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Heating and Cooling Equipment

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Heating and Cooling Equipment, UL 1995

Third Edition, Dated February 18, 2005

Summary of Topics

This new edition of UL 1995 incorporates revisions in accordance with UL's Bulletins on this subject dated August 6, 2001 and October 31, 2002. It is also a periodic re-issuance to ensure that UL's Standards remain up-to-date with regard to format and editorial issues such as renumbering, repaginating, correction of editorial errors, correction of cross-references and updating titles of referenced Standards.

The following table lists the future effective dates with the corresponding reference.

Future Effective Dates	References
February 15, 2006	19.15
February 17, 2007	Paragraph 26.2, Section 65, Section 67, Section 68, and Section 76.

The requirements contained in the third edition are substantially in accordance with UL's Bulletin(s) on this subject dated August 6, 2001 and October 31, 2002. The bulletin(s) is now obsolete and may be discarded.

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.

As indicated on the title page (page 1), this UL Standard for Safety has been adopted by the Department of Defense.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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:

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CSA C22.2 236-05
Third Edition



Underwriters Laboratories Inc.
UL 1995
Third Edition

Heating and Cooling Equipment

February 18, 2005



ANSI/UL 1995-2003

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (CSA), and Underwriters Laboratories Incorporated (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of CSA and UL. CSA and UL will issue revisions to this Standard by means of a new edition or revised or additional pages bearing their date of issue.

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The most recent designation of ANSI/UL 1995 as an American National Standard (ANSI) occurred on August 25, 2003. The ANSI approval for this standard does not include the Cover Page, Transmittal Pages, Title Page, Preface, Forewords, or Annex A.

This ANSI/UL Standard for Safety, which consists of the Third edition is under continuous maintenance, whereby each revision is ANSI approved upon publication. 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>.

The Department of Defense (DoD) has adopted UL 1995 on March 9, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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Preface

This is the common CSA and UL Standard for Heating and Cooling Equipment. It is the third edition of CAN/CSA–C22.2 No. 236 and the third edition of UL 1995. This edition of CAN/CSA–C22.2 No. 236 and UL 1995 supersedes the previous editions published in 1995 and 1990.

This common Standard was prepared by Canadian Standards Association, Underwriters Laboratories Inc., and the heating and cooling equipment industry. The efforts and support of the Air Conditioning and Refrigeration Institute (ARI) and the Heating, Refrigerating, and Air Conditioning Institute of Canada (HRAI) are acknowledged.

This Standard addresses safety requirements for various types of heating, air-conditioning, and ventilation equipment.

This Standard was reviewed by the CSA Subcommittee on C22.2 No. 236, under the jurisdiction of the CSA Technical Committee on Consumer and Commercial Products and the CSA Strategic Steering Committee on the Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committees. It was also reviewed by the UL Standards Technical Panel 1995 and processed according to the method of development, revision, and implementation of UL standards for safety.

This Standard has been approved as a National Standard of Canada by the Standards Council of Canada and as a National Standard of the U.S.A. by the American National Standards Institute (ANSI).

Note: Although the intended primary application of this Standard is stated in its scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

Level of harmonization

This Standard is published as an identical Standard. An identical Standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

Interpretations

The interpretation by the SDO of an identical standard shall be based on the literal text to determine compliance with the standard in accordance with the procedural rules of the SDO. If more than one interpretation of the literal text has been identified, a revision shall be proposed as soon as possible to each of the SDOs to more accurately reflect the intent.

UL Effective Date

This standard is now in effect for all products except for paragraph 19.15 which becomes effective February 15, 2006 and paragraph 26.2 and Sections 65, 67, 68, and 76 which become effective February 17, 2007.

CSA Effective Date

The effective date for CSA International will be announced through CSA Informs or a CSA certification notice.

Foreword (CSA)

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Manufacturers should note that, in the event of the failure of CSA International to resolve an issue arising from the interpretation of requirements, there is an appeal procedure: the complainant should submit the matter, in writing, to the Secretary of the Canadian Standards Association.

If this Standard is to be used in obtaining CSA Certification please remember, when making application for certification, to request all current Amendments, Bulletins, Notices, and Technical Information Letters that may be applicable and for which there may be a nominal charge. For such information or for further information concerning CSA Certification, please address your inquiry to Applications and Customer Service, CSA International, 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3.

Heating and cooling equipment

1 Scope

1.1 These requirements apply to the following stationary equipment for use in nonhazardous locations rated 7200 V or less, single- or 3-phase, and remote control assemblies for such equipment:

- a) Heat pumps, for heating and cooling with or without factory or field-installed electric resistance heaters, or hot water or steam heating coils.
- b) Air conditioners for cooling with or without factory or field-installed electric resistance heaters, or hot water or steam heating coils.
- c) Cooling portion and associated components of combination heating and cooling equipment employing gas-, oil-, or gas-oil-fired heating means. However, the requirements for the construction and performance of the gas-, oil-, or gas-oil-fired heating means, and their associated components, shall conform to the particular standards covering such heating equipment and components.
- d) Liquid chillers and compressor-evaporator or liquid chiller assemblies intended for use with remote condensers.
- e) Condensing units intended for connection to a remote nonspecified evaporator and compressor units intended for connection to a remote nonspecified evaporator and condenser.
- f) Add-on heat pumps for comfort heating or heating and cooling.
- g) Heat pump water heaters and refrigerant desuperheaters, and packaged heat pump water heaters consisting of a heat pump water heater and an associated storage tank.
- h) Fan units and fan coil units for comfort heating and/or comfort cooling.
- i) Room fan heater units, central heating furnaces, and similar fixed electric space heating for comfort heating.

1.2 The units referenced in Clause 1.1(g), self contained heat pumps and air conditioners may be cord-connected if they

- a) are for indoor use only;
- b) are rated 250 V or less, single phase, with a marked rating of 24 A or less; and
- c) comply with Clause 1.11.

1.3 A fan unit includes a motor-operated fan or blower and is intended to be connected to a duct system that supplies conditioned air for environmental heating and/or cooling. Such a unit may have air-controlled dampers, but does not include a factory-installed heat exchanger or any other integral heating or cooling means.

1.4 A fan coil unit includes a motor-operated fan or blower together with a cooling coil, a heating coil, or both. The fan or blower is intended to recirculate air, and may introduce air from outside of the heated or cooled space. The coil may be used for refrigerant cooling, for chilled water cooling, for hot water heating, for steam heating, or for combinations of these functions.

1.5 A fan coil unit is intended to be piped to a remote source of the heating and/or cooling mediums. A unit that includes an electric resistance heater is considered to be a fan coil unit if a water or refrigerant coil for comfort cooling and/or a water or steam coil for comfort heating is provided in the unit.

1.6 A room fan heater unit is intended for heating only, includes a motor-operated fan or blower, employs electric resistance heat as the only heat source, and is intended to serve only one room or space.

1.7 A fan coil unit or electric space heating equipment, as covered by these requirements, may be designed for free discharge of air to the room or may be provided with means for duct connection.

1.8 A central warm air furnace is a heating appliance that consists of an electric heating element or elements with an air-circulating fan or blower, is provided with appropriate integral operating and temperature-limiting controls, and is housed in an enclosure designed to be connected to ductwork for the distribution of the heated air remote from the unit.

1.9 The units referenced in Clause 1.1 may consist of one or more factory-made assemblies. If provided in more than one assembly, the separate assemblies are to be used together, and the requirements are based on the use of matched assemblies. These requirements apply to assemblies designed for free discharge of air into the conditioned space as well as those which may be provided with means for duct connection.

1.10 These requirements do not apply to add-on heat pump systems designed to utilize the indoor fan motor assembly of an installed furnace where

a) the heat pump and furnace are intended to operate simultaneously during heating operation except as noted in the Exception to Clause 26.14; or

b) the refrigerant coil is intended to be mounted upstream (return air side) of the furnace.

1.11 These requirements apply to equipment designed to be used in nonhazardous locations in accordance with the rules of the CSA C22.1, ANSI/NFPA No. 70, CSA B52, ANSI/ASHRAE 15, NFPA 90A, and NFPA 90B.

Note: Requirements for the installation of units designed to be connected to air duct systems are also included in codes such as the BOCA Basic National Mechanical Code, the ICC's Standard Mechanical Code, and the ICC's Uniform Mechanical Code.

1.12 The values given in SI (metric) units are the standard. The values given in parentheses are for information only.

1.13 Units intended for connection to telecommunication equipment shall have the appropriate assembly containing such circuitry meet the CAN/CSA C22.2 No. 225 and UL 1459.

1.14 The following Clauses or Sections of CAN/CSA-C22.2 No. 0 are superseded by the requirements of this Standard:

- a) "General Requirements", Section 3, and "Construction Details", Section 4 (refer to Sections 2 through 34 of this standard);
- b) "Marking", Section 5 (refer to Sections 35, 36, and 37 of this standard);
- c) "Tests", Section 6 (refer to Sections 38 through 69 of this standard).

1.15 These requirements do not cover panel or cable type radiant heating equipment, electric boilers, baseboard heaters, air heaters, duct heaters, and unit coolers for refrigeration purposes, nor any other electric heating equipment or appliances which are covered in or as a part of separate, individual standards.

2 Definitions

2.1 The following definitions apply in this Standard:

Add-on heat pump – a pump that normally consists of an outdoor section, one or more indoor sections (without circulating fan), and related control devices.

Air-circulating blower – the complete blower or fan assembly, including the blower wheel or fan, the blower housing, and the motor used to provide the means for the circulation of air in a system.

Barrier – a partition for the isolation (insulation) of hazardous voltage electrical circuits or isolation of electrical arcs or moving parts

Cabinet – that part of the unit that encloses insulated wiring, electrical enclosures, moving parts, motors or enclosed electrical parts.

Circuit, extra-low-voltage – a circuit that has an ac potential of not more than 30 V (42.4 V 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 an extra-low-voltage circuit.

Circuit, hazardous voltage – a circuit having characteristics in excess of those of an extra-low-voltage circuit.

Combination temperature-regulating and -limiting thermostat – a thermostat that functions to regulate the temperature under normal conditions of use, and also serves to prevent a hazard that might result from conditions of abnormal operation of the heater.

Compressor unit – an assembly that includes one or more compressors with associated controls and wiring. A compressor unit may be intended for field connection to a remote evaporator, which may be an integral part of other refrigeration equipment, and to a remote condenser.

Compressor evaporator unit – an assembly that includes one or more compressors and evaporators, with associated controls and wiring, and which are intended for field connection to a remote condenser.

Condenser, forced-air cooled – an assembly that includes an air-cooled condenser and one or more electric motor-driven fans or blowers to circulate air through the condenser coil.

Condensing unit – an assembly that includes one or more compressors and condensers with interconnecting refrigerant piping and associated controls and wiring. A condensing unit may be intended for field connection to a remote evaporator, which may be an integral part of other refrigeration or air-conditioning equipment.

Design pressure – the maximum allowable working pressure for which a specific part of a system or the unit is designed.

Desuperheater – factory-assembled equipment in which the flows of refrigerant vapour and water are maintained in such heat transfer relationship that the refrigerant vapour is desuperheated and the water is heated. Normally it consists of a heat exchanger, water pump, and associated controls, but without a self-contained refrigerating system.

Downflow unit – a forced air unit so designed that the air to be heated is forced vertically downward through the equipment heating compartment and discharged through the equipment base.

Enclosure – that part that houses electrical components, internal wiring, and uninsulated hazardous voltage live parts.

Functional part – a part other than an enclosure, cabinet, or structural part but which is necessary for the intended operation of the unit (for example, fan blade, etc.)

Guard – that part of the cabinet which, while permitting the passage of air, prevents contact with moving or electrical parts.

Heater assembly – a complete or partial assembly of the heating element, electrical insulation (for example, refractory or mica), metal sheath, thermal insulation, and frame or adaptor for holding the assembly together and fastening it in the heater enclosure; and leads and terminal connections, or both.

Heating element – the electrical conducting medium that is intended to be heated by an electric current.

Heat exchanger – a device specifically designed to transfer heat between two physically separated fluids.

Heat exchanger, double wall – a heat exchanger that has two distinct thicknesses of material separating any liquid or fluid from the heat transfer fluid.

Heat exchanger, single wall – a heat exchanger with only one distinct thickness of material separating any liquid or fluid from the heat transfer fluid.

Heat pump water heater – factory-assembled equipment in which a self-contained refrigerating system is employed to transfer heat into water. The condenser provides the heat, while the evaporator is arranged to pick up heat from the air.

Heater guard – that part of the enclosure provided to prevent accidental contact with the heater assembly, or to prevent debris from falling on the heater assembly.

High side – that part of a refrigerating system subject to condenser pressure.

Horizontal unit – a forced-air unit intended for installation in a horizontal position, and with the heater casing located in the same horizontal plane as the air-circulating blower compartment.

Low side – that part of a refrigerating system subject to evaporator pressure.

Multi-circuit unit – an assembly intended primarily for refrigeration applications that includes multiple condensing units, compressor units, or compressors, with single or multiple condensers, with associated piping, controls, and wiring, mounted on a common frame or in a common housing. A multi-circuit unit may be intended for field connection to remote evaporators that form multiple refrigeration or air-conditioning systems.

Piping – the pipe or tube mains for interconnecting the various parts of a refrigerating system. Piping includes pipe, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components such as expansion joints, strainers, and devices that serve such purposes as mixing, separating, snubbing, distributing, metering, or controlling flow, pipe-supporting fixtures, and structural attachments.

Plenum – a chamber associated with air-handling apparatus, for distributing the processed air from the apparatus (outlet plenum) to the outlet ducts, or for receiving air to be processed by the apparatus (return plenum).

Potable water – water intended for human consumption.

Pressure-limiting device – a mechanism that automatically responds to a predetermined pressure by stopping the operation of the pressure-imposing element.

Pressure relief device – a pressure (not temperature)-actuated valve or rupture member that functions to relieve excessive pressure automatically. A hermetic compressor's internal pressure relief valve is not considered a pressure relief device.

Pressure vessel – a closed vessel, used for containing, storing, distributing, transferring, distilling, processing, or otherwise handling any gas, vapour, or liquid under pressure and as further defined in the CSA B52 and ANSI/ASHRAE 15.

Rooftop equipment – horizontally-mounted, downflow or horizontal flow equipment, or similar equipment intended to be installed on rooftops; and equipped with means for attaching pipes or ducts for the distribution of the conditioned air.

Self-contained unit – a complete factory-made and factory-tested unit, in a suitable frame or enclosure, that is fabricated and shipped in one or more sections, and has no refrigerant-containing parts connected in the field other than by companion or block valves.

Structural part – a part other than an enclosure or cabinet used in such a manner that failure of the part may present risk of electric shock or personal injury (for example, motor mount, etc).

Temperature-limiting thermostat – a thermostat that functions only under conditions that produce abnormal temperatures. The failure of such a thermostat might result in a hazard.

Temperature-regulating thermostat – a thermostat that functions only to regulate the temperature under normal conditions of use, the failure of which would not result in a hazard.

Ultimate strength – the highest stress level that the refrigeration component or vessel can tolerate without rupture.

Unitary heat pump (or equipment) – a device for circulating, filtering, heating, or heating and cooling the air, that consists of one or more factory-made matched assemblies, which normally include an indoor coil, compressor(s), and an outdoor coil or chiller/condenser, and an electric resistance heater package with controls for automatic heating or cooling functions.

Upflow unit – a forced-air unit intended for installation in a vertical position; and with the heater casing located above the air-circulating blower compartment.

3 Reference publications

3.1 Where reference is made to any Standards (see Sections 77 and 78) such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified. Also, except as indicated in Clause 3.2, a component of a product covered by this Standard shall comply with all the requirements for that component.

3.2 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.

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

3.4 Specific components are accepted 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 investigated.

4 Installation and operating instructions

4.1 A copy of the installation and operating instructions intended to accompany each unit or component, or equivalent information, is to be included in the examination and test of the equipment. For this purpose, a draft, rather than a printed edition, is acceptable.

4.2 If a unit containing an indoor coil has no provision for connecting a return air duct, or if the instructions indicate that a return air duct need not be used, the instructions may indicate that applicable installation codes may limit this unit to installation only in a single story residence.

4.3 Applicable installation codes or CSA C22.1 or ANSI/NFPA No. 70 may limit the number of field wiring system connections. See Connection to Power Supply, Section 17 of this Standard.

CONSTRUCTION

5 Enclosures

5.1 Enclosures for electrical equipment shall be so formed and assembled that, if abused during shipment, installation, or use, they will have the strength and rigidity to resist such abuses 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 Clause 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 may be expected under conditions of anticipated use or by electrical disturbances within.

5.4 Polymeric enclosures shall be considered to comply with Clause 5.3, provided that

- a) they comply with tests specified in the CAN/CSA-C22.2 No. 0.17 and Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C, and
- b) they have temperature ratings not less than the maximum temperatures to which they may be exposed during normal operation.

Enclosures need not comply with Section 5.10.

5.5 Polymeric materials not used as enclosures shall comply with Section 5.10.

5.6 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 0.51 mm (0.020 in) if uncoated or 0.58 mm (0.023 in) if galvanized, or nonferrous sheet metal having a thickness of less than 0.58 mm (0.023 in) are 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.

5.7 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. A free-standing, floor-supported unit need not be provided with mounting means. A unit designed for installation in a manufactured (mobile) home shall have provision for permanent mounting.

5.8 An electrical part within the outer cabinet need not be individually enclosed if 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 like to drop onto flammable material. See Clause 20.9 on 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 would permit objects to fall on or near uninsulated live parts.

Exception: Motors, electric resistance heating elements, metal-case capacitors, and other similar components that would not emit smoke or components protected to prevent emission of smoke into the air-handling compartment need not be individually enclosed.

5.9 To determine if a product complies with Clause 5.8, all of its intended mounting positions shall be considered. For this purpose an air filter is not considered to be part of the enclosure.

5.10 Polymeric materials other than enclosures

General

5.10.1 Polymeric materials or other nonmetallic materials are identified as follows:

- a) 5VA,
- b) 5VB,
- c) V-0,
- d) V-1,
- e) V-2,
- f) HF-1,
- g) HF-2,
- h) HB, and

- i) HBF.

See Table 5.10.1 for determination of material classifications and uses.

5.10.2 This section covers polymeric materials used for cabinets and structural or functional parts.

5.10.3 These requirements do not apply to polymeric materials specified in items (a), (b), (c), and (d) of Clause 18.2.

5.10.4 See Table 38.3 for determination of properties to be evaluated for testing. Unit application shall determine properties to be evaluated.

Isolation From Ignition Sources

5.10.5 Ignition sources within the unit are considered to be insulated or uninsulated live parts such as:

- a) hazardous voltage circuit wiring;
- b) hazardous voltage electrical components (some examples are; switches, relays, transformer windings, motor windings etc).

5.10.6 Polymeric materials located below an ignition source and within Space A of Figure 5.10.1 shall be isolated by a barrier extending to the sides of Space A.

5.10.7 Polymeric materials located above an ignition source and within Space B of Figure 5.10.1 shall be isolated by a barrier and extending to the sides of Space B. This barrier shall be positioned so that a minimum distance of 51 mm (2 in) from hazardous voltage wiring and 102 mm (4 in) from hazardous voltage electrical components are maintained.

5.10.8 Polymeric materials located outside of Space A and/or B shall be isolated by a barrier from the ignition source.

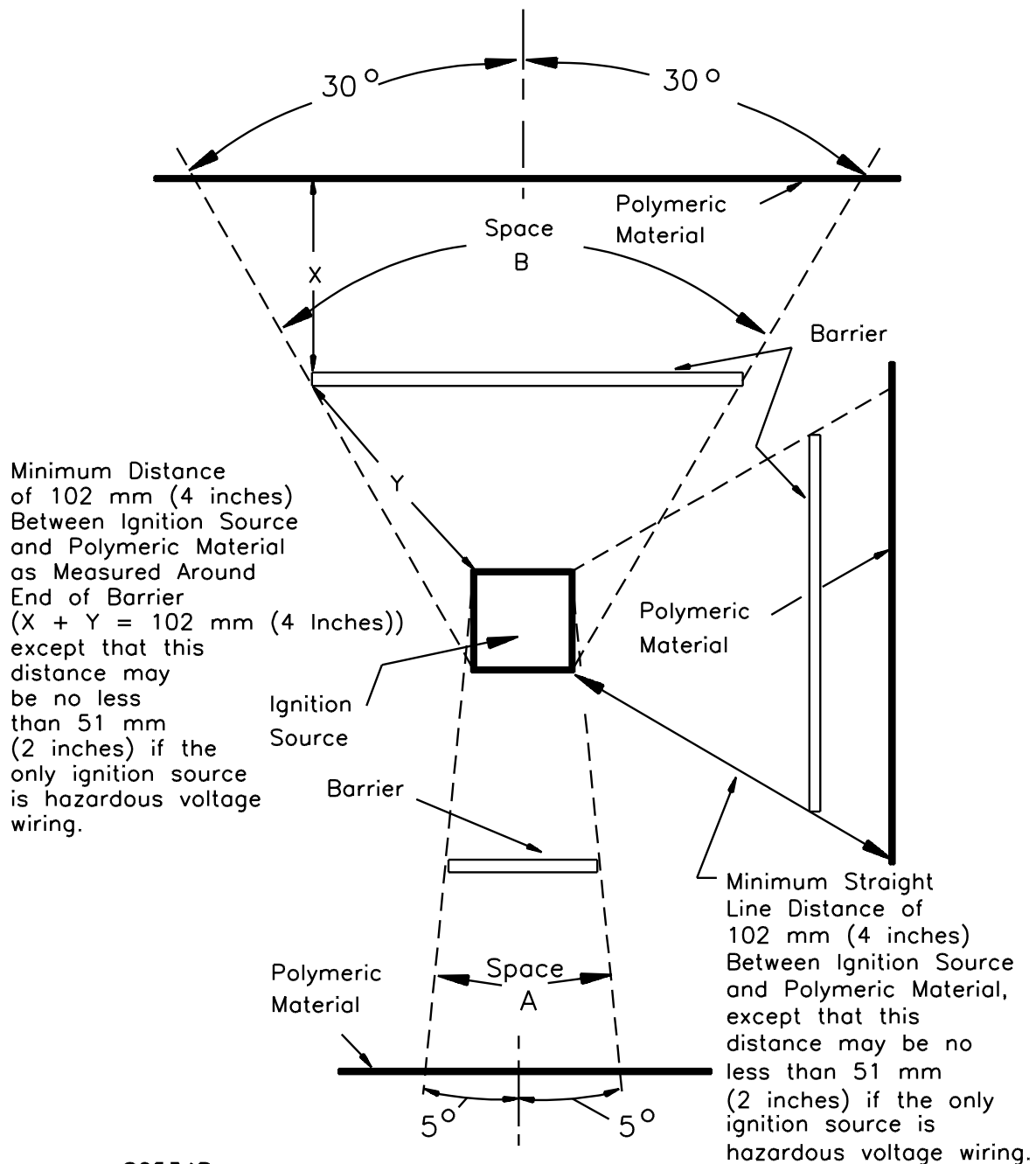
Exception: this barrier may be deleted if the materials are positioned so that a minimum distance of 51 mm (2 in) from hazardous voltage wiring and 102 mm (4 in) from hazardous voltage electrical components are maintained.

5.10.9 Hazardous voltage wiring, in which the flame test, CSA FT-1 and UL VW-1 or the vertical flame test as described in CSA C22.2 No. 49 and UL 1581 is conducted, is considered to comply with Clauses 5.10.6 through 5.10.8 and need not be isolated by the barriers described.

5.10.10 The barriers required in Clauses 5.10.6 through 5.10.8 shall be mechanically secured and:

- a) be constructed of metal at least 0.25 mm (0.010 in) thick; or
- b) be constructed of polymeric material rated 5VA.

Figure 5.10.1 – Exposure to ignition



S2534B

Space A represents the volume below the ignition source determined by a straight line that moves about the ignition source while remaining at an angle of 5° from the vertical and is always so oriented that the volume is a maximum.

Space B represents the volume above the ignition source determined in the same manner as Space A, except that the angle is 30° from the vertical.

Table 5.10.1
– Uses of materials based on flammability classifications

Degree of exposure to ignition source	Material flammability rating					
	HB or HBF	HF-1	HF-2	V-2	V-0 or V-1	5VA, 5VB
Not exposed	Yes	Yes	Yes	Yes	Yes	Yes
Exposed, but isolated as shown in Fig. 5.10.1 ^d	No ^d	No ^c	No ^{a,c}	Yes ^a	Yes	Yes
Exposed	No ^b	No ^{b,c}	No ^{b,c}	No ^{b,c}	No ^{b,c}	Yes

^a May not be used in Space A illustrated in Figure 5.10.1 if there are openings in the enclosure bottom in that space.
^b Vertically oriented material when laminated between two metal surfaces each no less than 0.25 mm (0.010 in) thick, may have an exposed vertical surface no more than 9.5 mm (0.75 in) wide.
^c May be used if the ignition sources are appliance wiring material or flexible cord as listed in Table 20.2, Group B.
^d Exception: Materials with a minimum rating of HB or HBF may be used in the outdoor section outside of spaces A and B if the distance between an ignition source and polymeric materials or openings are not less than 102 mm (4 in) and no less than 50.8 mm (2 in) from wiring.

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 Clause 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			
Maximum width ^b mm (in)	Maximum length ^c mm (in)	Maximum width ^b mm (in)	Maximum length ^c mm (in)	Minimum thickness of metal uncoated mm (in) coated mm (in)	
102 (4.0)	Not limited	159 (6.25)	Not limited	0.51 (0.020 ^d)	0.58 (0.023 ^d)
121 (4.75)	146 (5.75)	171 (6.75)	210 (8.25)		
152 (6.0)	Not limited	241 (9.5)	Not limited	0.66 (0.026 ^d)	0.74 (0.029 ^d)
178 (7.0)	222 (8.75)	254 (10.0)	318 (12.5)		
203 (8.0)	Not limited	305 (12.0)	Not limited	0.81 (0.032)	0.86 (0.034)
229 (9.0)	292 (11.5)	330 (13.0)	406 (16.0)		
318 (12.5)	Not limited	495 (19.5)	Not limited	1.07 (0.042)	1.14 (0.045)
356 (14.0)	457 (18.0)	533 (21.0)	635 (25.0)		
457 (18.0)	Not limited	686 (27.0)	Not limited	1.35 (0.053)	1.42 (0.056)
508 (20.0)	635 (25.0)	737 (29.0)	914 (36.0)		
559 (22.0)	Not limited	838 (33.0)	Not limited	1.52 (0.060)	1.60 (0.063)
635 (25.0)	787 (31.0)	889 (35.0)	1092 (43.0)		
635 (25.0)	Not limited	991 (39.0)	Not limited	1.70 (0.067)	1.78 (0.070)
737 (29.0)	914 (36.0)	1041 (41.0)	1295 (51.0)		
838 (33.0)	Not limited	1295 (51.0)	Not limited	2.03 (0.080)	2.13 (0.084)
965 (38.0)	1194 (47.0)	1372 (54.0)	1676 (66.0)		
1067 (42.0)	Not limited	1626 (64.0)	Not limited	2.36 (0.093)	2.46 (0.097)
1194 (47.0)	1499 (59.0)	1727 (68.0)	2134 (84.0)		
1321 (52.0)	Not limited	2032 (80.0)	Not limited	2.74 (0.108)	2.82 (0.111)
1524 (60.0)	1880 (74.0)	2134 (84.0)	2616 (103.0)		

Table 6.1 Continued on Next Page

Table 6.1 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a			
Maximum width ^b mm (in)	Maximum length ^c mm (in)	Maximum width ^b mm (in)	Maximum length ^c mm (in)	Minimum thickness of metal uncoated mm (in) coated mm (in)	
1600 (63.0)	Not limited	2464 (97.0)	Not limited	3.12 (0.123)	3.20 (0.126)
1854 (73.0)	2286 (90.0)	2616 (103.0)	3226 (127.0)		
^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 may be applied via the enclosure surface when it is deflected. Construction considered to have equivalent reinforcing may be accomplished by designs that will 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 12.7 mm (1/2 in) wide ^d Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.					

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			
Maximum width ^b mm (in)	Maximum length ^c mm (in)	Maximum width ^b mm (in)	Maximum length ^c mm (in)	Minimum thickness mm (in)	
76 (3.0)	Not limited	178 (7.0)	Not limited	0.58 ^d	(0.023)
89 (3.5)	102 (4.0)	216 (8.5)	241 (9.5)		
102 (4.0)	Not limited	254 (10.0)	Not limited	0.74	(0.029)
127 (5.0)	152 (6.0)	267 (10.5)	343 (13.5)		
152 (6.0)	Not limited	356 (14.0)	Not limited	0.91	(0.036)
165 (6.5)	203 (8.0)	381 (15.0)	457 (18.0)		
203 (8.0)	Not limited	483 (19.0)	Not limited	1.14	(0.045)
241 (9.5)	292 (11.5)	533 (21.0)	635 (25.0)		
305 (12.0)	Not limited	711 (28.0)	Not limited	1.47	(0.058)
356 (14.0)	406 (16.0)	762 (30.0)	940 (37.0)		
457 (18.0)	Not limited	1067 (42.0)	Not limited	1.91	(0.075)
508 (20.0)	634 (25.0)	1143 (45.0)	1397 (55.0)		
635 (25.0)	Not limited	1524 (60.0)	Not limited	2.41	(0.095)
737 (29.0)	914 (36.0)	1626 (64.0)	1981 (78.0)		
940 (37.0)	Not limited	2210 (87.0)	Not limited	3.10	(0.122)
1067 (42.0)	1346 (53.0)	2362 (93.0)	2896 (114.0)		
1321 (52.0)	Not limited	3124 (123.0)	Not limited	3.89	(0.153)
1524 (60.0)	1880 (74.0)	3302 (130.0)	4064 (160.0)		

Table 6.2 Continued on Next Page

Table 6.2 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		
Maximum width ^b mm (in)	Maximum length ^c mm (in)	Maximum width ^b mm (in)	Maximum length ^c mm (in)	Minimum thickness mm (in)
^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 may be applied via the enclosure surface when it is deflected. Construction considered to have equivalent reinforcing may be accomplished by designs that will 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 12.7 mm (1/2 in) wide ^d Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.				

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, mm (in)		
	Plain walls		Around conduit holes
	Maximum area ^a 154.9 cm ² (24 in ²) Maximum length 152.4 mm (6 in)	Area over 154.9 cm ² (24 in ²) Maximum length 152.4 mm (6 in)	
Die-Cast	1.6 (1/16) ^{b,c}	2.4 (3/32)	6.3 (1/4)
Other	3.2 (1/8)	3.2 (1/8)	6.3 (1/4)
^a Area and length limitations may be complied with by subdividing larger areas by means of suitable reinforcing ribs. ^b May be reduced to 0.9 mm (1/32 in) if: 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 V dc or single-phase ac. ^c May be reduced to 0.7 mm (0.028 in) minimum thickness for enclosures housing only extra-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) 0.35 mm (0.014 in) if steel, or 0.48 mm (0.019 in) if nonferrous metal, for a hole having a 6.4 mm (1/4 in) maximum dimension; and
- b) 0.68 mm (0.027 in) if steel, or 0.81 mm (0.032 in) if nonferrous metal, for a hole having a 34.9 mm (1-3/8 in) 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 Clause 6.1, the thickness of an enclosure may be two gauge sizes less than indicated in Tables 6.1 and 6.2, if the electrical components are located at least 64 mm (2-1/2 in) from the surface, and 4 gauge sizes less if the components are located at least 128 mm (5 in) from the surface. The thickness shall be not 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 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

Technical drawing of a mechanical part, PA100A, showing front, side, and cross-sectional views with dimensions in millimeters.

Front View (Left):

- Top feature: 3.5 RADIUS.
- Section A-A: Circular cross-section with hatching.
- Dimensions: .05, .05, .05, .05, .05, 78, 97, 16, 25.4, 50, .05, 78.

Side View (Right):

- Top feature: APPROX. 30°.
- Dimensions: 5.0, 5.8, 30, 60, 90, 96, 100, 136, 154, 234, 15, 19, 21.5, 25.4.

Bottom View (Bottom):

- Dimensions: 78, 25 RADIUS, 25 RADIUS.

ALL DIMENSIONS IN MILLIMETERS

7.1 Uninsulated live parts excluding film-coated wire, of hazardous 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 oiling motors, replacing air filters, adjusting controls, or performing other intended service and maintenance operations.

7.2 Openings in enclosures, including perforations, louvres, 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 Clause 7.6 for film-coated wire.

7.3 During the examination of a unit or part thereof, in connection with the requirements in Clause 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 Clause 36.3(r) will be disregarded in establishing compliance with these requirements.

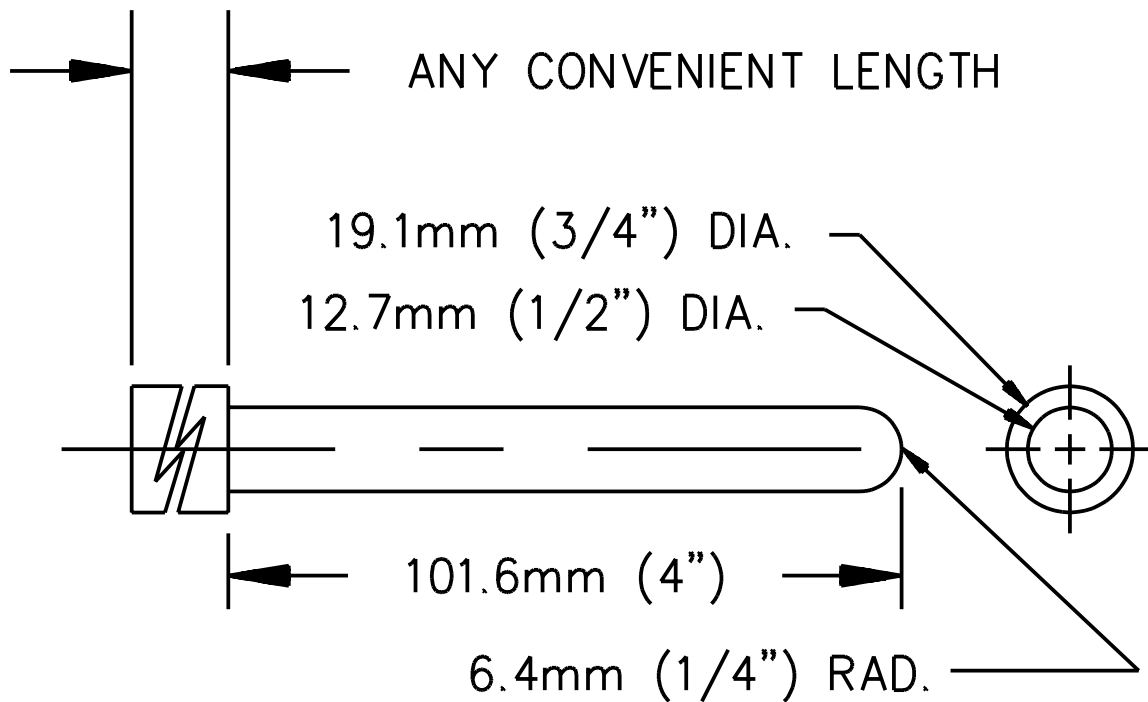
7.4 In the case of downflow units provided with open coil elements that do not comply with Clause 5.7, the manufacturer's installation instructions shall specify that an L-shaped exhaust duct be used as a bottom closure, without any outlets or registers located directly below open coil elements.

Exception: An acceptable barrier is considered to be provided by a finned coil construction at least two rows in depth and with at least 12 fins per 25.4 mm (1 in).

7.5 With reference to Clause 7.4, an air filter is not acceptable as a barrier.

7.6 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)



PA140C

8 Enclosures, doors, and covers

8.1 Doors and covers that give access to uninsulated live hazardous 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 Clause 8.1 if it

- a) secures the cover in the closed position when engaged; and
- b) must be engaged before parts in a hazardous voltage circuit can be energized.

9 Accessibility of parts

9.1 Sufficient and reasonable accessibility shall be afforded to all parts that require normal servicing or adjustment (for example, controls, filters, oiling of bearings, adjustment of belts) 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 hazardous voltage live parts.

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

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

Exception: If more than one door or cover has to be opened to provide access, only one of these need to comply with this requirement.

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

- a) fuses connected in extra-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 A or less used in small, auxiliary resistance heater circuits having a maximum rating of 100 W.

9.5 The reset button or lever of manual resettable devices (for example, the operating handle of a circuit breaker, the reset button of a motor protector, the reset button of a pressure switch, the adjusting screw or knob of an adjustable temperature or pressure 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 hazardous voltage parts or moving parts. Outdoor units are to meet the rain test requirements of Clauses 13.1, 13.3, and Section 58.

9.6 A cover as specified in Clause 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 will hold the door in place and would require some effort on the user's part to open is considered to be acceptable for holding the door closed. A cover interlocking mechanism, as described in Clause 8.2, and provided as the sole means for securing the cover or panel, is considered to comply.

10 Assembly

10.1 A unit for use with a duct system 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 or refrigeration components and wiring. A distance of 152 mm (6 in) separating the opening from all components and wiring is considered to prevent damage due to drilling or cutting. Protection may be provided by equivalent means.

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

10.3 Provision for the connection of water supply, drainage lines, and refrigerant lines shall be made as required.

10.4 The components of a condensing unit and compressor unit, as covered by these requirements (Clause 2.1), shall be factory-assembled to form a single structural assembly such as a base or frame or refrigeration component.

Exception No. 1: The motor overload protective devices and motor controllers may be packaged with a condensing unit or compressor unit, provided they are of a type that is suitable for remote mounting and field wiring to the unit.

Exception No. 2: Dryers, filters, and the like that are intended for installation in the field may be packaged with the condensing unit or compressor unit, provided that they comply with the requirements in this Standard.

10.5 On liquid chillers employing centrifugal motor compressors, the motor-compressor controller and overload protection are not required to be provided. Where not provided, the manufacturer shall provide a specification for the controller and overload protection to be provided by the customer. The specification shall include information as to the required controller rating, sequencing of start, overload protection trip current, connections to the chiller control system, etc. If a current transformer is to be provided, as part of the controller, to provide a signal input circuit to the chiller control system, the specification is to include the requirements for the current transformer and its shunting resistor, if any. The controller and overload protection shall be provided for all other motors incorporated in the chiller assembly (see Clause 36.9).

11 Mechanical protection

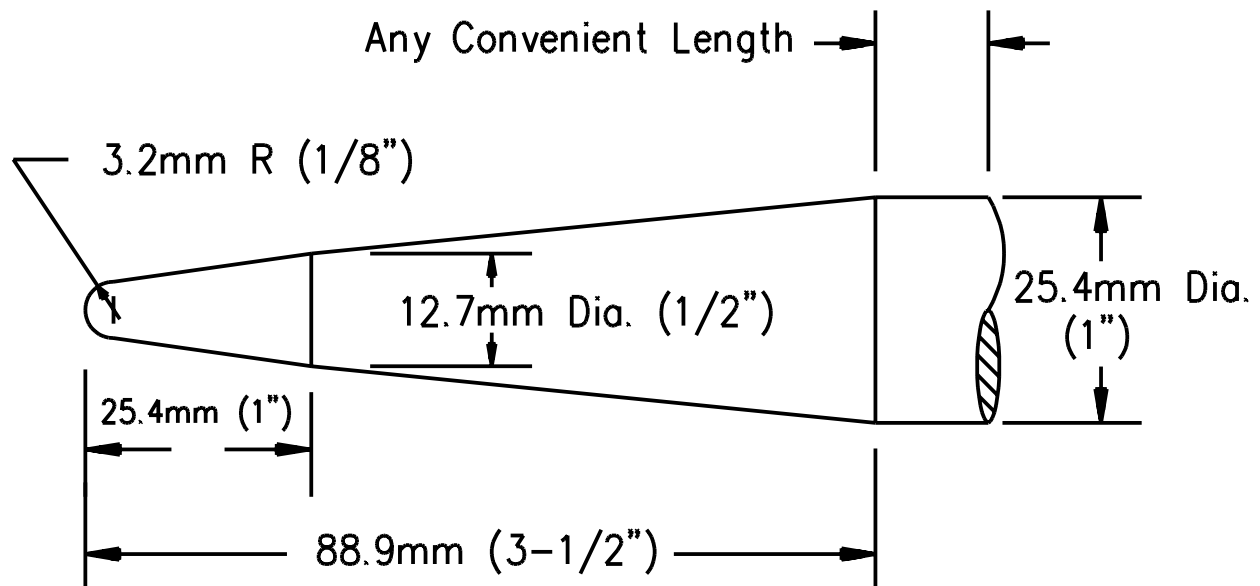
11.1 All moving parts (for example, fan blades, blower wheels, pulleys, and belts) that, if accidentally contacted, could cause bodily injury, shall be guarded against accidental contact by an enclosure or screen requiring tools for removal, or permanently attached.

11.2 Openings in external enclosures or guards provided for compliance with the requirements specified in Clause 11.1, are acceptable if they prevent the probe, illustrated in Figure 11.1, applied at any angle without a force, from making contact with moving parts.

Exception No. 1): Equipment marked as required by Clause 36.3(s) need not be provided with guarding.

Exception No. 2): Openings of 25.4 mm (1 in) or larger shall be guarded such that the distance from an opening to the moving parts is in accordance with Table 11.1.

Figure 11.1 – Probe (Moving Parts)



PA160A

Table 11.1 – Clearance from openings

Minor dimensions of opening		Minimum distance from opening to moving parts	
mm	(in)	mm	(in)
More than 25.4 but not more than 38.1	More than (1) but not more than (1-1/2)	212.7	(8-3/8)
More than 38.1 but not more than 50.8	More than (1-1/2) but not more than (2)	295.3	(11-5/8)
More than 50.8 but not more than 76.2	More than (2) but not more than (3)	762.0	(30)

11.3 An interlocking mechanism that operates to disconnect power to the drive motor when a cover or panel is removed or opened to provide access to moving parts is considered to provide the protection required by Clause 11.1.

11.4 Perforated sheet steel or expanded steel mesh used to cover openings shall give equivalent mechanical strength to that of a blank sheet of the thickness that will be required when determining compliance with Table 6.1.

11.5 If the starting or restarting of a motor driving a moving part is provided by an automatic cycling device, the moving part shall be guarded if the part is exposed when operating adjustments are made, or air filters changed, or if the part is accessible without the use of tools.

12 Outdoor use equipment

12.1 Sheet steel cabinets and enclosures of units intended for outdoor use shall be protected against corrosion as specified in Table 12.1, or by other metallic or nonmetallic coatings that have been shown to give equivalent protection.

Nonferrous cabinets and enclosures may be employed without special corrosion protection. The thickness of the material shall be judged on the basis of its strength and rigidity.

Table 12.1 – Corrosion protection

Type of cabinet and enclosure	1.35 mm (0.053 in) uncoated/1.42 mm (0.056 in) coated and greater as specified by Clause:	Less than 1.35 mm (0.053 in) uncoated and 1.42 mm (0.056 in) coated as specified by Clause:
Outer cabinets that protect motors, wiring, or enclosed current-carrying parts	12.2	12.3
Inside enclosures that protect current-carrying parts other than motors	12.2	12.3
Outer cabinets that are the sole enclosure of current-carrying parts	12.3	12.3

12.2 Where Table 12.1 references this Clause, 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 ASTM A653 or in Table 1 of 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 may be determined by any recognized method; however, where results are in question, the weight of coating shall be established in accordance with Tests for Weight of Coating on Zinc-Coated Iron or Steel Articles, 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.

12.3 Where Table 12.1 references this Clause, 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 may 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 Item (a) or (b) of Clause 12.2, plus one coat of outdoor paint as specified in Item (c) of Clause 12.2 on each surface.

12.4 Other finishes, including paints, special metallic finishes, and combinations of the two may be accepted when comparisons with galvanized sheet steel (without annealing, wiping, or other surface treatment) that complies with Item (a) of Clause 12.2 or 12.3, as applicable, indicate they provide equivalent protection.

12.5 Metals shall not be used in combinations such as to cause galvanic action that will adversely affect cabinets or enclosures.

13 Enclosures, outdoor use

13.1 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 58). If of steel, it shall be not less than 0.78 mm (0.0307 in) thick, and shall be suitably protected against corrosion as required by Section 12. 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.

13.2 An enclosure that is formed of metal which is thinner than specified in Clause 13.1, and which complies with Tables 6.1 and 6.2, whichever applies, is acceptable if 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 Clause 13.1, may be used if equivalent in all respects, including mechanical strength and corrosion resistance, to a single sheet of steel of the thickness specified in Clause 13.1.

13.3 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 58.

13.4 An enclosure for electrical components shall have provision for drainage if 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.

13.5 Units with polymeric cabinets shall comply with Section 5.10.

13.6 Gaskets required to seal enclosures of electrical components shall comply with the requirements of Section 59, Accelerated aging tests – Gaskets.

14 Field wiring connections, outdoor use equipment

14.1 Conduit openings or knockouts shall be provided for all field wiring connections, and shall be at least 22.2 mm (7/8 in) in diameter. Threaded openings shall be provided unless

- a) the opening is wholly below the lowest uninsulated live hazardous voltage part within the enclosure; or
- b) the opening prevents drainage into the enclosure along the outside surface of a field supplied wireway; or
- c) the routing of the factory- or field-supplied wiring is necessarily such that a drip-loop is formed, which physically prevents any entering moisture from reaching uninsulated live parts.

14.2 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 nor more than five threads in the metal. Construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal. There shall be a smooth, rounded inlet hole for the conductors which shall 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.

14.3 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging with the conduit.

15 Mechanical assembly

15.1 Parts used in the construction of the complete assembly shall have adequate strength, and shall be assembled and secured in position to ensure proper functioning under both normal and abnormal conditions that may be met in service. Refrigerant-containing parts shall have all joints made to prevent leakage of refrigerant under the aforementioned conditions.

15.2 Self-contained units that are designed to be shipped in separable sections (eg, wall sleeve, cooling section, heating section, control section, front panel) shall be marked in accordance with the requirements of Clause 36.3, and the following shall be complied with:

- a) each section shall be constructed and packaged so as to prevent damage to the parts during shipment and assembly;

- b) each section and the contents shall be identified as required by Clause 36.3(a) and (b); additionally the unit shall be marked to identify each section;
- c) electrical connections between the separable sections shall be capable of being made without additional parts being required, such as wiring, connectors, receptacles, terminal blocks;
- d) electrical bonding shall be maintained between sections after assembly;
- e) all connections shall be properly marked for assembly;
- f) guards required by Section 11 shall be secured to the appropriate section, and shall not be shipped as a separate item for field assembly;
- g) safety controls shall be an integral part of the sections requiring them; and
- h) each package shall contain that part of the installation instructions necessary to assemble it into the other sections.

15.3 The heating section referred to in Clause 15.2 may be a separable heater element assembly with all associated controls necessary for the proper operation of the elements, without an integral casing or enclosure for the electrical components, provided that the assembly is designed for field installation within the unit enclosure.

16 Auxiliary devices

16.1 A unit having provisions for the use of additional auxiliary devices intended to be attached in the field shall be constructed so that their use will not cause a risk of fire, electric shock, or injury.

16.2 The unit shall comply with the requirements of this Standard, both with and without the auxiliary device installed.

16.3 The installation of auxiliary devices by service personnel shall be by means of receptacles, plug-in connectors, wiring terminals, insulated wire connectors, or by connection to existing wire terminals.

16.4 Any installation of an auxiliary device shall not require the cutting of wiring or the soldering of connections by the installer, and shall not require cutting, drilling, or welding in electrical enclosures and in other areas where such operations may damage electrical or refrigeration components and wiring.

16.5 Field rearrangement of components shall not be acceptable.

Exception: The rearrangement of components to provide field change of direction of air flow, is acceptable if factory provisions are made for such an option.

16.6 As part of the investigation, a trial installation of auxiliary devices may be made, to determine that its installation is feasible, that the instructions are detailed and correct, and that its use does not cause a risk of fire, electric shock, or injury.

16.7 A strain relief means shall be provided for the wiring in the auxiliary device, if there is any possibility of transmitting stress to the terminal connections during installation.

16.8 All terminals and wiring intended to be field-connected shall be identified on the auxiliary device, the unit (if connections are made between the device and the unit), and the wiring diagram.

16.9 The mounting location of the auxiliary device shall be indicated on the unit. However, if the mounting location is predetermined by the function of the device and arrangement of the unit, and if instructions are provided covering the installation and location for the device, the mounting location of the device need not be indicated (for example, no indication is needed where an air heater is to be installed on the outlet duct flanges of the unit).

17 Connection to power supply

17.1 Equipment other than cord-connected (see Clause 1.2) shall have provision for the connection of conduit (or conduits) of a size (see Table 17.1) suitable for the supply circuit conductors (see Table 17.2) needed to connect the unit in accordance with Tables 1 through 4 in the CSA C22.1 and Tables 310-16 and 310-17 in ANSI/NFPA No. 70. Provisions may be made for field cutting the openings necessary for field wiring system connections, provided that their intended locations are indicated by one of the following methods:

- a) use of pilot holes intended for use with a hole punch; or
- b) an attached marking showing the exact centre of each opening; or
- c) an attached marking showing the area in which the openings can be located.

17.2 Field-provided openings for field wiring system connections shall be so located that the necessary cutting, drilling, or punching operation is not likely to damage components or wiring within the enclosure. Separation shall be maintained as specified in Clause 10.1.

17.3 A metal plate to which conduit is to be attached in the field shall be not less than 0.78 mm (0.0307 in) thick if uncoated steel, not less than 0.88 mm (0.0346 in) thick if galvanized steel, and not less than 1.14 mm (0.045 in) thick if nonferrous metal.

17.4 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing, and shall be located so 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 of less than those required by Section 32, Spacings.

17.5 The construction of the equipment at the point where the conduit of the supply is attached shall be such that supply conductors can be installed in compliance with the requirements of Section 21, Separation of circuits.

17.6 The space provided at terminals or leads intended for the connection of supply conductors, or other conductors to be connected at the time of installation, shall be sufficient for acceptable installation (see Clause 17.7) including the accommodation of the necessary splices.

17.7 An acceptable installation shall

- a) be possible using ordinary tools suitable for the installation; and
- b) not require installed conductors to be forced into contact with uninsulated live parts, or with noncurrent-carrying parts likely to be grounded.

A trial installation may be performed to determine compliance with these requirements.

17.8 Equipment which incorporates more than one independent internal circuit, and is designed for connection to more than one source of electrical power supply shall have each internal circuit provided with means for connection to the supply, in accordance with Section 17.

17.9 Hazardous voltage circuit connections shall be made within acceptable enclosures or outlet boxes.

The location of an outlet box or compartment in which supply connections are made shall be such that the connections will be readily accessible for inspection after the equipment is installed as intended.

Table 17.1 – Knockout or hole sizes and dimensions of bushings

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

Table 17.2 – Trade size of conduit^a

Wire size		Number of wires				
		2	3	4	5	6
(mm ²)	AWG					
(2.1)	14	1/2	1/2	1/2	1/2	1/2
(3.3)	12	1/2	1/2	1/2	3/4	3/4
(5.3)	10	1/2	1/2	1/2	3/4	3/4
(8.4)	8	3/4	3/4	1	1	1-1/4
(13.3)	6	3/4	1	1	1-1/4	1-1/4
(21.2)	4	1	1	1-1/4	1-1/4	1-1/2
(26.7)	3	1	1-1/4	1-1/4	1-1/2	1-1/2
(33.6)	2	1	1-1/4	1-1/4	1-1/2	2
(42.4)	1	1-1/4	1-1/4	1-1/2	2	2
(53.5)	0	1-1/4	1-1/2	2	2	2-1/2
(67.4)	2/0	1-1/2	1-1/2	2	2	2-1/2
(85.0)	3/0	1-1/2	2	2	2-1/2	2-1/2
(107.2)	4/0	2	2	2-1/2	2-1/2	3
kcmil						
(127)	250	2	2-1/2	2-1/2	3	3
(152)	300	2	2-1/2	3	3	3-1/2
(177)	350	2-1/2	2-1/2	3	3-1/2	3-1/2
(203)	400	2-1/2	3	3	3-1/2	4
(253)	500	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 specified in the ANSI/NFPA No. 70 or type TW75, specified in CSA C22.1.

18 Thermal insulation and air filters

18.1 Thermal insulation such as mineral wool, which may contain conductive impurities, shall not contact uninsulated live parts.

18.2 Materials in a compartment handling conditioned air for circulation through a duct system^a shall have a flame spread rating of not more than 25, and a smoke developed rating of not more than 50, when tested as specified in CAN/ULC-S102 and UL 723. This requirement does not apply to the following:

- a) air filters, drive belts, wire insulation, paint applied for corrosion protection, or 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 refrigerant line bushings or insulating bushings, resilient or vibration mounts, wire ties, clamps, labels, or drain line fittings having a total exposed surface area not exceeding 161.29 cm² (25 in²);
- d) an adhesive that, when tested in combination with the specific insulating material, complies with the requirement;

- e) moulded or formed components (not liners) of polymeric materials in such quantities that their total exposed surface area within the compartment does not exceed 0.93 m² (10 ft²); or
- f) materials in a compartment handling air for circulation through a duct supplying only one room;
- g) Vibration isolation connectors having a maximum length of 10 in (25.4 cm) in the direction of airflow and rated as a flame retardant fabrics in accordance with UL 214.

^aSee Table 38.3 when material is not in a compartment handling conditioned air for circulation through a duct system.

18.3 Polymeric materials exempted by Item (e) of Clause 18.2 shall have a flame spread rating of not more than 25, or shall comply with the requirements of the vertical burning test for classifying materials 94-5 VA or 5VB in accordance with UL 94 and Test 5 V (500 W) of CAN/CSA-C22.2 No. 0.17 with a flammability rating of 5 VA.

18.4 Thermal or acoustic insulating material shall be securely positioned if loosening may reduce or block air flow so as to cause temperatures or pressures in excess of those acceptable in the temperature and pressure tests, or 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 moving air.

18.5 A mechanical fastener for each 0.1 m² (1 ft²) of exposed surface is considered to securely position insulating liners to meet the requirement of Clause 18.4. Mechanical fasteners may be bolts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads normally provide protection for leading edges against damage from the effects of moving air. Rigid or semi-rigid sheets of insulating material may not require fastening to the extent needed for less rigid material, nor is protection of leading edges, for such material, required.

18.6 An adhesive provided to secure insulating material, to comply with Clause 18.4, shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the requirements of this Standard, and at -18°C (0°F) for indoor use equipment, and at -29°C (-20°F) for outdoor use equipment.

18.7 Liquid adhesive coatings, where used with air filters, shall have a flash point of 176.7°C (350°F) or higher.

18.8 As a protection against overheating, there shall be a minimum clearance of 50 mm (2 in) between the motor of an air circulating blower and the face of an air filter exposed to the motor, with the air filter in the intended position above the motor, and with the motor adjusted to its minimum clearance from the filter face. Alternatively, the equivalent protection may be afforded by suitable baffles, or by a motor having an enclosed housing.

18.9 Adequate support shall be provided to maintain the air filters in their intended position.

19 Terminal parts and leads for field wiring connections

General

19.1 A unit shall have provision for connection of one or more of the power supply wiring systems that, in accordance with CSA C22.1 and ANSI/NFPA No. 70 is applicable to the unit.

19.2 Where leads are provided for making connection to the power supply, they shall be not less than No. 18 AWG. These leads shall be provided with means for strain relief if stress on the leads may be transmitted to terminals, splices, or internal wiring that may cause the leads to separate from their terminations, or subject them to damage by sharp edges.

19.3 Field wiring terminals shall have means other than friction to prevent them from turning, which might result in unacceptable electrical spacings.

19.4 Line terminals of an approved control or fuseholder may be used as field wiring terminals provided they comply with the requirements of Clauses 19.13 and 19.14.

19.5 The location of an outlet box or compartment in which field wiring connections are to be made shall allow these connections to be inspected after the unit is installed as intended.

19.6 The connections shall be accessible without removal of parts other than service covers or panels and the cover of the outlet box or compartment in which the connections are made.

19.7 The free end of any lead that may not be used in every installation shall be insulated, if that end could reduce spacings below the minimum acceptable values.

19.8 Equipment (including auxiliary devices) that is not part of the unit, but that is supplied for field installation, shall have provision for field wiring connections as specified above, except that special connectors may be used if both mating parts are provided and factory-attached to the equipment.

19.9 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be finished a continuous green, or a green with one or more yellow stripes. No other leads visible to the installer, other than grounding conductors, shall be so identified.

Exception No. 1: This requirement does not apply to leads or wiring that are intended to be field-connected to extra-low-voltage circuits, and that are separated or segregated by barriers from field wiring connections in circuits exceeding 30 V.

Exception No. 2: This requirement does not apply to internal wiring that is not visible in a field wiring compartment.

19.10 Control equipment, including an auxiliary device that is not part of the product but is supplied with the product for field installation, shall have provision for field wiring connections as required by Section 17, Connection to power supply, except that special connectors may be used if both mating parts are provided, and factory-attached to the product or the auxiliary device.

Hazardous Voltage Circuits

19.11 Units other than cord-connected (see Clause 1.2) shall be equipped with wiring terminals or leads not less than 152 mm (6 in.) long for connection of field wiring conductors. If a single conductor larger than 500 kcmil would be required, the unit shall have provision for the connection of conductors in parallel.

If a product is marked (see Clause 37.9) to indicate that it is acceptable for use with either copper, copper clad aluminum, or aluminum power supply conductors, a field wiring terminal shall comply with the requirement in Clause 19.1 for a wire of each metal.

19.12 A field wiring terminal or lead for the connection of a grounded conductor in accordance with NEC and the identified conductor in accordance with CSA C22.1 shall be finished a white or natural grey. No other leads other than grounded conductors shall be so identified.

Exception No. 1: This requirement does not apply to internal wiring that is not visible in a field wiring compartment; or

Exception No. 2: This requirement does not apply to terminals that are identified by a marking on the unit "WHITE" or equivalent.

19.13 If a wire binding screw is employed at a field wiring terminal intended for the connection of supply circuit conductors, it shall be not smaller than No. 8 if the supply circuit conductors are No. 14 AWG; and not smaller than No. 10 if the supply circuit conductors are No. 12 or No. 10.

19.14 If conductors of the field wiring to be connected will be larger than No. 10 AWG, a field wiring terminal part shall either include a connector suitable for clamping the required conductors, or shall be suitable for use with such a connector or an appropriate soldering lug.

19.15 In determining the size of the power supply terminals or conductors required, unless the equipment is otherwise marked it is assumed that supply conductors rated 75°C (167°F) will be used.

Exception: For equipment rated over 2000 volts, 90°C or 105°C rated conductors shall be used.

19.16 Terminal parts for factory-installed conductors that are larger than No. 8 AWG shall include solderless connectors or soldering lugs, unless the suitability of the combination of terminal and conductor termination has been investigated.

19.17 For equipment intended for connection with two or more supply conductors in parallel per terminal, the terminals shall be of a size suitable for securing connectors that are appropriate for the termination of the conductors.

19.18 A field wiring terminal or lead shall be provided for connection of an equipment grounding conductor.

Exception: The equipment grounding terminal or lead may be omitted if all the following conditions are satisfied:

1) the rating of the product is such that the power supply conductors are likely to be larger than No. 2 AWG;

2) the construction is such that an acceptable terminal can be installed in the field, for example, the terminal can be secured as intended without a drilling or cutting operation upon installation, and sufficient space for the equipment grounding conductor is provided; and

3) the product is marked: "If this product is supplied by a wiring system that, in accordance with CSA C22.1 and ANSI/NFPA No. 70, requires the installation of an equipment grounding conductor or conductors, a terminal or terminals for connection thereof must be installed", or with an equivalent statement. This marking shall be located in the wiring compartment where the power supply conductors will be connected, and shall give adequate pertinent information, such as where the terminal or terminals should be mounted, how they should be mounted, etc.