are not secured by screws or other fasteners requiring the use of tools to remove them shall be left open or removed during the Rain Test described in Section 41.

11.2.4 An enclosure for electrical components shall have provision for drainage when the enclosure employs knockouts or unthreaded openings. The drainage holes shall be not less than 3.2 mm (1/8 in) in diameter, or drainage openings of at least equivalent size shall be included.