

**Underwriters Laboratories Inc.®**

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

May 1, 1996**Revision pages for****Standard for****Ducted Heat Recovery Ventilators****UL 1812, Second Edition**

Attached to this transmittal notice is a revision of the Second edition of UL 1812.

A CHANGE ON A PAGE DATED MAY 1, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT.

The new and revised requirements are substantially in accordance with UL's bulletin on this subject dated January 12, 1996. The bulletin is now obsolete and may be discarded.

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

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

Page	Date
1	April 11, 1995(Reprinted: May 1, 1996)
2 – 16	April 11, 1995
17	June 23, 1995
18 – 92	April 11, 1995
93	May 1, 1996
94, 95, A1, A2	April 11, 1995

APRIL 11, 1995

(Title Page Reprinted: May 1, 1996)

1

UL 1812

Standard for

Ducted Heat Recovery Ventilators

First Edition – April 11, 1990

Second Edition

April 11, 1995

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

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

ISBN 1-55989-836-4

COPYRIGHT © 1990, 1996 UNDERWRITERS LABORATORIES INC.

CONTENTS**FOREWORD****INTRODUCTION**

1 Scope	5
2 General	5
3 Glossary	6
4 Installation and Operating Instructions	7

CONSTRUCTION

5 General	7
6 Protection of Service Personnel	8
7 Enclosures	9
8 Protection Against Corrosion	24
9 Materials in Air-Handling Compartments	25
10 Polymeric and Other Nonmetallic Materials	26
11 Power Supply Connections	30
12 Internal Wiring	36
13 Separation of Circuits	39
14 Bonding for Grounding	41

ELECTRICAL COMPONENTS

15 Mounting of Components	44
16 Live Parts	45
17 Electrical Insulating Material	45
18 Motors and Motor Protection	45
19 Capacitors	48
20 Circuit Breakers and Fuseholders	48
21 Overcurrent Protection, General	48
22 Overcurrent Protection, High-Voltage Control Circuit Conductors	49
23 Transformer Protection	51
24 Switches and Controllers	53
25 Safety Devices	54

SPACINGS

26 General	54
------------------	----

PERFORMANCE

27 Installation	56
28 Test Voltage	57
29 Input Test	58
30 Normal Temperature Test	58
31 Overflow Tests	63
32 Motor Overload Tests	63
33 Switch Overload Test	64
34 Dielectric Voltage-Withstand Test	64
35 Insulation Resistance Test	65

Table 58.2
Accelerated aging conditions

Measured temperature rise degrees		Material	Test program
C	F		
35	63	Rubber or neoprene	Air oven aging for 70 hours at $100 \pm 2^\circ\text{C}$ ($212 \pm 3.6^\circ\text{F}$)
35	63	Thermoplastic	7 days in an air circulating oven at 87°C (189°F)
50	90	Rubber or neoprene	Air oven aging for 168 hours at $100 \pm 2^\circ\text{C}$ ($212 \pm 3.6^\circ\text{F}$)
50	90	Thermoplastic	10 days in an air circulating oven at 100°C (212°F)
55	99	Rubber, neoprene or thermoplastic	7 days in an air circulating oven at 113°C (235.4°F)
65	117	Rubber or neoprene	10 days in an air circulating oven at 121°C (249.8°F)
65	117	Thermoplastic	7 days at 121°C (249.8°F) or 60 days at 97°C (206.6°F) in an air-circulating oven
80	144	Rubber, neoprene or thermoplastic	7 days in an air circulating oven at 136°C (276.8°F)

Table 58.2 revised May 1, 1996

59 Metallic Coating Thickness Test

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

59.2 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.025 milliliter each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ± 5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

59.3 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at an ambient temperature of $70 - 90^\circ\text{F}$ ($21.1 - 32.2^\circ\text{C}$).

59.4 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Samples are then to be thoroughly rinsed in water and dried. Care should be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

59.5 The sample to be tested is to be supported from 0.7 to 1 inch (17.8 – 25 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested should be inclined about 45 degrees from horizontal.

59.6 The stopcock is to be opened and the time in seconds is to be measured until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

59.7 Each sample of a test lot is to be subjected to the test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface, at places where the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

59.8 To calculate the thickness of the coating being tested, select from Table 59.1 the thickness factor appropriate for the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as noted in 59.6.

Table 59.1
Coating thickness factors

Temperature, °C (°F)		Thickness factors, 0.0001 inches (0.0003 mm) per second	
		Cadmium platings	Zinc platings
21.1	(70)	1.331	0.980
21.7	(71)	1.340	0.990
22.2	(72)	1.352	1.000
22.8	(73)	1.362	1.010
23.3	(74)	1.372	1.015
23.9	(75)	1.383	1.025
24.4	(76)	1.395	1.033
25.0	(77)	1.405	1.042
25.6	(78)	1.416	1.050
26.1	(79)	1.427	1.060
26.7	(80)	1.438	1.070
27.2	(81)	1.450	1.080
27.8	(82)	1.460	1.085
28.3	(83)	1.470	1.095
28.9	(84)	1.480	1.100
29.4	(85)	1.490	1.110
30.0	(86)	1.501	1.120
30.6	(87)	1.513	1.130
31.1	(88)	1.524	1.141
31.7	(89)	1.534	1.150
32.2	(90)	1.546	1.160

MARKING — OUTDOOR-USE EQUIPMENT

60 General

60.1 A nameplate on an outdoor use unit shall be of corrosion resistant material.

60.2 Among the factors to be considered in judging the acceptability of a nameplate on an outdoor use unit are its degree of adhesion, resistance to defacement, and legibility after being exposed to appropriate aging and immersion.



Underwriters Laboratories Inc.®

A not-for-profit organization dedicated to public safety
and committed to quality service

June 23, 1995

Revision pages for

Standard for

Ducted Heat Recovery Ventilators

UL 1812, Second Edition

Attached to this transmittal notice is a revision of the Second edition of UL 1812.

A CHANGE ON A PAGE DATED JUNE 23, 1995 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THIS REVISION IS BEING ISSUED TO EDITORIALY CLARIFY PARAGRAPH 7.7.1. THIS REQUIREMENT IS NOW IN EFFECT.

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

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

Page	Date
1 – 16	April 11, 1995
17	June 23, 1995
18 – 95, A1, A2	April 11, 1995

7.6.3 Other than as noted in 7.6.4, an opening for ventilation in an enclosure, other than in the bottom, shall be provided with one or more baffles to reduce the risk of emission of flame, molten metal, burning insulation, or the like, from the unit.

7.6.4 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 7.6.3 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 unit is so constructed that it is suitable for the purpose, as shown by an investigation, including short-circuit tests.

7.7 Accessibility of uninsulated live parts, film-coated wire, and moving parts

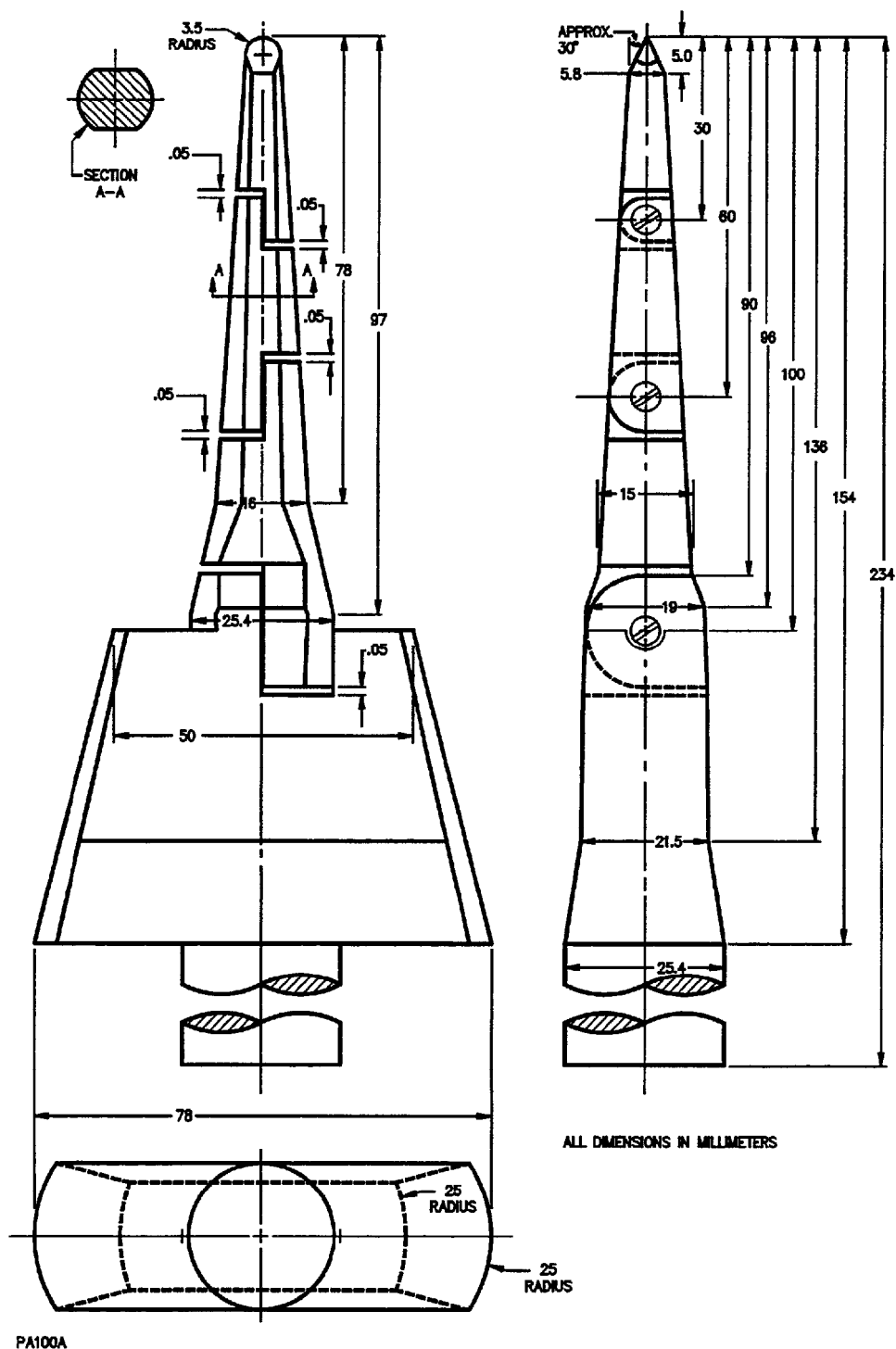
7.7.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from uninsulated live parts or film-coated wire, or injury to persons from a moving part, an opening in the outer enclosure shall comply with either (a) or (b):

- a) For an opening that has a minor dimension (see 7.7.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 7.1.
- b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 7.5.

Exception: A motor need not comply with these requirements if it complies with the requirements in 7.7.2.

7.7.1 revised June 23, 1995

Figure 7.1
Articulate probe with web stop



UL 1812

ISBN 1-55989-836-4

Ducted Heat Recovery Ventilators



Northbrook, Illinois • (708) 272-8800

Melville, New York • (516) 271-6200

Santa Clara, California • (408) 985-2400

Research Triangle Park,
North Carolina • (919) 549-1400**Underwriters Laboratories Inc.®**

Underwriters Laboratories Inc., founded in 1894, is chartered as a not-for-profit organization without capital stock, under the laws of the State of Delaware, to establish, maintain, and operate laboratories for the examination and testing of devices, systems and materials to determine their relation to hazards to life and property, and to ascertain, define and publish standards, classifications and specifications for materials, devices, products, equipment, constructions, methods, and systems affecting such hazards.

UL Standards for Safety are developed under a procedure which provides for participation and comment from the affected public as well as industry. The procedure takes into consideration a survey of known existing standards and the needs and opinions of a wide variety of interests concerned with the subject matter of the standard. Thus manufacturers, consumers, individuals associated with consumer-oriented organizations, academicians, government officials, industrial and commercial users, inspection authorities, insurance interests and others provide input to UL in the formulating of UL Standards for Safety, to keep them consonant with social and technological advances.

A not-for-profit organization
dedicated to public safety and
committed to quality service



Underwriters Laboratories Inc.®

A not-for-profit organization dedicated to public safety
and committed to quality service

April 11, 1995

Standard for

Ducted Heat Recovery Ventilators

UL 1812, Second Edition

Accompanying this transmittal notice is a copy of the Second edition of UL 1812.

THIS EDITION OF THE STANDARD IS NOW IN EFFECT.

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

APRIL 11, 1995

1

UL 1812

Standard for

Ducted Heat Recovery Ventilators

First Edition – April 11, 1990

Second Edition

April 11, 1995

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

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

ISBN 1-55989-836-4

COPYRIGHT © 1990, 1995 UNDERWRITERS LABORATORIES INC.

CONTENTS**FOREWORD****INTRODUCTION**

1 Scope	5
2 General	5
3 Glossary	6
4 Installation and Operating Instructions	7

CONSTRUCTION

5 General	7
6 Protection of Service Personnel	8
7 Enclosures	9
8 Protection Against Corrosion	24
9 Materials in Air-Handling Compartments	25
10 Polymeric and Other Nonmetallic Materials	26
11 Power Supply Connections	30
12 Internal Wiring	36
13 Separation of Circuits	39
14 Bonding for Grounding	41

ELECTRICAL COMPONENTS

15 Mounting of Components	44
16 Live Parts	45
17 Electrical Insulating Material	45
18 Motors and Motor Protection	45
19 Capacitors	48
20 Circuit Breakers and Fuseholders	48
21 Overcurrent Protection, General	48
22 Overcurrent Protection, High-Voltage Control Circuit Conductors	49
23 Transformer Protection	51
24 Switches and Controllers	53
25 Safety Devices	54

SPACINGS

26 General	54
------------------	----

PERFORMANCE

27 Installation	56
28 Test Voltage	57
29 Input Test	58
30 Normal Temperature Test	58
31 Overflow Tests	63
32 Motor Overload Tests	63
33 Switch Overload Test	64
34 Dielectric Voltage-Withstand Test	64
35 Insulation Resistance Test	65

36	Overvoltage and Undervoltage Tests	65
37	Tests for Polymeric Materials	65
38	Short-Circuit Tests	69
39	Starting Test	70
40	Overload Test — High-Voltage Transformer	71
41	Burnout Test — High-Voltage Transformer	71
42	Grounding Means Overload Test	72
43	Condensation Test	72
44	Leakage Current Test	73
45	Continuity of Grounding Circuit Test	76
46	Humidity Conditioning Test	76
47	Strain Relief Test	76

MANUFACTURING AND PRODUCTION TESTS

48	Production Line Dielectric Voltage-Withstand Tests	77
49	Grounding Continuity Test	78

MARKING

50	Nameplate	78
51	Supplementary	80

CONSTRUCTION — OUTDOOR-USE EQUIPMENT

52	General	84
53	Enclosure	84
54	Field-Wiring Connections	86
55	Internal Wiring	86
56	Electrical Insulating Material	87

PERFORMANCE — OUTDOOR-USE EQUIPMENT

57	Rain Test	87
58	Gasket Tests	92
59	Metallic Coating Thickness Test	93

MARKING — OUTDOOR-USE EQUIPMENT

60	General	94
----	---------------	----

APPENDIX A

Standards for Components	96
--------------------------------	----

FOREWORD

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

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

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

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

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover ducted heat recovery ventilators intended to remove air from buildings, replace it with outside air, and in the process transfer heat from the warmer to the colder air. These units are intended to be connected to duct systems that interconnect rooms or spaces within buildings for exhausting the indoor air and/or distributing the outdoor air.

1.2 These requirements cover heat recovery ventilators rated at 600 volts or less, and intended to be installed in ordinary locations in accordance with the National Electrical Code, NFPA 70. These units may also include means for air filtration.

1.3 These requirements apply to heat recovery ventilators employing gas-, oil-, or gas-oil-fired or electric resistance heating means. The requirements for the construction and performance of gas, oil, and gas-oil burners, heat exchangers, electric resistance heaters, and components for the direct control of the utilization of these heating means are to be those included in other applicable standards.

1.4 Heat recovery ventilators 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 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involve a risk of fire, electric shock, or injury to persons, shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, 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.

2.1.2 A component need not comply with a specific requirement that:

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

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

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

2.2 Units of measurement

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

2.2.2 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.

2.3 Undated references

2.3.1 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 Glossary

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

3.2 **BARRIER** — A partition for the insulation or isolation of electrical circuits or isolation of electrical arcs.

3.3 **CONTROL CIRCUIT** — the circuit that carries the electric signals directing the performance of a controller. A control circuit does not carry the main power current.

3.4 **CONTROLLER** — A device or group of devices that governs power delivered to a motor or other load in the equipment.

3.5 **DIRECT-CONNECTED HIGH-VOLTAGE CONTROL CIRCUIT** — A circuit that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the equipment. It is not tapped from the load side of the overcurrent device(s) of the controlled circuit(s) within the equipment.

3.6 **ENCLOSURE** — That part of a unit which by itself or in conjunction with barriers reduces the risk of contacting all or any parts of the unit that may otherwise present a risk of electric shock or injury to persons and/or prevents propagation of flame initiated by electrical disturbances occurring within.

3.7 **FUNCTIONAL PART** — A part other than an enclosure or structural part that is necessary for the intended operation of a unit.

3.8 **HIGH-VOLTAGE CIRCUIT** — A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

3.9 **LOW-VOLTAGE CIRCUIT** — A circuit involving a potential of not more than 30 volts alternating current (42.4 volts peak) or direct current, and supplied by:

- a) a primary battery,
- b) a Class 2 transformer, or
- c) a combination of transformer and fixed impedance which, as a unit, complies with all the performance requirements for a Class 2 transformer.

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

3.10 **STRUCTURAL PART** — A part used in such a manner that failure of the part may present a risk of electric shock or injury to persons.

3.11 **TAPPED HIGH-VOLTAGE CONTROL CIRCUIT** — A circuit that is tapped within the unit from a circuit supplying one or more loads that are not part of the control circuit.

4 Installation and Operating Instructions

4.1 Installation and operating instructions shall be furnished with units and accessories.

4.2 Instructions are to accompany each unit and accessory, either individually or with each shipment to the installer. If the instructions for the unit do not cover a field installed accessory, instructions are to be furnished with the accessory.

4.3 A copy of the installation and operating instructions or equivalent information is to be furnished with the samples submitted for investigation for use as a guide in the examination and test of the unit. For this purpose, the instructions need not be in final printed form.

4.4 The instructions shall include directions and information deemed by the manufacturer to be adequate for the intended installation, maintenance, and use of the unit, including application information as to mounting. Applicable information as to such quantities as air flow velocity and static pressure shall be made available by the manufacturer.

4.5 If a unit having provision for connection of a fresh air discharge duct does not also have provision for connection of an indoor air intake duct, or if the instructions indicate that an indoor air intake duct need not be connected, the instructions should indicate that applicable installation codes may limit the unit to installation only in a single story residence.

CONSTRUCTION

5 General

5.1 A component of a unit intended to be manually operated or adjusted by the user or that will 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 5.2.

5.2 With reference to 5.1, ordinary tools are considered to be pliers, flat-bladed and cross-recessed head (Phillips) screwdrivers, and hexagonal-recessed head screw (Allen) wrenches.

5.3 Other than as indicated in 5.4 and 5.5, a unit shall be completely assembled when shipped from the factory.

5.4 If the markings described in 5.1.8 are provided, a motor, a blower-drive package, a remote or unit mounted control assembly, or a control to be mounted on the outside of the unit may be shipped from the factory separate from the remainder of the unit.

5.5 A louvered panel or grille for indoor air intake or fresh air discharge intended to be installed as part of a unit intended for built-in installation or an enclosure panel that is not required for every intended installation of a unit may be shipped separately if:

- a) the unit complies with the performance requirements without the panel or grille installed,
- b) markings in accordance with 5.1.8 are provided, and
- c) instructions provided describe installation of the panel or grille.

5.6 Any installation that requires the cutting of wiring or the soldering of connections by the installer is not acceptable. Installations that require cutting, drilling, or welding, are not acceptable in electrical enclosures and in other areas where such operations may damage electrical components and wiring within the enclosure. In general, a distance of 6 inches (152 mm) from the opening is considered adequate to reduce the risk of damage due to drilling or cutting, but other forms of protection may be acceptable.

5.7 A unit shall be so arranged that condensate from the heat exchanger will not wet uninsulated live parts or film-coated wire.

5.8 A condensate pan shall be designed and located so that overflow due to a blocked drain will not wet uninsulated live parts other than motor windings. See 5.9 and Section 31. Overflowing water also shall not be retained within the enclosure containing electrical parts or wiring.

5.9 A suitably located overflow spout or cutout in the condensate pan may be acceptable for preventing dripping of water on electrical parts.

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 need to be performed with the unit energized. See 6.2 and 6.3.

6.2 Mechanical service functions that may have to be performed with the unit energized include:

- a) adjusting the setting of temperature controls with or without marked dial settings,
- b) resetting the control trip mechanism,
- c) operating manual switches, and
- d) adjusting air flow dampers.

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

6.3 The requirements in 6.1 are not applicable to mechanical service functions that are not intended to be performed with the equipment energized. Such functions include opening of drain plugs, adjusting or replacing drive belts, replacing components, and the like.

6.4 Other than as indicated in 6.5, an electrical component that may require examination, adjustment, servicing, or maintenance is one of the following: a fuse, an adjustable or resettable overload relay, a manual or magnetic motor controller, a magnetically operated relay, an adjustable or resettable temperature controller, a manual switching device, a clock timer, and an incremental voltage-tap or motor-speed-tap terminals for a variable-speed motor. Such a component in a low-voltage circuit shall comply with the requirements in 6.1 in relation to an uninsulated live part in a high-voltage circuit and to a moving part likely to cause a risk of injury to persons.

6.5 Under certain conditions some of the components referred to in 6.4 are not required to be accessible for service as follows:

- a) a nonadjustable magnetic motor controller or a magnetically operated relay that is inaccessible for service while energized because it is located behind subbases and the like and is not visible when the access panel(s) is removed;
- b) an enclosed potential or current type single phase motor starting relay; and

- c) an incremental voltage tap or a motor speed tap for a variable speed motor that requires contact with a bare live part of the voltage or speed tap to effect the speed or voltage change, such as an uninsulated screw or quick-connect terminal.

6.6 The following are not considered to be uninsulated live parts:

- a) coils of controllers, relays, solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps,
- b) enclosed motor windings,
- c) terminals and splices with insulation, and
- d) insulated wire.

7 Enclosures

7.1 General

7.1.1 An enclosure shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected without total or partial collapse in shipment, installation, and use resulting in reduction of spacings, loosening or displacement of parts, or other defects.

7.1.2 An enclosure for an individual electrical component, an outer enclosure, and a combination of the two are to be considered in determining compliance with the requirement in 7.1.1.

7.1.3 The enclosure of a unit shall be provided with means for mounting in the intended manner. Any unique fittings necessary for such mounting shall be shipped with the unit. Other than as indicated in 7.1.4, a freestanding, floor supported unit need not be provided with mounting means. See also 7.9.2.

7.1.4 A unit designed for installation in a mobile home shall have provision for securing it in place.

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

7.1.6 An outer cabinet is to be judged with respect to the size, shape, thickness of metal, and its acceptability for the particular application. Sheet steel having a thickness of less than 0.020 inch (0.51 mm) if uncoated, or 0.023 inch (0.58 mm) if galvanized, or nonferrous sheet metal having a thickness of less than 0.023 inch shall not be used except for relatively small areas or for surfaces that are curved or otherwise reinforced.

7.1.7 Among the factors that are taken into consideration when judging the acceptability of a polymeric enclosure or an enclosure of magnesium are:

- a) flame resistance,
- b) mechanical strength,
- c) resistance to impact,
- d) moisture absorptive properties, and

- e) resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal usage.

For a polymeric enclosure all of these factors are considered with respect to aging. See Polymeric and Other Nonmetallic Materials, Section 10.

7.2 Enclosure thickness

7.2.1 Sheet metal that serves as an electrical enclosure shall comply with Table 7.1 or 7.2, whichever applies, except that if the:

- a) location of the enclosure,
- b) design and location of components, or
- c) the strength and rigidity of the frame and enclosure are adequate to comply with 7.1.1, an enclosure thinner than specified in Tables 7.1 and 7.2 may be employed. See 7.4.1.

7.2.2 With reference to 7.2.1(a), the surface of an enclosure that will be protected from damage, such as by being mounted against a duct, may not be less than 0.020 inch (0.51 mm) if uncoated steel, not less than 0.023 inch (0.58 mm) if galvanized steel, not less than 0.036 inch (0.91 mm) if aluminum, and not less than 0.033 inch (0.84 mm) if copper or brass, unless a lesser thickness would be acceptable in accordance with Tables 7.1 and 7.2.

7.2.3 With reference to 7.2.1(b), the surface of an enclosure may be:

- a) two gage sizes less than indicated in Tables 7.1 and 7.2 if the electrical components are located at least 2-1/2 inches (64 mm) from the surface, and
- b) four gage sizes less if the components are located at least 5 inches (128 mm) from the surface.

The thickness shall not be less than No. 24 MSG or GSG (steel) or No. 18 AWG (aluminum, copper, or brass) unless a lesser thickness would be acceptable in accordance with Tables 7.1 and 7.2. 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.

7.2.4 With reference to 7.2.1(c), consideration is to be given to the degree of deflection or distortion that may affect the results contemplated by the requirements in 7.1.1.

7.3 Doors and covers

7.3.1 Except as indicated in 7.3.2 and 7.3.3, the door or cover of an enclosure shall be hinged:

- a) if it gives access to any fuse, circuit-breaker handle, or manually resettable lever of a temperature control in other than a low-voltage circuit, and
- b) 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 or the equivalent, and, if live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, shall be provided with a captive screw or equivalent means, requiring the use of a tool to open, and to reliably secure the door or cover in place. See 7.3.4 and 7.3.5.

7.3.2 A hinged cover is not required for a device in which the only fuses enclosed are:

- a) control circuit fuses, provided the fuses and control circuit loads (other than a fixed control circuit load, such as a pilot lamp) are within the same enclosure, or
- b) an extractor type fuse with its own enclosure that is accessible without exposing live parts other than a fuse contact of the fuseholder.

7.3.3 The removable portion of a fused pullout switch that complies with the requirements in 7.1.1 and 7.1.2, 7.1.6 – 7.2.4, 7.3.7, and 7.3.8 is considered to be an acceptable cover for the fuseholder and need not comply with the requirements in 7.3.1.

7.3.4 A spring latch, a magnetic latch, a dimple, or other mechanical arrangement that will hold the door closed and would require some effort on the user's part to open is considered to provide the "automatic latching means" for holding the door closed as required in 7.3.1.

Table 7.1
Minimum thickness of sheet metal for electrical enclosures —
carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness in inches (mm)	
Maximum width, ^b	Maximum length, ^c	Maximum width, ^b	Maximum length, ^c	Uncoated (MSG)	Metal coated (GSG)
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)		
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 ^d (0.51)	0.023 ^d (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 ^d (0.66)	0.029 ^d (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 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 continuous flange at least 1/2 inch (12.7 mm) wide.

^d Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for Outdoor Use Equipment.

Table 7.2
Minimum thickness of sheet metal for electrical enclosures —
aluminum, copper, or brass

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length	
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)	Inches (mm) AWG
3.0 (7.6)	Not limited	7.0 (17.8)	Not limited	0.023 ^d (22)
3.5 (8.9)	4.0 (10.2)	8.5 (21.6)	9.5 (24.1)	(0.58)
4.0 (10.2)	Not limited	10.0 (25.4)	Not limited	0.029 (20)
5.0 (12.7)	6.0 (15.2)	10.5 (26.7)	13.5 (34.3)	(0.74)
6.0 (15.2)	Not limited	14.0 (35.6)	Not limited	0.036 (18)
6.5 (16.5)	8.0 (20.3)	15.0 (38.1)	18.0 (45.7)	(0.91)
8.0 (20.3)	Not limited	19.0 (48.3)	Not limited	0.045 (16)
9.5 (24.1)	11.5 (29.2)	21.0 (53.3)	25.0 (63.5)	(1.14)
12.0 (30.5)	Not limited	28.0 (71.1)	Not limited	0.058 (14)
14.0 (35.6)	16.0 (40.6)	30.0 (76.2)	37.0 (94.0)	(1.47)
18.0 (45.7)	Not limited	42.0 (106.7)	Not limited	0.075 (12)
20.0 (50.8)	25.0 (63.5)	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 a 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 continuous flange at least 1/2 inch (12.7 mm) wide.

^d Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall comply with the requirements for Outdoor Use Equipment.

7.3.5 A cover interlocking mechanism that:

- a) must be engaged in the closed position of the cover before any uninsulated live part is energized, and
- b) will secure the cover in the closed position, if provided as the sole means for securing the door or cover closed, is considered to comply with the requirement for an automatic latch in 7.3.1.

7.3.6 A screw with a knurled and slotted head (for securing with a screwdriver) and that can be manually turned is not acceptable as a required enclosure securing means.

7.3.7 A door or cover giving direct access to fuses in other than a low-voltage circuit shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges and angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box no less than 1/2 inch (12.7 mm).

Exception: A construction that affords equivalent protection or a combination of flange and rabbet is acceptable.

7.3.8 A strip used to provide a rabbet and an angle strip fastened to the edges of a door shall be secured:

- a) at no less than two points,
- b) no more than 1-1/2 inches (38 mm) from each end of each strip, and
- c) at points between these end fastenings no more than 6 inches (152 mm) apart.

7.4 Field wiring system connections

7.4.1 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than:

- a) 0.032 inch (0.81 mm) if uncoated steel,
- b) 0.034 inch (0.86 mm) if galvanized steel, and
- c) 0.045 inch (1.14 mm) if nonferrous material.

7.4.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be less than three or more than five threads in the metal. The construction of the device shall be such that a conduit bushing can be attached.

7.4.3 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal. There shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and that shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

7.4.4 A knockout in a sheet metal enclosure shall be capable of being removed without deformation of the enclosure that would affect the intended attachment of a conduit fitting.

7.4.5 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.

7.4.6 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing less than those specified in Table 26.1 or 26.2, as applicable.

7.4.7 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout, it is to be assumed that a bushing having the dimension indicated in Table 7.3 is in place, in conjunction with a single locknut on the outside of the enclosure.

7.5 User servicing

7.5.1 Uninsulated high-voltage live parts of a unit shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by persons performing operations such as oiling motors, replacing filters, or adjusting controls. See 51.1.

Table 7.3
Knockout or hole sizes and dimensions of bushings

Trade size of conduit		Knockout or hole diameter		Bushing dimensions			
				Overall diameter		Height	
Inches	mm OD	Inches	mm	Inches	mm	Inches	mm
1/2	21.3	7/8	22.2	1	25.4	3/8	9.5
3/4	26.7	1-3/32	27.8	1-15/64	31.4	27/64	10.7
1	33.4	1-23/64	34.5	1-19/32	40.5	33/64	13.1
1-1/4	42.3	1-23/32	43.7	1-15/16	49.2	9/16	14.3
1-1/2	48.3	1-31/32	50.0	2-13/64	56.0	19/32	15.1
2	60.3	2-15/32	62.7	2-45/64	68.7	5/8	15.9
2-1/2	73.0	3	76.2	3-7/32	81.8	3/4	19.1
3	88.9	3-5/8	92.1	3-7/8	98.4	13/16	20.6
3-1/2	101.6	4-1/8	104.8	4-7/16	112.7	15/16	23.8
4	114.0	4-5/8	117.5	4-31/32	126.2	1	25.4
4-1/2	127.0	5-1/8	130.2	5-35/64	140.9	1-1/16	27.0
5	141.3	5-5/8	142.9	6-7/32	158.0	1-3/16	30.2
6	168.3	6-3/4	171.5	7-7/32	183.4	1-1/4	31.8

7.5.2 A rubber or neoprene boot over the terminal of a motor capacitor that is accessible during user servicing:

- shall not be less than 1/32 inch (0.8 mm) thick,
- shall resist thermal degradation, and
- shall incorporate means to secure the boot in place, such as a molded lip that fits over the flange of the capacitor case.

7.5.3 Fan blades, blower wheels, pulleys, belts, and the like, shall be enclosed or guarded to reduce the risk of injury to persons. See 7.5.4 – 7.5.8.

7.5.4 The degree of protection required in 7.5.3 depends upon the general design and the intended use of the unit. Factors to be taken into consideration in judging the acceptability of protection against contact with moving parts are:

- a) the degree of exposure afforded by intended locations in use,
- b) the sharpness of the moving parts,
- c) the likelihood of unintentional contact with the moving parts,
- d) the speed of movement, and
- e) 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).

7.5.5 An interlocking mechanism that 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 7.5.3.

7.5.6 The requirement in 7.5.3 will ordinarily necessitate that an opening in the required guard or enclosure around a moving part comply with Table 7.4.

Table 7.4
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)

7.5.7 If the starting or restarting of a motor driving a moving part such as described in 7.5.3 is provided by an automatic cycling device such as a thermostat, thermal protector, or the like, a guard shall be provided if the part is exposed when making normal operating adjustments or changing air filters or if the part is accessible without requiring the use of tools.

7.5.8 With reference to 7.5.7, the scroll of a centrifugal blower is an acceptable guard for a blower wheel.

7.6 Electrical components

7.6.1 Other than as indicated in 7.6.2, an opening in the enclosure of a unit or in an externally mounted component shall be located so that it will not vent into a concealed space of a building structure, such as a false ceiling space, a hollow space in the wall, and the like, when installed as intended.

7.6.2 The requirement in 7.6.1 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 (6.8 mm) or an area no more than 0.055 square inch (35.5 mm²).

7.6.3 Other than as noted in 7.6.4, an opening for ventilation in an enclosure, other than in the bottom, shall be provided with one or more baffles to reduce the risk of emission of flame, molten metal, burning insulation, or the like, from the unit.

7.6.4 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 7.6.3 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 unit is so constructed that it is suitable for the purpose, as shown by an investigation, including short-circuit tests.

7.7 Accessibility of uninsulated live parts, film-coated wire, and moving parts

7.7.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from uninsulated live part or film-coated wire, or an opening in an enclosure of an appliance or in a motor shall be investigated as described in (a) or (b):

- a) For an opening that has a minor dimension (see 7.7.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 7.1.
- b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 7.5.

Exception: A motor need not comply with these requirements if it complies with the requirements in 7.7.2.

Table 7.5
Minimum acceptable distance from an opening to a part
that may involve a risk of
electric shock or injury to persons

Minor dimension of opening ^a ,		Minimum distance from opening to part,	
Inches ^b	(mm) ^b	Inches ^b	(mm) ^b
3/4 ^c	(19.1)	4-1/2	(114.0)
1 ^c	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
d		30	(762.0)

^a See 7.7.5.
^b Between 3/4 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
^c Any dimension less than 1 inch applies to a motor only.
^d More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

7.7.2 With respect to a part or wire as mentioned in 7.7.1, in an integral enclosure of a motor as mentioned in the exception to 7.7.1:

- a) An opening that has a minor dimension (see 7.7.5) less than 3/4 inch (19.1 mm) is acceptable if:
- 1) A moving part cannot be contacted by the probe illustrated in Figure 7.2;
 - 2) Film-coated wire cannot be contacted by the probe illustrated in Figure 7.3;
 - 3) In a directly accessible motor (see 7.7.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.4; or
 - 4) In an indirectly accessible motor (see 7.7.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.2.
- b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 7.5.

Figure 7.2
Probe for moving parts and uninsulated live parts

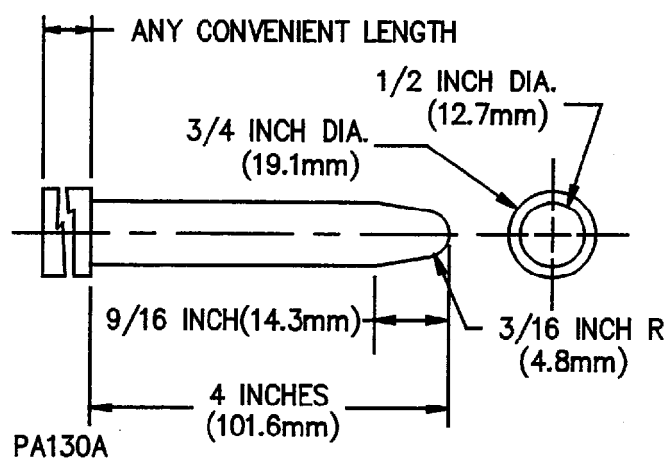


Figure 7.3
Probe for film-coated wire

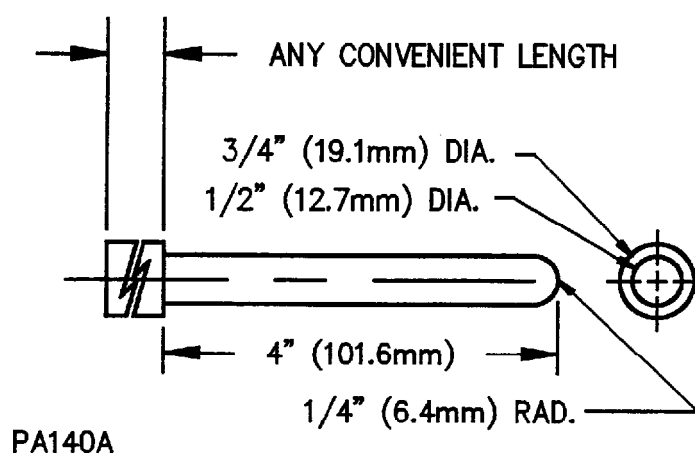
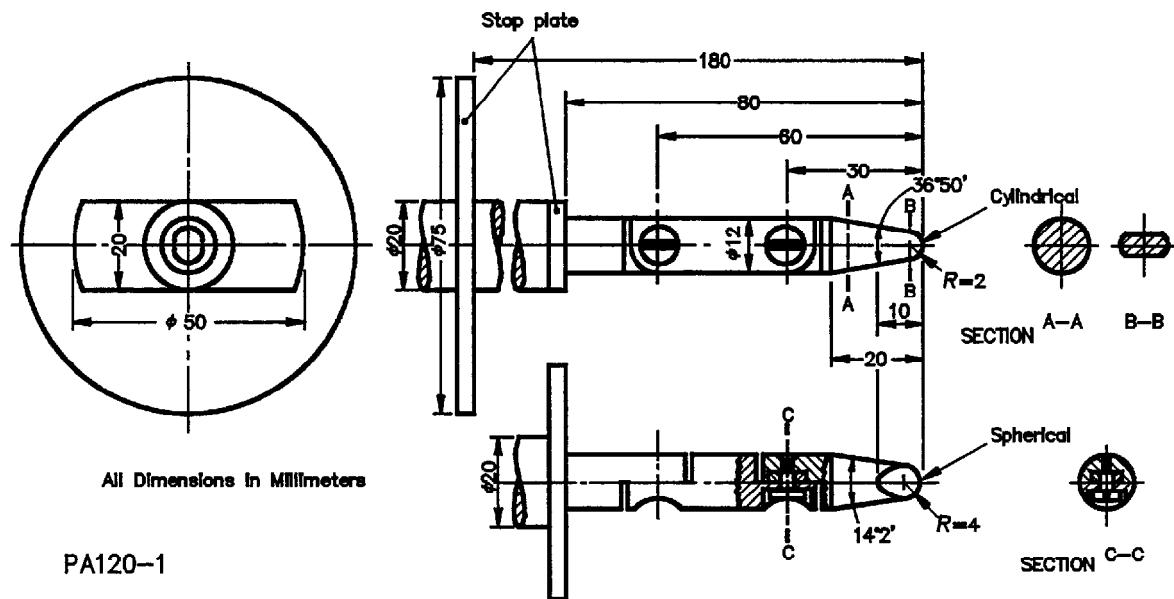


Figure 7.4
IEC articulate probe



7.7.3 The probes mentioned in 7.7.1 and 7.7.2 and illustrated in Figures 7.1 – 7.4 are to be applied to any depth that the opening will permit; and are to be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figures 7.1 and 7.4 are to be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

7.7.4 The probes mentioned in 7.7.1 and 7.7.2 are to be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

7.7.5 With reference to the requirements in 7.7.1 and 7.7.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

7.7.6 With reference to the requirements in 7.7.2, an indirectly accessible motor is a motor:

- that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool, or
- that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

A directly accessible motor is a motor that can be contacted without opening or removing any part or that is located so as to be accessible to contact.

7.7.7 During the examination of a product to determine whether it complies with the requirements in 7.7.1 or 7.7.2, an air filter and a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

7.7.8 With reference to the requirements in 7.7.1 and 7.7.2, insulated brush caps are not required to be additionally enclosed.

7.8 Bottom closure

7.8.1 An enclosure shall reduce the risk of molten metal, burning insulation, flaming particles, or the like, from falling onto flammable materials, including the surface upon which a unit is supported. See 7.6.3, 7.6.4, and 7.8.2 – 7.8.8.

7.8.2 All intended mounting positions of a unit are to be considered in determining if the unit complies with the requirements in 7.8.1.

7.8.3 An acceptable bottom closure is considered to be provided if the bottom opening is always intended to be connected to a fresh air discharge duct or an indoor intake air duct and:

- a) the unit includes space-heating means (electric, hot water, or steam), or
- b) the unit is intended only for nonresidential applications and a marking as specified in 50.13 is provided.

7.8.4 An air filter is not acceptable as part of the bottom closure or as a barrier.

7.8.5 Other than as indicated in 7.8.3, the requirement in 7.8.1 will necessitate that a nonflammable bottom closure with no openings be provided for a unit or a compartment thereof that contains:

- a) Opening wiring (that is, wiring that is not separately and immediately enclosed in conduit, metal clad cable, metal raceway, or the like); or
- b) An electrical component (other than a motor) that is not individually and completely enclosed, other than terminals.

Exception: This requirement does not apply if it can be shown that failure of the component would not result in a risk of fire.

7.8.6 With reference to 7.8.5(a), a channel or trough under the wiring is acceptable as a bottom closure if:

- a) The wires do not project through the plane of the top of the trough or channel; and
- b) If judged as film-coated wire, the wiring would be acceptable in accordance with 7.7.1 and 7.7.2.

7.8.7 The requirement in 7.8.1 will necessitate the use of a barrier of metal or a material classed 94-5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, under an open type motor unless:

- a) The structural parts of the motor or unit, such as the bottom closure, provide the equivalent of such a barrier;