UL 1995

STANDARD FOR SAFETY

Heating and Cooling Equipment

UL Standard for Safety for Heating and Cooling Equipment, UL 1995

Fifth Edition, Dated July 31, 2015

Summary of Topics

The revision of UL 1995 dated August 1, 2022 is being issued to remove the ANSI logo and approval from the title page. Other ANSI related notes for UL 1995 have been removed. No technical changes have been made.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and CSA are committed to updating this harmonized standard jointly. However, the revision pages dated August 1, 2022 will not be jointly issued by UL and CSA as these revisions only address the UL ANSI removal.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

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CSA Group
CSA C22.2 No. 236-15
Fifth Edition

Underwriters Laboratories Inc.
UL 1995
Fifth Edition

Heating and Cooling Equipment

July 31, 2015

(Title Page Reprinted: August 1, 2022)

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as CSA Group) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group will not be issuing revisions dated August 1, 2022.

ISBN 978-1-77139-831-2 © 2015 Canadian Standards Association

This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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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.

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 https://csds.ul.com.

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Preface

This is the harmonized CSA Group and UL standard for Heating and Cooling Equipment. It is the fifth edition of CSA-C22.2 No. 236, and the fifth edition of UL 1995.

This harmonized standard was prepared by the CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the heating and cooling equipment industry, the Air Conditioning and Refrigeration Institute (ARI), and the Heating, Refrigerating, and Air Conditioning Institute of Canada (HRAI) are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This Standard was reviewed by the CSA Subcommittee on Appliances for Air-Conditioning for Household and Similar Purposes, 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.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

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 uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for CSA Group and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The THSC investigated and found no existing IEC standards or work programs covering the scope of the products in this standard.

Interpretations

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

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Heating and cooling equipment

1 Scope

1.1 These requirements apply to the following stationary equipment for use in nonhazardous locations rated greater than 600 volts up to 7200 V, 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) Liquid chillers and compressor-evaporator or liquid chiller assemblies intended for use with remote condensers;

d) Add-on heat pumps for comfort heating or heating and cooling; and

e) 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;

Note: The above equipment rated 600 V or less are covered by the scope of ANCE/CSA/UL 60335-2-40.

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, are to 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 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) 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;

b) Condensing units intended for connection to a remote nonspecified evaporator and compressor units intended for connection to a remote nonspecified evaporator and condenser; and

c) Room fan heater units, central heating furnaces, and similar fixed electric space heating for comfort heating.

Note: The equipment mentioned in Clauses 1.3, 1.4, 1.5, 1.6, 1.7 and 1.13 are rated 7200 V or less, single or 3-phase. These products are not covered by the scope of ANCE/CSA/UL 60335-2-40.

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 can introduce air from outside of the heated or cooled space. The coil can 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, can be designed for free discharge of air to the room or can 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 and 1.2 can 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.

The units referenced in Clause 1.1 can 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 26.17; or

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

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 26.17; 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 CSA C22.1, ANSI/NFPA No. 70, CSA B52, ANSI/ASHRAE 15, NFPA 90A, and NFPA 90B.

Note 1: 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.

Note 2: Coolant distribution equipment are intended for use in an information technology room (ITE) that comples with NFPA 75.

These requirements apply to equipment designed to be used in nonhazardous locations in accordance with the rules of 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 normative. Any other values given are for informational purposes only.

The values given in SI (metric) units are normative. Any other values given are for informational purposes only.

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

1.14 The general requirements of CSA C22.2 No. 0 apply, except as follows:

a) “General Requirements”, Clause 3, and “Construction Details”, Clause 4 (refer to Clauses 2 through 36 of this standard);

b) “Marking”, Clause 5 (refer to Clauses 43, 44, and 45 of this standard);

c) “Tests”, Clause 6 (refer to Clauses 46 through 79 of this standard).

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

a) "General Requirements", Clause 3, and "Construction Details", Clause 4 (refer to Clauses 2 through 36 of this standard);

b) "Marking", Clause 5 (refer to Clauses 43, 44, and 45 of this standard);

c) "Tests", Clause 6 (refer to Clauses 46 through 79 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:

Absolute Irradiance – E, (W/cm^2), Radiant Flux incident on a surface. The quotient of radiant flux at that element of a surface to the area of that element.

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.

Adjustable Speed Drive – A combination of the power converter, inverter, motor(s), motor-compressor(s) and motor-mounted auxiliary devices such as encoders, tachometers, thermal switches and detectors, air blowers, heaters, and vibration sensors.

Adjustable Speed Drive System – An interconnected combination of equipment that provides a means of adjusting the speed of a mechanical load coupled to motor(s) and/or motor-compressor(s). A drive system typically consists of an adjustable speed drive and auxiliary electrical apparatus.

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.

Appliance Coupler – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug). Note: Female contact device is defined as an electrical connector surrounded by an electrically isolated material such that the electrical contact cannot be accessed with the probe illustrated in Figure 7.1.

Appliance Inlet (Motor Attachment Plug) – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector. Note: Male contact device is an electrical connector that is inserted into a corresponding female contact device to complete the electrical connection for the appliance.

Ballast – A current limiting device required to start and operate fluorescent lamps.

Barrier – A partition for the isolation (insulation) of hazardous voltage electrical circuits or isolation of electrical arcs, moving parts, or ultraviolet (UV) radiation from lamps.

Blocking diode – A diode used to block reverse flow of current into a photovoltaic source circuit.

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

Cascade system – A refrigeration system that incorporates two or more independent vapor-compressor refrigeration cycles in series. This is done to acquire low temperatures that might not be readily achieved with a single refrigeration cycle.

Charge controller – Equipment that controls dc voltage or dc current, or both, used to charge a battery.

Circuit, Class 2 – An extra-low voltage circuit with a power of 100 VA or less; or has 30 V dc supplied by a primary battery; or is supplied by a Class 2 transformer; or is 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, or is supplied by a power supply (such as a switching power supply) whose output meets the requirements of a Class 2 circuit. A circuit that is derived from a circuit that exceeds 30 V by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not considered to be a class 2 circuit.

Circuit, extra-low-voltage – A circuit that has an ac potential of not more than 30 V rms (42.4 V peak or 30 V dc).

Circuit, hazardous voltage – A circuit of any voltage exceeding 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. Operation may include reverse cycle mode.

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.

Computer room air conditoner (CRAC) – An air-cooled or water-cooled, special purpose air conditioner, factory assembled as a portable package, which is a self-contained combination of cooling and optional heating components. This equipment is intended to provide supplemental cooling only for Information Technology Equipment (ITE) and may contain network connections to ITE. It is intended to condition a single equipment room or space. It may contain condenser intake/exhaust grill(s) or separate ducts; and contain return air plenum with duct(s), filter, or grill(s) but is not designed for connection to an HVAC system.

In the US, this equipment is to be installed in accordance with Article 645 of NFPA 70 (National Electrical Code).

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. Operation may include reverse cycle mode.

Control, auxiliary – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency

control not relied upon to reduce the risk of electric shock, fire, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

Control, manual – A device that requires direct human interaction to activate or reset the control.

Control, operating – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, an electronic motor on/off control, the failure of which another layer of protection (e,g, a warning marking on a motorized brush) would reduce the risk of electric shock, fire, or injury to persons, is considered an operating control.

Control, protective – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the appliance. For example, a motor overload protector or a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. During the evaluation of the protective control / circuit, the protective functions are verified under normal and single-fault conditions of the control.

Control, type 1 action – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence has not been declared and tested under this standard.

Control, type 2 action – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence have been declared and tested under this standard.

Converter – A device that accepts ac or dc power input and converts it to another form of ac or dc power.

Coolant distribution equipment – Air or water-cooled equipment that is factory assembled and consists of a coolant distribution (pumping) unit and separate evaporator (air conditioner) units intended to service a single ITE equipment rack. The pumping unit is intended for connection to a dedicated branch circuit. This equipment is not provided with a hermetic refrigerant motor-compressor and not designed for connection to an HVAC system that serves other occupancies. The equipment may contain network connections, condenser intake/exhaust grill(s) or separate ducts; and return air plenum with duct(s), filter, or grill(s).

In the US, this equipment is dedicated solely for Information Technology Equipment use and intended to be located only within a single ITE room that is separated from other areas of occupancy in accordance with NFPA 70, Article 645.

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.

Flash gas bypass valve – Regulates the removal of gas from the flash gas tank for compression.

Flash gas tank – Supercritical gas after cooling in gas cooler is throttled to subcritical region and enters this device whose function is to separate the vapor and supply liquid to evaporators for further expansion.

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.)

Gas cooler – A heat exchanger designed to remove heat from a transcritical system.

Guard – That part of the cabinet, which, while permitting the passage of air, prevents contact with moving or electrical parts. Guards may also protect users from exposure to Ultraviolet (UV) radiation from lamps.

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.

Heat recovery unit – A system used in conjunction with air conditioning or refrigeration equipment for the purpose of extracting heat from the refrigerant to heat potable water. These products include a heat exchanger, water temperature control components and may also include additional components such as hot water storage tanks, electric heaters and water circulating pumps. These products differ from heat pump water heaters in that they do not utilize a self-contained refrigeration system, but rather use heat from an external (remotely located) refrigeration or air conditioning system to heat the water by way of a heat exchanger.

High side – That part of a refrigerating system subject to condenser or gas cooler 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.

Interactive system – A solar photovoltaic system providing power to a utilization load and operating in parallel with, and may deliver power to, an electrical production and distribution network.

Intermediate Pressure Stage – An intermediate pressure stage on CO_2 transcritical systems that lays between the highside and lowside pressure stages. This intermediate pressure range may be regulated by a flash gas bypass valve and this stage may include a flash gas tank and gas cooler.

Lampholder – A wiring device intended for making connection to the electrical circuits of a lamp and, in some cases, providing support.

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

Maximum Operating Current (MOC) – MOC is marked instead of motor FLA on air-conditioning and refrigerating equipment having adjustable speed drives or drive systems. MOC is the current resulting when an electric motor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor/adjustable speed drive or drive system is at a maximum. The MOC is the current at the input of the adjustable speed drive.

Maximum Rated Current (MRC) – MRC is marked instead of motor-compressor RLA and LRA on equipment having adjustable speed drives or drive systems. MRC is the current resulting when a hermetic refrigerant motor-compressor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor-compressor/adjustable speed drive or drive system is at a maximum . The MRC is the current at the input of the adjustable speed drive. The test conditions to determine the MRC are found in Annex AA of UL 60335-2-34 or CAN/CSA C22.2 No. 60335-2-34.

Media wheel – Non metallic device that transfers energy from one air stream to another air stream.

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.

Photovoltaic (PV) cell – The basic photovoltaic device that generates electricity when exposed to sunlight.

Photovoltaic (PV) inverter – Equipment that is used to change the voltage level or waveform, or both, of electrical energy. Typically changes dc input to an ac output.

Photovoltaic (PV) module – A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of a solar tracker mechanism, designed to generate dc power when exposed to sunlight.

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-regulating relief valve – Similar to a pressure-relief valve except specifically intended for use with refrigeration systems utilizing carbon dioxide (R744) as the refrigerant in a secondary loop or cascade system. The pressure-relief setting of this valve is always lower than the relief setting of a pressure-relief valve. This valve may open and re-close many times during the life of the system.

Pressure-relief valve – A pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

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 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.

Secondary loop – A piping circuit containing a fluid circulating within the circuit. The fluid transfers heat from a remote-type refrigerator to a colder heat exchanger located within the circuit. The circuit normally includes a circulating pump as well as other associated fittings. Such a circuit is considered to be equivalent to the low-side parts that are located in a refrigeration system.

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.

Solar photovoltaic (PV) system – The total components and subsystems that, in combination, convert solar energy into electric energy suitable for connection to a utilization load.

Stand-alone system – A solar photovoltaic system that supplies power independently of an electrical production and distribution network.

Start-to-discharge pressure – The pressure at which a relief valve begins to discharge, typically the pressure where the first bubbles can be seen when a valve is immersed in water.

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.

Transcritical system – A refrigeration system where evaporation occurs in the subcritical region and heat rejection may occur above the critical point of the refrigerant (e.g. R-744).

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

Ultraviolet (UV) Lamp – Equipment that directly generates ultraviolet radiation typically used to supplement the normal unit air filters for enhanced air purification and surface cleaning. For the purpose of the standard, UV lamp systems are divided into 3 categories and are defined below:

a) **Factory Installed** – A UV lamp system that is located within the unit (integral) and installed at the factory. For the purpose of these requirements the term “within the unit” includes all space within the area between inlet and outlet air side of the heating and cooling unit including the area housing the evaporator coil if mounted directly on the unit.

b) **Field Installed** – A factory designated UV lamp system that is located within the unit (integral) and field installed per the manufactures procedures. For the purpose of these requirements the term “within the unit” includes all within the area between inlet and outlet side of the heating and cooling unit including the area housing the evaporator coil if mounted directly on the unit.

c) **Non Integral Field Installed** – A duct mounted UV lamp system that is not integral to the unit. For the purpose of these requirements, the term “non integral” refers to all areas of the ductwork that is outside of the heating and cooling unit inlet and outlet excluding the area housing the evaporator coil if mounted directly on the unit.

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.

UV-C Irradiance – For the purpose of this standard UV-C irradiance is the effective irradiance (E_{eff} = $\mu W/cm^2$). Effective irradiance is the absolute irradiance that has been weighted against the spectral effectiveness curve (S_λ) for ultraviolet (UV) radiation as denoted in the current edition of the ACGIH TLVs and BEIs. For the purposes of this standard, UV-C lamps are limited to the low pressure florescent type construction with a predominate output of 254 nm.

3 Reference publications

3.1 Where reference is made to any Standards (see Clauses 90 and 92) 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 of a product covered by this standard shall comply with the following in (a) – (f). 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 temperatures not exceeding specified limits, and shall be used only under those specified conditions for which they have been investigated.

a) Comply with the requirements for that component as indicated in Clauses 3.9 – 3.17;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability;

d) Comply with both the Underwriters Laboratories Inc. and the CSA Group standard for the component;

e) Additionally comply with the applicable requirements of this end product standard; and

f) Not contain mercury.

3.3 A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product,

b) Is superseded by a requirement in this end product standard, or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

3.4 A component that complies with a component standard other than those specified in Clauses 3.9 – 3.17 is acceptable if:

a) The component also complies with the applicable component standard of Clauses 3.9 – 3.17; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements of the Canadian Electrical Code, Part I, C22.1 in Canada, and the National Electric Code, NFPA 70 in the US, where appropriate;

2) Considers long-term thermal properties of polymeric insulating materials in accordance the Standard for Evaluations of Properties of Polymeric Materials, C22.2 No. 0.17 and the Standard for Polymeric Materials - Long Term Property Evaluations, UL 746B; and

3) Any use limitations of the other component standard are identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

3.5 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable CSA Group and UL standard(s) that cover devices that provide those functions.

3.6 Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

3.7 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in Clauses 3.9 – 3.17, and that involves a risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable CSA Group and UL standard, and shall comply with Clause 3.2 (b) – (f).

3.8 With regard to a component being additionally investigated per Clause 3.7, reference to construction and performance requirements in another CSA Group and UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of this end product standard.

3.9 Attachment plugs, receptacles, connectors, and terminals

3.9.1 Attachment plugs, receptacles, shall comply with the Standard for General Use Receptacles, Attachment Plugs, and Similar Wiring Devices, C22.2 No. 42 and the Standard for Attachment Plugs and Receptacles, UL 498.

3.9.2 Attachment plugs integral to cord sets or power supply cords are investigated in accordance with the requirements of the Standard for Cord Sets and Power Supply Cords, C22.2 No. 21 and the Standard for Cord Sets and Power Supply Cords, UL 817, and need not comply with the Standard for General Use Receptacles, Attachment Plugs, and Similar Wiring Devices, C22.2 No. 42 and the Standard for Attachment Plugs and Receptacles, UL 498.

3.9.3 Quick-connect terminals, both connectors and tabs, for use with one or two 0.34 – 5.3 mm^2 (22 – 10 AWG) copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Quick-Connect Terminals, C22.2 No. 153 and the Standard for Electrical Quick-Connect Terminals, UL 310.

3.9.4 Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with the Standard for Quick-Connect Terminals, C22.2 No. 153 and the Standard for Electrical Quick-Connect Terminals, UL 310.

3.9.5 Wire connectors shall comply with the Standard for Wire Connectors, C22.2 No. 65 and the Standard for Wire Connectors, UL 486A-486B.

3.9.6 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, C22.2 No. 188 and the Standard for Splicing Wire Connectors, UL 486C.

3.9.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the Standard for Terminal Blocks, C22.2 No. 158 and the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

3.9.8 Terminal blocks shall comply with the Standard for Terminal Blocks, C22.2 No. 158 and the Standard for Terminal Blocks, UL 1059, and if applicable, be suitably rated for field wiring.

3.10 Controls

3.10.1 General

3.10.1.1 Operating (regulating) controls, the failure of which would increase the risk of electric shock, fire, or personal injury, shall be evaluated using the applicable component standard requirements specified in Clauses 3.10.1 – 3.10.5, and if applicable, the requirements in Controls – End product Test Parameters, Clause 90, unless otherwise specified in this end product standard.

3.10.1.2 With reference to Clause 3.10.1.1, operating controls that rely upon software for the normal operation of the end product where deviation or drift of the operating parameters of the control may result in an increased risk of electric shock, fire, or injury to persons, shall comply with:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 and the Standard for Software in Programmable Components, UL 1998 and C22.2 No. 08 and CSA-ISO/IEC 16085; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

3.10.1.3 Solid-state protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in Clauses 3.10.1 – 3.10.4, and if applicable, the parameters in Clause 90, unless otherwise specified in this end product standard.

3.10.1.4 With reference to Clause 3.10.1.3, protective controls that do not rely upon software as a protective component shall comply with:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 and C22.2 No. 08; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, except Controls Using Software.

3.10.1.5 With reference to Clause 3.10.1.3, protective controls that rely upon software as a protective component shall comply with:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 and the Standard for Software in Programmable Components, UL 1998 and CSA22.2 No.08 and CSA-ISO/IEC 16085 or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

3.10.2 Liquid level controls

3.10.2.1 A liquid level control shall comply with:

a) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and Regulating Equipment, C22.2 No. 24 and the Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Industrial Control Equipment, UL 508; or

d) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and:

1) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow, and Water Level Sensing, E60730-2-15 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Water Level Controls of the Float Type for Household and Similar Applications, UL 60730-2-16A; or

2) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow, and Water Level Sensing, E60730-2-15 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Water and Air Flow Sensing Controls, Including Mechanical Requirements, UL 60730-2-18.

3.10.3 Motor and speed controls

3.10.3.1 A control used to start, stop, regulate or control the speed of a motor shall comply with:

a) The Standard for Solid-State Speed Controls, C22.2 No. 156 and the Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and Regulating Equipment, C22.2 No. 24 and the Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Industrial Control Equipment, UL 508;

d) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Power Conversion Equipment, UL 508C; or

e) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

3.10.4 Pressure controls

3.10.4.1 A pressure control shall comply with:

a) The Standard for Temperature-Indicating and Regulating Equipment, C22.2 No. 24 and the Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

b) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Industrial Control Equipment, UL 508; or

c) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, E730-2-6; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

3.10.5 Temperature controls

3.10.5.1 A temperature control shall comply with:

a) The Standard for Temperature-Indicating and Regulating Equipment, C22.2 No. 24 and the Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and Regulating Equipment, C22.2 No. 24 and the Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Industrial Control Equipment, UL 508; or

d) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Temperature Sensing Controls, E60730-2-9; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General

Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

3.10.5.2 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1, the Annex for Requirements for Controls Using Thermistors, and the Standard for Thermistor-Type Devices, UL 1434.

3.10.5.3 A thermal cutoff shall comply with the Standard for Thermal-Links, Requirements and Application Guide, E60691 and the Standard for Thermal-Links, Requirements and Application Guide, UL 60691.

3.10.6 Timer controls

3.10.6.1 A timer control shall comply with:

a) The Standard for Industrial Control Equipment, C22.2 No. 14 and the Standard for Solid-State Controls for Appliances, UL 244A; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Timers and Time Switches, E730-2-7; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

3.10.7 Electrically Operated valves

3.10.7.1 Electrically operated general purpose and safety valves intended for the control of fluids, such as air, gases, oils, refrigerants, steam, or water shall comply with the Standard for Electrically Operated Valves, UL 429 or Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, UL 60730-2-8 and Standard for Electrically Operated Valves, C22.2 No. 139 or Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, CSA E60730-2-8.

3.11 Cords, cables, and internal wiring

3.11.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, C22.2 No. 21, and the Standard for Cord Sets and Power Supply Cords, UL 817.

3.11.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, C22.2 No. 49, and the Standard for Flexible Cord and Cables, UL 62. Flexible cord and cables are considered to comply with this requirement when preassembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, C22.2 No. 21 and the Standard for Cord Sets and Power Supply Cords, UL 817.

3.11.3 Internal wiring composed of insulated conductors shall comply with the Standard for Equipment and Lead Wires , C22.2 No. 127 or the Standard for Appliance Wiring Material Products, C22.2 No. 210 and the Standard for Appliance Wiring Material, UL 758.

3.11.4 Insulated conductors need not comply with the above reference standards if they comply with:

a) The Standard for Thermoset-Insulated Wires and Cables, C22.2 No. 38 and the Standard for Thermoset-Insulated Wires and Cables, UL 44; or

b) The Standard for Thermoplastic-Insulated Wires and Cables, C22.2 No. 75 and the Standard for Thermoplastic-Insulated Wires and Cables, UL 83; or

c) The Standard for Flexible Cords and Cables, C22.2 No. 49 and the Standard for Flexible Cords and Cables, UL 62; or

d) The applicable CSA Group and UL standard(s) for other insulated conductor types specified in the Canadian Electrical Code, Part I, C22.1 Wiring Methods, and the National Electric Code, NFPA 70, Wiring Methods and Materials.

3.11.5 Insulated conductors for specialty applications (e.g. data processing or communications) and located in a low-voltage circuit not involving the risk of fire or personal injury need not comply with the Standard for Equipment and Lead Wires, C22.2 No. 127 or the Standard for Standard for Appliance Wiring Material Products, C22.2 No. 210 and the Standard for Appliance Wiring Material, UL 758.

3.12 Light sources and associated components

3.12.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, C22.2 No. 43 and the Standard for Lampholders, UL 496.

3.12.2 Lampholders forming part of a luminaire that complies with the applicable CSA Group and UL luminaire standard are considered to comply with this requirement.

3.13 Marking and labeling systems

3.13.1 A marking and labeling system shall comply with the Standard for Adhesive Labels, C22.2 No. 0.15 and the Standard for Marking and Labelling Systems, UL 969 under the specified environmental conditions.

3.14 Power supplies

3.14.1 A Class 2 power supply shall comply with:

a) The Standard for Power Supplies with Extra-Low-Voltage Class 2 Outputs, C22.2 No. 223 and the Standard for Class 2 Power Units, UL 1310; or

b) The Standard for Information Technology Equipment, C22.2 No. 60950-1 and the Standard for Information Technology Equipment, UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

3.14.2 A non-Class 2 power supply shall comply with:

a) The Standard for General-Use Power Supplies, C22.2 No. 107.1, and the Standard for Power Units Other Than Class 2, UL 1012; or

b) The Standard for Information Technology Equipment, C22.2 No. 60950-1 and the Standard for Information Technology Equipment, UL 60950-1.

3.15 Printed wiring boards

3.15.1 Printed wiring boards, including the coatings, shall comply with the Standard for Evaluation of Properties of Polymeric Materials, C22.2 No. 0.17 and the Standard for Printed Wiring Boards, UL 796.

3.15.2 A printed-wiring board in an extra-low voltage, nonsafety circuit is not required to comply with the bonding requirements in the Standard for Evaluation of Properties of Polymeric Materials, C22.2 No. 0.17 and the Standard for Printed Wiring Boards, UL 796 if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

3.15.3 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for insulating materials in the Standard for Evaluation of Properties of Polymeric Materials, C22.2 No. 0.17 and the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

3.15.4 Unless otherwise specified, the flammability class and temperature rating shall be that specified for insulating materials in the Standard for Evaluation of Properties of Polymeric Materials, C22.2 No. 0.17 and the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

3.16 Switches

3.16.1 A clock-operated switch, in which the switching contacts are actuated by a clock-work, by a gear-train, by electrically-wound spring motors, by electric clock-type motors, or by equivalent arrangements shall comply with:

a) The Standard for Clock-Operated Switches, C22.2 No. 177 and the Standard for Clock-Operated Switches, UL 917; or

b) The Standard for Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, E60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Timers and Time Switches, E730-2-7; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

3.16.2 Enclosed and dead-front switches shall comply with the Standard for Enclosed and Dead-Front Switches C22.2 No. 4-04 and the Standard Switches, Enclosed and Dead-Front UL 98.

3.17 Transformers

3.17.1 General-purpose transformers shall comply with the Standard for Low-Voltage Transformers – Part 1: General Requirements, C22.2 No. 66-1 and the Standard for Low-Voltage Transformers – Part 2: General Purpose Transformers, C22.2 No. 66-2, and the Standard for Low-Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low-Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

3.17.2 Class 2 and Class 3 transformers shall comply with the Standard for Low-Voltage Transformers – Part 1: General Requirements, C22.2 No. 66-1 and the Standard for Low-Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, C22.2 No. 66-3, and the Standard for Low-Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low-Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

3.17.3 Specialty transformers shall comply with the Standard for Transformers, Specialty UL 506 and CSA C22.2 No. 13 Transformers for oil-or gas-burner ignition equipment.

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, shall 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 can 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 can limit the number of field wiring system connections. See Connection to Power Supply, Clause 17 of this Standard.

4.4 Equipment intended to utilize carbon dioxide (R744) in a secondary loop, cascade, or transcritial system and required to include pressure regulating relief valves per item (a) of Clause 34.32 shall provide instructions indicating that:

a) if the system is de-energized, venting of the R744 through the pressure-regulating relief valves on the equipment can occur. In such cases, the system might need to be recharged with R744, but in any case, the pressure-regulating relief valve(s) shall not be defeated or capped. The relief setting shall not be altered.

b) a sufficient number of pressure-relief and pressure-regulating relief valves may need to be provided based on the system capacity and located such that no stop valve is provided between the relief valves and the parts or section of the system being protected.

c) if the equipment contains a pressure vessel but the pressure-regulating and -relief valves are not installed as part of the equipment as permitted by Clauses 34.33 and 34.34, the instructions shall specify:

1) the method for installing the valves within the fittings, and

2) that the equipment must be provided with an adequate number of pressure regulating and relief valves based on the system capacity and located such that no stop valve(s) are provided between the relief valve(s) and the parts or section of the system being protected.

4.5 The instructions for heating and cooling equipment employing a solar PV system or subsystems thereof shall identify the major PV system components and shall describe the intended installation, including appropriate reference to installation requirements of Article 690 of NFPA 70 and Section 50 of the CEC C22.1.

4.6 The required markings specified in Clause 45.17 shall be repeated in the instructions.

4.7 Equipment intended to employ Ultraviolet (UV) radiation lamp systems shall provide instructions that:

a) Repeats the required markings of Clauses 44.3 (z1), 44.3 (z2) and 45.17.

b) Provides information for replacement of the lamps to include wattage, model and/or part number.

c) Provide instructions for the installation of field installed factory designated UV lamp systems that are integral to the system.

4.8 A heat recovery unit shall be provided with instructions indicating:

a) the types of air conditioning or refrigeration systems for which it is intended; and,

b) the method for interconnecting the heat recovery unit with the intended air conditioning or refrigeration equipment.

4.9 In reference to 4.7(b), the instructions shall include the method for interconnecting the water piping and hot water storage tank, if applicable, and for making electrical connections.

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 CAN/CSA-C22.2 No. 0.17 and UL 746C, and

b) They have temperature ratings not less than the maximum temperatures to which they may be exposed during normal operation, and

c) They are suitable for exposure to UV-C radiation. The enclosure material must be suitable for the measured UV-C irradiance levels as stated in Clause 89.1.

Enclosures need not comply with Clause 5.10.

5.5 Polymeric materials not used as enclosures shall comply with Clause 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 20.10 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 Clause 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 Clause 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 5.1 for determination of material classifications and uses.

5.10.2 This Clause 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 46.3 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 5.1 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 5.1 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 is 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 is 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.

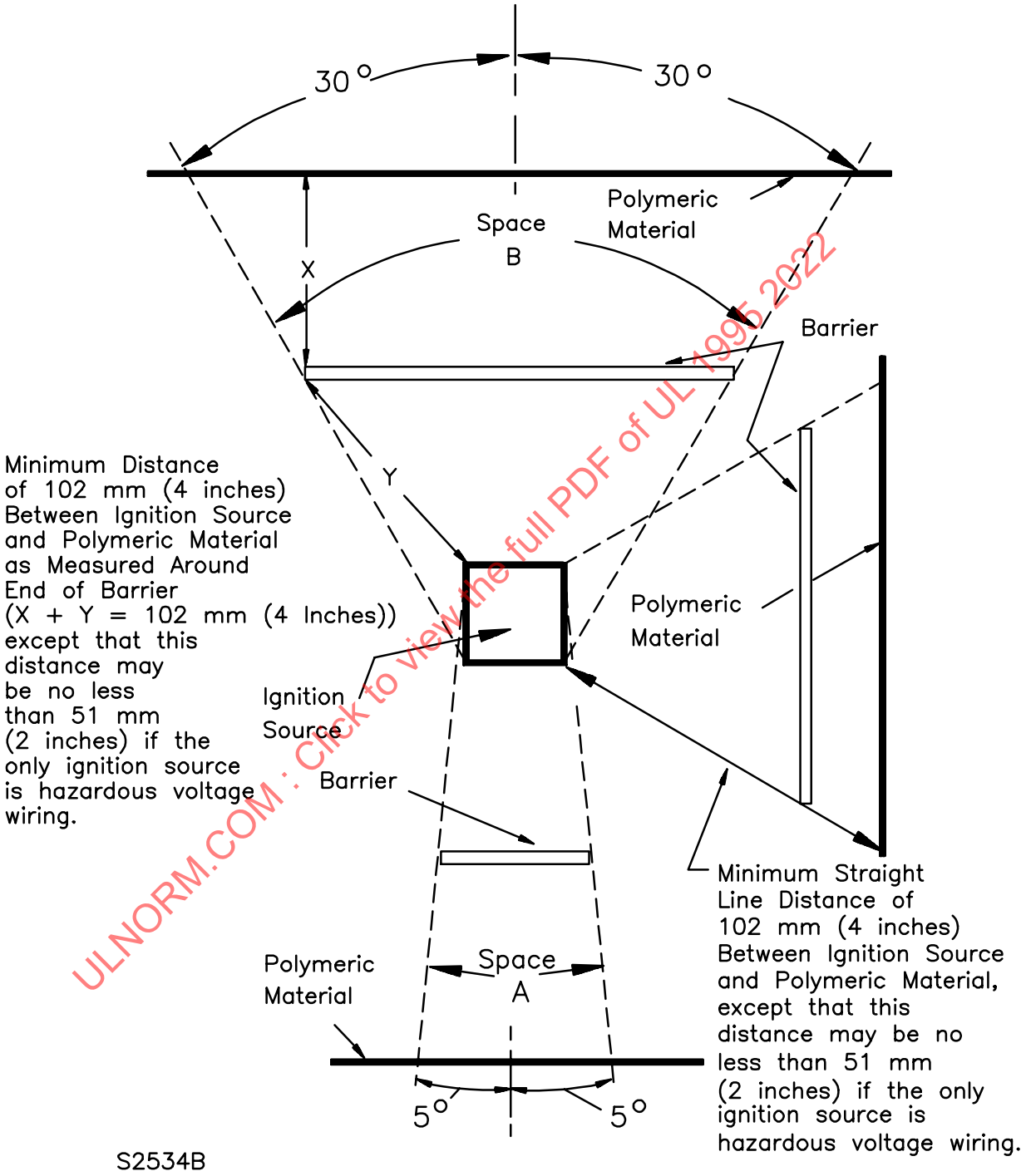
5.10.10 The barriers required in Clauses 5.10.6 through 5.10.8 shall be mechanically secured and:

a) be constructed of metal at least 0.25 mm (0.010 in) thick; or

b) be constructed of polymeric material rated 5VA.

Figure 5.1

Exposure to ignition



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 5.1
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 Figure 5.1[d]	No[d,e]	No[c,e]	No[a,c,e]	Yes[a]	Yes	Yes
Exposed	No[b]	No[b,c]	No[b,c]	No[b,c,e]	No[b,c,e]	Yes

[a] Shall not be used in Space A illustrated in Figure 5.1 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 can 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 is not less than 102 mm (4 in) and no less than 50.8 mm (2 in) from wiring.*

[e] May be used if at a distance of not less than 610 mm (24 in) from the ignition source, except for directly below (5 deg, Space A) and above (30 deg, Space B).

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 Table 6.1 and Table 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)	Minimum thickness of metal 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)

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]	Maximum length[c]	Maximum width[b]	Maximum length[c]	Minimum thickness of metal	
				uncoated	coated
mm (in)	mm (in)	mm (in)	mm (in)	mm (in)	mm (in)
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)		
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]	Maximum length[c]	Maximum width[b]	Maximum length[c]	Minimum thickness	
mm (in)	mm (in)	mm (in)	mm (in)	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)

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)
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)		

[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)[bc]	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

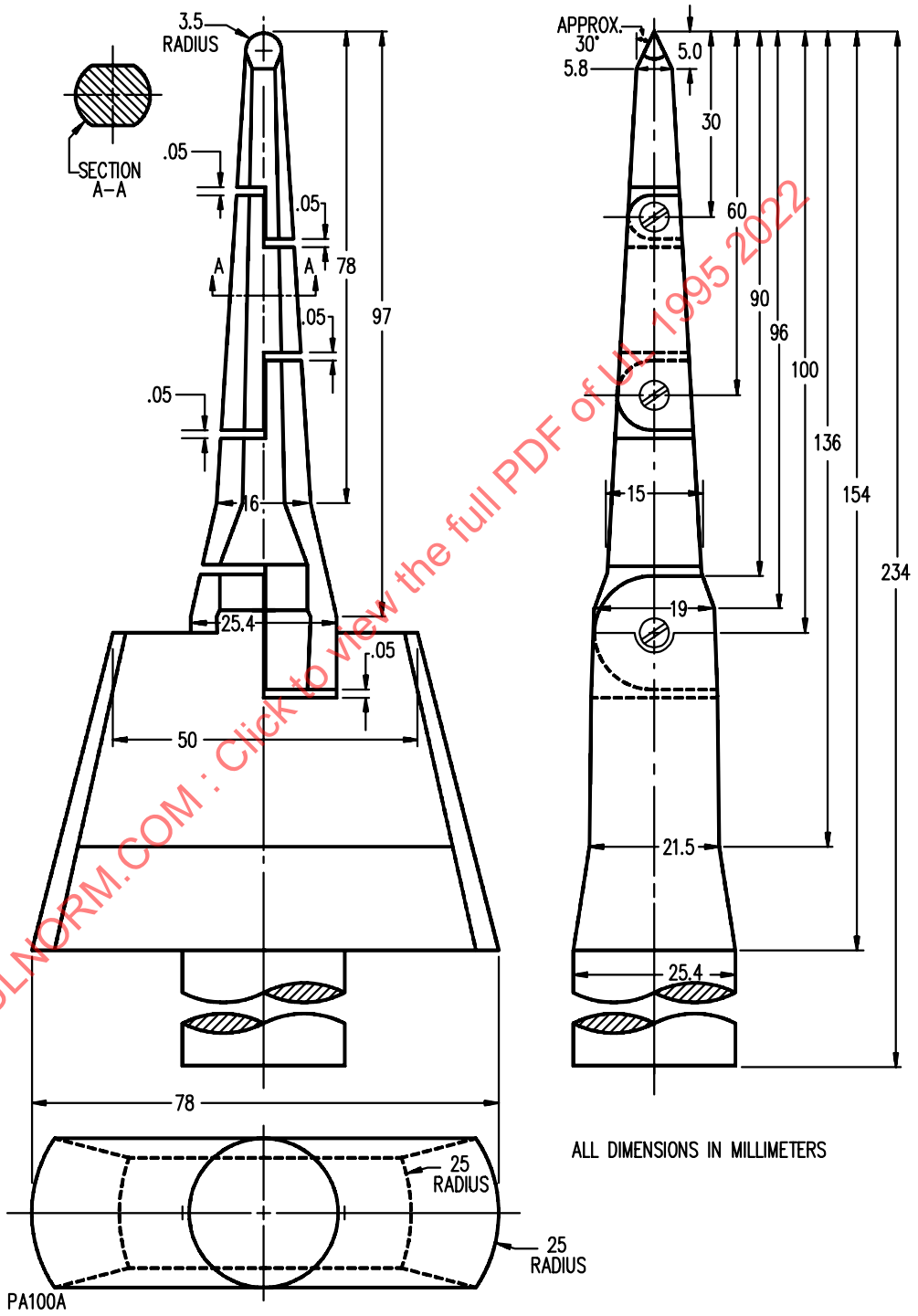
that required for the enclosure of the device, or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

6.4 With reference to Clause 6.1, the thickness of an enclosure may be two gauge sizes less than indicated in Table 6.1 and Table 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 Table 6.1 and Table 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

Figure 7.1

Probe (Other than Moving Parts)



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 shall be removed unless tools are required for their removal. A warning marking, such as specified in Clause 44.3(r), shall 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 5.8, 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.

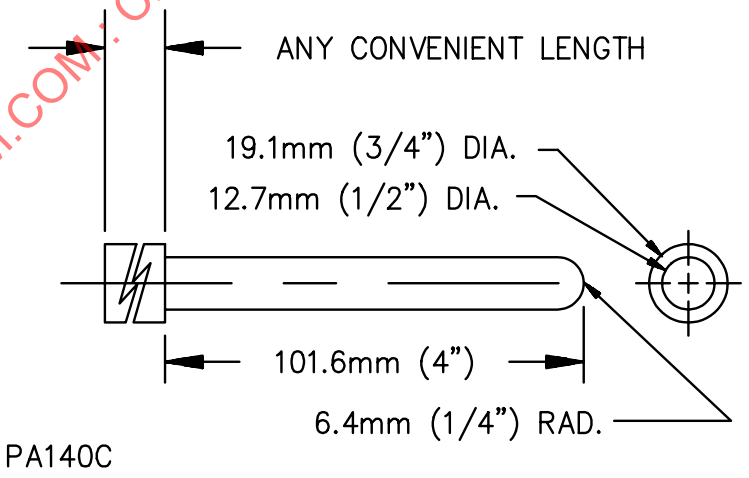
Exception: An acceptable barrier is considered to be provided by a finned coil construction at least two rows in depth and with at least 12 fins per 25.4 mm (1 in).

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)



Openings in enclosures

7.7 For enclosures containing ultraviolet (UV) radiation lamp systems, there shall be no openings that permits a leakage outside of the unit into occupied space greater than the effective irradiance value specified in Clause 89.2.1

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;

b) must be engaged before parts in a hazardous voltage circuit can be energized; and

c) is located so that unintentional operation is unlikely during normal servicing.

8.3 An interlock that is required to reduce a risk of electric shock or injury to persons shall withstand 1000 cycles with a load not less than that controlled in the equipment, and 5,000 cycles without a load, or shall comply with CSA-C22.2 No. 55; and UL 353

8.4 An interlock that is required to reduce the risk of electric shock shall open all supply conductors.

Enclosures, doors, and covers

8.5 Doors and covers that give direct access to Ultraviolet (UV) radiation lamp systems shall be equipped with an interlocking mechanism that removes power from the Ultraviolet (UV) radiation lamp system.

8.6 Access panels and components, that are removable for cleaning and servicing that provide access to other areas inside a unit shall require an interlock switch if the UV-C irradiance exceeds the value specified in Clause 89.2.2.

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, changing ultraviolet (UV) lamps) 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 or UV light hazards.

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 Class 2 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 shall meet the rain test requirements of Clauses 13.1, 13.3, and Clause 67.

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.

9.7 Units employing Ultraviolet (UV) radiation lamp systems may need protection barriers to:

a) Protect users from exposure to Ultraviolet (UV) radiation through openings in the enclosure;

b) Protect service personnel from over exposure to Ultraviolet (UV) radiation when servicing the unit; and

c) Protect non-metallic materials that are not rated for exposure to Ultraviolet (UV) radiation.

9.8 Barriers shall be constructed of a suitable material that will not be affected by radiated Ultraviolet (UV) exposure per the requirements of Clause 89.1. Non-metallic materials may be protected by directly attached barriers such as aluminum metal coated tape.

9.9 The ultraviolet (UV) lamp and removable barriers shall be located in such a manner that the ultraviolet (UV) radiation is not emitted outside the unit into occupied space at a level exceeding the effective irradiance limit specified in Clause 89.2.1 and for service areas inside the unit the effective irradiance shall not exceed the limit specified in Clause 89.2.2.

9.10 Both the unit inlet and outlet should be considered as possible Ultraviolet (UV) radiation paths when determining barrier locations.

9.11 The unit filters are not considered Ultraviolet (UV) radiation barriers.

9.12 Removable Ultraviolet (UV) radiation barriers shall be marked per Clause 45.17. The marking must be located on, or adjacent to the ultraviolet (UV) barrier.

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 shall 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 44.9).

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 44.3(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)

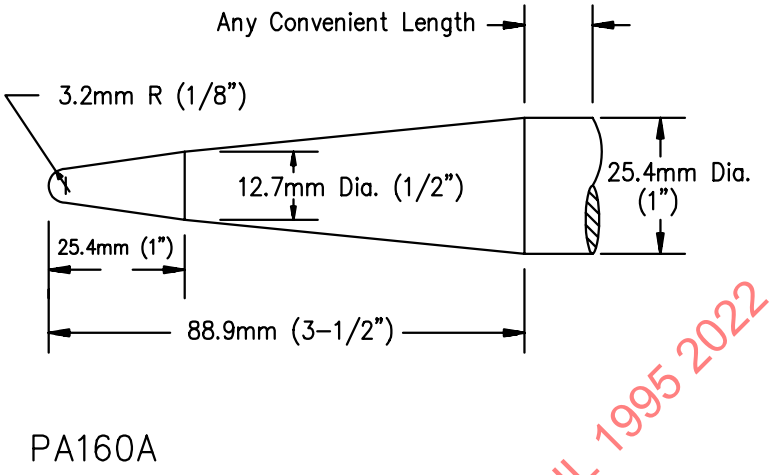


Table 11.1
Clearance from openings

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 and extra-low-voltage safety circuits), and shall protect the system against risk of shock due to exposure to rain (see Rain Test, Clause 67). 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 Clause 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 Table 6.1 and Table 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 Clause 67.

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 Clause 5.10.

13.6 Gaskets required to seal enclosures of electrical components shall comply with the requirements of Clause 68, 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 – field 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 can 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, and UV lamp systems) shall be marked in accordance with the requirements of item (z1) of Clause 44.3(z1), 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 44.3 (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 Clause 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 With reference to the requirements of item g), for factory specified field installed integral UV systems, the safety interlock need not be preinstalled, but termination points and mounting provisions shall be provided and the safety interlock installation procedures shall be clearly defined in the instructions and marked on wiring diagram.

15.4 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, exposure to Ultraviolet (UV) radiation, 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, exposure to Ultraviolet (UV) radiation, 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).

16.10 Units that are designed and marked per item (z1) of Clause 44.3 to indicate the possible installation of non Integral field Installed (duct mounted) UV lamp systems shall include wiring connection terminals for the UV lamp system. These connections shall include:

a) Interlock circuit connections, and

b) UV lamp power circuit power connections.

16.11 If the equipment is intended to be used with an auxiliary device that derives the power from the equipment power supply, the equipment shall be marked as indicated in 38.18.

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 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 Clause 33, 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 Clause 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 Clause 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.

17.10 A terminal block shall be used for field wiring connections unless the contactor is acceptable for field wiring connections.

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
16	1/2	22.2	7/8	25.4	1	9.5	3/8
21	3/4	27.8	1-3/32	31.4	1-15/64	10.7	27/64
27	1	34.5	1-23/64	40.5	1-19/32	13.1	33/64
35	1-1/4	43.7	1-23/32	49.2	1-15/16	14.3	9/16
41	1-1/2	50.0	1-31/32	56.0	2-13/64	15.1	19/32
53	2	62.7	2-15/32	68.7	2-45/64	15.9	5/8

Table 17.1 Continued on Next Page

Table 17.1 Continued

Trade size of conduit		Knockout or hole diameter		Bushings dimensions			
				Overall diameter		Height	
mm	in	mm	in	mm	in	mm	in
63	2-1/2	76.2	3	81.8	3-7/32	19.1	3/4
78	3	92.1	3-5/8	98.4	3-7/8	20.6	13/16
91	3-1/2	104.8	4-1/8	112.7	4-7/16	23.8	15/16
103	4	117.5	4-5/8	126.2	4-31/32	25.4	1
–	4-1/2	130.2	5-1/8	140.9	5-35/64	27.0	1-1/16
129	5	142.9	5-5/8	158.0	6-7/32	30.2	1-3/16
155	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. Alternately, the material shall be evaluated and determined to have a maximum optical density of 0.5 or less and an average optical density of 0.15 or less and a peak heat release rate of 100 kW or less when tested in accordance with UL 2043. If a unit is intended for installation in a building plenum, then the entire unit is considered to be in a compartment handling conditioned air for circulation through a duct system. This requirement does not apply to the following:

a) 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 cm^2 (25 in^2);

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 m^2 (10 ft^2);

f) Materials in a compartment handling air for circulation through a duct supplying only one room; or

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 ANSI/NFPA 701.

h) Air filters and media wheels or plates meeting the test requirements in UL 900.

[a] See Table 46.3 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 m^2 (1 ft^2) 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 Terminal blocks used for field wiring connections shall comply with the applicable requirements of CSA-C22.2 No. 158 and UL 1059.

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

19.5 Line terminals of an approved control or fuseholder may be used as field wiring terminals provided they comply with the requirements of Clauses 19.14 and 19.15.

19.6 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.

19.7 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.

19.8 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.

19.9 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.

19.10 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 Class 2 circuits, and that are separated or segregated by barriers from field wiring connections for hazardous voltage circuits.

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

19.11 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 Clause 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

19.12 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 45.10) 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.

19.13 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.

19.14 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.

19.15 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.

19.16 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.

19.17 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.

19.18 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.

19.19 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.

19.20 Each equipment grounding terminal or lead shall be located in the field wiring compartment, and shall be identified as specified in Clause 19.10 or 19.24, as applicable.

19.21 If more than one circuit is intended to be connected to the unit, the terminals or leads provided for field connection of the equipment grounding conductor shall comply with the applicable requirements for connection of a separate grounding conductor for each circuit.

19.22 If provision is made for connection of two or more power supply conductors in parallel at each terminal, as mentioned in Clause 19.12, provision shall be made for connection of an equal number of equipment grounding conductors.

19.23 The size of each grounding conductor shall comply with the applicable requirements for connection of an equipment grounding conductor as specified in Table 16 of CSA C22.1 and Table 250-122 of ANSI/NFPA No. 70, except that such a conductor need be no larger than one of the power supply conductors.

19.24 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green coloured head that is hexagonal shaped, slotted, or both. A pressure wire connector intended for connection of this conductor shall be identified by being marked “G”, “GR”, or the equivalent, or by being represented on a wiring diagram provided on the unit. The wire binding screw or pressure wire connector shall be located so that it does not need to be removed during servicing of the equipment. Upturned lugs or the equivalent shall be provided at a wire binding screw to retain the conductor. If a pressure connector is used adjacent to the connectors intended for the supply conductors involving the neutral of a grounded supply, a marking shall also be provided indicating “equipment ground” or the connector shall be identified by a green colour.

19.25 The wiring compartment intended for connection of the power supply conduit or raceway shall be attached to the unit so that it is prevented from turning.

This does not preclude the application of an outlet box, control box, or equivalent enclosure (to which the power supply connections are to be made) connected to the unit by suitable factory wiring enclosed within a length of flexible metal conduit, providing that suitable conduit fittings are applied. Unless the conduit is terminated in an outlet box no larger than 102 × 102 × 51 mm (4 × 4 × 2 in) for the splice connections, locknuts on the fittings are not considered to be an acceptable means of preventing loosening of the conduit fittings. A grounding conductor of the size specified in Clause 19.23 shall be included.

19.26 A field wiring lead shall be no more than two standard wire sizes smaller than the conductor to which it will be connected, except as indicated in Clause 19.27.

19.27 The leads specified in Clause 19.26 may be more than two wire sizes smaller than the field provided conductors to which they will be connected (but not smaller than No. 18 AWG) when more than one factory-provided lead is intended for connection to the same field-provided lead wire, providing that

a) the wire connector for the splice connection to the field-provided wire is provided as part of the unit, and the wire connector is acceptable for the combination of wires that will be spliced;

b) a marking is included indicating that the provided wire connector is to be used for the field wiring splice connection; and

c) the factory-provided leads are grouped in a manner to prevent stress on an individual lead.

19.28 A lead provided for connection to an external circuit shall not be connected to a wire binding screw or pressure terminal connector located in the same compartment as the splice, unless

a) the screw or connector is rendered unusable for field wiring connections; or

b) the lead is insulated at the unconnected end, and its intended use is clearly indicated (for example, on the applied wiring diagram).

19.29 A terminal plate for a wire binding screw shall be of metal not less than 0.76 mm (0.030 in) thick for a conductor sized No. 14 AWG or smaller, and not less than 1.27 mm (0.050 in) thick for a conductor larger than No. 14 AWG. In either case there shall be not less than two full threads engaging. (The terminal plate may be extruded at the tapped hole to provide the two full threads.)

19.30 On cord-connected equipment, the power supply cord shall be Type S, SJ, SJO, SO, ST, SJT, or equivalent. The length of the cord shall be in accordance with Clause 78. The supply cord shall have an ampacity at least equal to the total input in amperes measured during the normal temperature test (see Clause 79). The supply cord ampacity shall be determined from Table 12 in CSA C22.1 and Table 400-5(A) in ANSI/NFPA No. 70.

19.31 On cord-connected equipment, the power supply cord shall terminate in a grounding type attachment plug that shall have a rating not less than 125% of the marked input in amperes.

19.32 On liquid chillers employing centrifugal motor-compressors, soldering lugs or pressure terminal connectors are not required to be provided by the manufacturer for connection of the field wiring to the motor-compressor power-supply terminals. Threaded studs of adequate size and length shall be provided. Nuts for the studs shall be provided to adequately secure at least one terminal connector to each threaded stud.

19.33 Equipment intended for cord connection to the supply shall be provided with:

a) A non-detachable power supply cord for connection to the supply by means of an attachment plug, or

b) A detachable power supply cord (cord set) and an appliance inlet (motor attachment plug).

19.34 With reference to 19.33 and in addition to the requirements in this standard, a power supply cord or cord set shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817 and CSA C22.2 No. 21. An appliance inlet shall comply with the Standard for Attachment Plugs and Receptacles, UL 498 and CSA C22.2 No. 182.3.

19.35 A Caution marking, such as specified in Clause 44.3(z) shall be located adjacent to the appliance inlet and repeated in the installation instructions.

Extra-Low-Voltage Circuits

19.36 Leads for making connection to the extra-low-voltage supply circuit shall be of adequate length as defined in Clause 19.12.

19.37 Openings for the entry of conductors of an extra-low-voltage circuit shall be provided with insulating bushings. The bushing shall be either mounted in place in the opening, or shall be packed within the enclosure for mounting when the unit is installed.

Exception: An insulating bushing need not be provided if

1) a wiring assembly for Class 2 control is furnished with the equipment;

2) the edges of the opening will not abrade the insulation on the wiring assembly; and

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

20 Internal wiring

20.1 This section shall apply to hazardous voltage circuits, extra-low-voltage safety circuits, and Class 2 safety circuits, unless stated otherwise. Wiring requirements for Class 2 circuits that are not safety are not specified. These conductors may be 22 AWG or larger as long as the requirements of Clause 20 are complied with.

20.2 Wireways shall be smooth and entirely free from sharp edges and burrs.

20.3 Only conductors having oil-resistant insulation shall be used where the conductors may be exposed to oil, grease, oily vapour, or other substances having a deleterious effect.

20.4 Wiring exposed periodically to moisture shall have moisture-resistant properties.

20.5 Wiring shall have insulation rated for the potential involved and the temperatures to which it may be subjected. Temperatures shall be judged on the basis of the temperatures measured during the applicable temperature tests specified in Clause 46.1.

Exception: If it can be determined that the wiring will not be exposed to heat from radiating sources or heated components, and if the ampacity of the conductors is in accordance with Table 20.1 and Clause 20.8, the temperature tests on the wiring may be waived.

Table 20.1
Wiring material ampacities[a]

Wire size		
mm²	AWG	Ampacity
0.41	22	4
0.66	20	7
0.82	18	10
1.3	16	13
2.1	14	18

Table 20.1 Continued on Next Page

Table 20.1 Continued

Wire size		
mm^2	AWG	Ampacity
3.3	12	25
5.3	10	30
8.4	8	40
13.3	6	55
21.2	4	70
33.6	2	95
42.4	1	110

[a] The ampacities shown apply to appliance wiring materials with insulation rated not less than 90°C (194°F).

For types of wires other than appliance wiring materials, the ampacity shall be determined from Tables 1 through 4 and Table 12 in CSA C22.1 and Tables 310-16 and 310-17 in ANSI/NFPA No. 70 for the type of wire employed. The correction factors of the referenced tables need not be applied.

20.6 For units or assemblies that include PV module(s) or cells, the PV source circuit wiring shall have insulation rated for the maximum potential involved, including the applicable thermal correction factor as defined by Clause 38.3, and the temperatures to which it may be subjected. Temperatures shall be judged on the basis of the temperatures measured during the applicable temperature tests specified in Clause 46.1.

20.7 The ampacity of PV output circuit wiring shall be sufficient for 125% of the maximum current available from the sum of parallel module rated short-circuit currents.

20.8 With reference to the exception in Clause 20.5, hazardous voltage circuit conductors supplying one motor shall have an ampacity not less than 125% of the motor full load current rating. Conductors supplying more than one motor shall have an ampacity not less than 125% of the full load current rating of the largest motor plus the full load current rating of any other motors supplied. Conductors supplying a motor load and other loads shall have an ampacity not less than 125% of the motor full load current rating plus the marked current ratings or measured inputs of the additional loads supplied.

20.9 With reference to the exception in Clause 20.5, as it applies to an adjustable speed drives, the ampacity is determined as follows:

a) The hazardous voltage circuit conductors supplying an adjustable speed drive with a controlled motor shall have an ampacity not less than 125% of the maximum operating current rating (MOC) or the input current rating of the adjustable speed drive.

b) The hazardous voltage circuit conductors supplying an adjustable speed drive with a controlled motor compressor shall have an ampacity not less than 125% of the maximum rated current rating (MRC) or the input current rating of the adjustable speed drive.

20.10 Conductors used in hazardous voltage circuits, extra-low-voltage safety circuits, and Class 2 safety circuits shall be selected from Table 20.2 in accordance with the circuit requirements for conductor size, voltage, and temperature rating.

Table 20.2
Typical wiring materials

Group	Type of wire, cord, or cable[a,b]	Wire size		Insulation thickness	
		mm²	No. AWG	mm	in
A	Thermoplastic or thermoset appliance wiring material, with insulation thicknesses shown at the right corresponding to wire sizes indicated; or Type TW; or Type[d] AC, ACT, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, THW, XHH, XHHW, MTW, THHN, THW-MTW, THWN, PF, PGF, PFF, PGFF; or Type[c] GTF, TW75, TEW, TR-32, R90, RW90, T90, SEW-1, SEW-2	5.3 to 0.41	10 to 22	0.8	2/64
		8.4	8	1.2	3/64
		13.3	6	1.6	4/64
		21.2	4	1.6	4/64
		26.7	3	1.6	4/64
		33.6	2	1.6	4/64
		42.4	1	2.0	5/64
		54.0	1/0	2.0	5/64
		67.0	2/0	2.0	5/64
		85.0	3/0	2/0	5/64
		107.2	4/0	2.0	5/64
B	Appliance wiring material having thermoplastic or thermoset insulation, with insulation thicknesses shown at right corresponding to the wire sizes indicated; or Type S, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, SPT-3, ST, STO, STOO; or Type[d] SE, SJE, or Type[c] NMD90, NMWU	0.82	18	1.6	4/64
		1.3	16	1.6	4/64
		2.1	14	2.0	5/64
		3.3	12	2.0	5/64
		5.3	10	2.0	5/64
		8.4	8	2.4	6/64
		13.3	6	3.2	8/64
		21.2	4	3.6	9/64
		33.6	2	4.0	10/64
C	Appliance wiring material with cross–linked synthetic polymer insulation; or Type S, SJ; or Type[d] SP-3	Same as for Group B			

[a] The designated cord or cable, or types of wire other than appliance wiring material, may be used without regard to the values specified in the Table.

[b] Type CL wire may be used within a separate metal enclosure as leads of components.

[c] Wire types included only in CSA C22.1.

[d] Wire types included only in ANSI/NFPA No. 70.

20.11 Wiring shall be enclosed in metal clad cable, conduit, electrical metallic tubing, or metal raceways, control boxes, or the equivalent. Appropriate fittings shall be used. Wiring of the types referenced in Groups B or C of Table 20.2 may be employed in lieu of enclosed wiring, provided the requirements of Clause 20.9 are met.

Exception: Wiring of the types in Group A of Table 20.2 may be employed if secured and supported to prevent damage and the requirements of Clause 20.9 are met.

20.12 Cords or appliance wiring material used in the cabinet of equipment shall be suitably enclosed so as to prevent damage to the wiring, ignition of combustible material, or emission of flame or molten metal through openings in the cabinet.

Such wiring is considered to be suitably enclosed when the cabinet or compartment enclosing the wiring has

a) no openings in the bottom, unless a U-shaped channel or trough is located beneath the wiring, and the wires do not project through the plane of the top of the channel or trough. A bottom closure is considered to be provided:

1) if the bottom opening is always intended to be connected to a supply or return indoor air duct; and the unit includes space heating means (electric heater, hot water, or steam heating coil); or

2) if the unit is intended only for nonresidential applications and is so marked, except those openings intended only for conduit or piping; or

3) if the bottom opening is provided with a finned coil construction at least two rows in depth and with at least 12 fins per 25.4 mm (1 in); or

4) if the bottom opening complies with Figure 23.1 and Clause 23.4; or

5) the bottom opening complies with the requirements of the tests specified in Annex B;

b) no louvre or openings, other than duct openings, that will permit the probe (Figure 7.1), when applied in a straight line, to contact wiring; and

c) no combustible material other than electrical insulation within the enclosure. An air filter may be employed within the enclosure.

Exception: The separation specified in Item (b) does not apply to wiring located above openings in the bottom enclosure of a unit for outdoor installation, provided that such openings comply with the requirements of Clause 20.13.

20.13 On a unit for outdoor installation, the bottom surface of the enclosure may have openings, provided that all of the following conditions are met (applies only to hazardous voltage circuits):

a) openings are less than 12.7 mm (1/2 in);

b) such openings are not located within 152 mm (6 in) of each other; and

c) the total area of such openings does not exceed 1% of the area of the enclosure bottom surface, less any area below a component such as a finned tube coil or hermetic motor compressor that is mounted directly on that surface.

20.14 Thermoplastic-insulated hazardous voltage wiring materials that are referenced in Group A of Table 20.2, and have an insulation thickness of 0.8 mm (2/64 in) for sizes 16 and 18 AWG, and 1.2 mm (3/64 in) for sizes Nos. 14, 12, 10, and 8 AWG, are considered to be equivalent to the wiring materials referenced in Group B when the conductors are covered with thermoplastic insulating tubing that has a wall thickness of 0.8 mm (2/64 in) and is of a type rated for the purpose from the standpoint of electrical, mechanical, and flammability properties. For sizes 6, 4, and 2 AWG, thermoplastic wiring materials that are referenced in Group A of Table 20.2 and enclosed in thermoplastic tubing as described in this requirement are considered to be equivalent to the wiring materials specified in Group B when the total wall thickness (of the conductor insulation plus tubing) is not less than the value specified for Group B.

20.15 Wiring shall be protected against damage, shall be supported and routed to prevent damage due to contact with sharp edges, such as fins on refrigeration coils, moving parts, or parts that may attain a temperature in excess of that for which the wiring insulation is rated, and shall not be immersed in water unless rated for use in wet locations. Self-draining raceways that do not retain water are not considered to require wiring for use in wet locations. For wiring run through flexible conduit, the conduit shall be secured or supported within 756 mm (30 in) of each box, cabinet, conduit body, or other conduit termination and shall be secured or supported at intervals not to exceed 1,361 mm (54 in).

20.16 Splices in wiring shall be located, enclosed, and supported so that they are not subject to damage, flexing, motion, or vibration. A splice is considered to be acceptably enclosed when installed in a junction box, control box, or other enclosed compartment in which the wiring materials, as specified in Group A of

Table 20.2, may be employed. A splice in an enclosed machinery compartment shall be secured to a fixed member in the compartment so that it is not subject to movement or damage during servicing. A splice or unused leads shall be provided with insulation equivalent in thickness, voltage and temperature rating to that of the wires involved.

20.17 Stranded conductors at terminals shall be prevented from contacting other uninsulated live parts, which may not always be of the same polarity as the wire, and from contacting dead metal parts. The shanks of terminal connectors shall be protected by insulating tubing, or equivalent, if the spacings specified in Clause 33 could be reduced by loosening the clamping means.

20.18 A hole in a wall or partition through which insulated wires or cords pass and on which they may bear shall be provided with a smooth, rounded bushing or shall have a smooth, rounded surface upon which the wires or cords can bear. The bushings, where required, shall be of ceramic, phenolic, cold-moulded composition, fibre, or other like material. Thermoplastic material shall not be clamped so as to cause cold-flow of the material that can result in a risk of fire or electric shock.

20.19 Except as indicated in Clause 20.20, conductors of crankcase heater circuits or conductors of hazardous voltage motor circuits having two or more thermal or overcurrent protected motors, or such (one or more) motors in combination with an electric resistance heater wired for connection to one power supply line, shall withstand short circuiting when tested in accordance with the short circuit test described in Clause 64. None of the conductors or lead terminations shall be damaged as a result of the short circuit test. A fuse or circuit breaker sized to the conductor supplying the load is deemed to meet the requirements of the short circuit test.

20.20 With reference to Clause 20.19, conductors that comply with at least one of the following are acceptable without test:

a) The conductors have an ampacity as determined from Table 20.1 for the type of wire or cord employed of not less than 1/3 the ampacity of the supply conductors.

b) The conductors are 18 AWG or larger, and not more than 1.2 m (4 ft) in length, and the circuit will be protected by an overcurrent protective device that is rated 60 A or less as specified on the unit nameplate or provided as part of the unit, and is acceptable for branch circuit protection.

c) The conductor is connected between two fixed impedances that reduce the risk of a high fault current within the conductor (for example, a conductor extending between a motor running capacitor and the start winding of a permanent split capacitor motor).

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

20.21 Wiring subjected to periodic movement during normal use (such as wiring that extends from the cabinet to a hinged door or to other parts) shall not cause undue stress to electrical connections and conductors. With the exception of wiring for Class 2 circuits that are not safety circuits and Group B flexible cords (Table 20.2), wiring shall be subjected to the flexing test as described in Clause 83.

21 Separation of circuits

21.1 Unless having insulation suitable for the highest voltage involved, insulated conductors of different circuits (internal wiring, including wires in a junction box or compartment) shall be separated by barriers, or shall be segregated, and shall, in any case, be separated or segregated from uninsulated live parts connected to different circuits. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that ensures permanent separation from insulated or uninsulated live parts of a different circuit.

21.2 There shall be provision for segregating or separating by barriers field-installed conductors of any circuit from field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are or will be insulated for the maximum voltage of either circuit.

21.3 Within a compartment that is not a control enclosure junction box or its equivalent, field-installed extra-low-voltage (including Class 2) circuit conductors may be segregated from factory-installed conductors of different circuits by locating field wiring openings, routing factory wiring, and locating electrical components so that the factory conductors are maintained at least 127 mm (5 in) from a line representing intended routing of the extra-low-voltage (including Class 2) circuit conductors. The line shall allow for droop, and shall connect the opening provided for entrance of the extra-low-voltage (including Class 2) conductors to the terminals or leads to which the conductors are attached.

21.4 There shall be provision for segregating or separating by barriers field-installed conductors of a hazardous voltage circuit from

a) uninsulated live parts connected to a different circuit, other than wiring terminals; and

b) any uninsulated live parts of electrical components such as a pressure-limiting device, motor overload protective device, or other protective device where short circuiting or grounding may result in unsafe operation of the equipment; except at wiring terminals.

21.5 There shall be provision for segregating or separating by barriers, field-installed conductors of an extra-low-voltage circuit from

a) uninsulated live hazardous voltage circuits; and

b) wiring terminals and any other uninsulated live parts of hazardous voltage electrical components such as a pressure-limiting device, motor overload protective device, or other protective device where short circuiting or grounding may result in unsafe operation of the unit.

21.6 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of suitable insulating material of adequate mechanical strength, and reliably held in place.

21.7 A metal barrier shall be at least 0.66 mm (0.026 in) thick if of uncoated steel, 0.74 mm (0.029 in) thick if of galvanized steel, and 0.91 mm (0.036 in) thick if of nonferrous metal. A barrier of insulating materials shall be not less than 0.71 mm (0.028 in) thick, and shall be of greater thickness if its deformation could be so readily accomplished as to defeat its purpose.

21.8 If the barrier is removable or has openings for the passage of conductors, it is acceptable provided that instructions for the use of the barrier are a permanent part of the device. In lieu of a barrier, complete instructions may be provided that, when used in conjunction with the wiring diagram, will provide for the separation of the circuits of different voltages.

21.9 Field-installed conductors may be segregated from other field-installed conductors and from uninsulated live parts connected to other circuits by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that conductors or parts of different circuits will not intermingle.

21.10 The output of a transformer device supplying circuit shall not be interconnected with the output of another such transformer device provided as a part of the equipment, unless the voltage and current measurements at the output terminals of the interconnected devices are extra-low-voltage.

21.11 Two or more transformer devices supplying Class 2 circuits and provided as a part of the equipment, shall be treated as separate circuits. If more than one such circuit is intended to be field-wired,

the several circuits shall be segregated or separated by barriers as specified in Clause 21.2, and the transformer output of each circuit shall be marked to warn that the separation shall be maintained.

21.12 On liquid chillers employing centrifugal motor compressors, a signal input circuit derived from a current transformer sensing the motor-compressor current and located in the (remote) motor-compressor controller shall be a CSA C22.1 and ANSI/NFPA No. 70 Class 1 circuit. (See Clause 26.17.)

22 Electrical insulation

22.1 Material for the mounting of uninsulated hazardous voltage parts shall be heat-resistant, absorption resistant insulating material that is suitable for its particular application, and that will withstand the most severe conditions likely to be encountered in service.

Such materials include porcelain, phenolic composition, cold-moulded composition, or a material having equivalent electrical and physical properties.

22.2 The acceptability of insulating materials shall include consideration of the following:

a) mechanical strength;

b) dielectric strength;

c) insulation resistance;

d) heat- and moisture-resistant properties;

e) the degree of enclosure or protection; and

f) other factors that might have a bearing on the risk of fire or electric shock under conditions of intended use.

23 Motors

Motor Enclosures

23.1 The type of motor enclosure shall be suitable for the particular location in which the motor is to be used, unless adequate supplementary means of protection for the motor is provided.

23.2 Openings in motors shall be located so that there is a noncombustible surface immediately below them.

23.3 In order to comply with the requirement of Clause 23.2, a barrier of noncombustible material shall be provided under an open type motor unless one of the alternatives described in Items (a) to (c) is used:

a) the structural parts of the motor or unit, such as the bottom closure, provide protection equivalent to that provided by such a barrier;

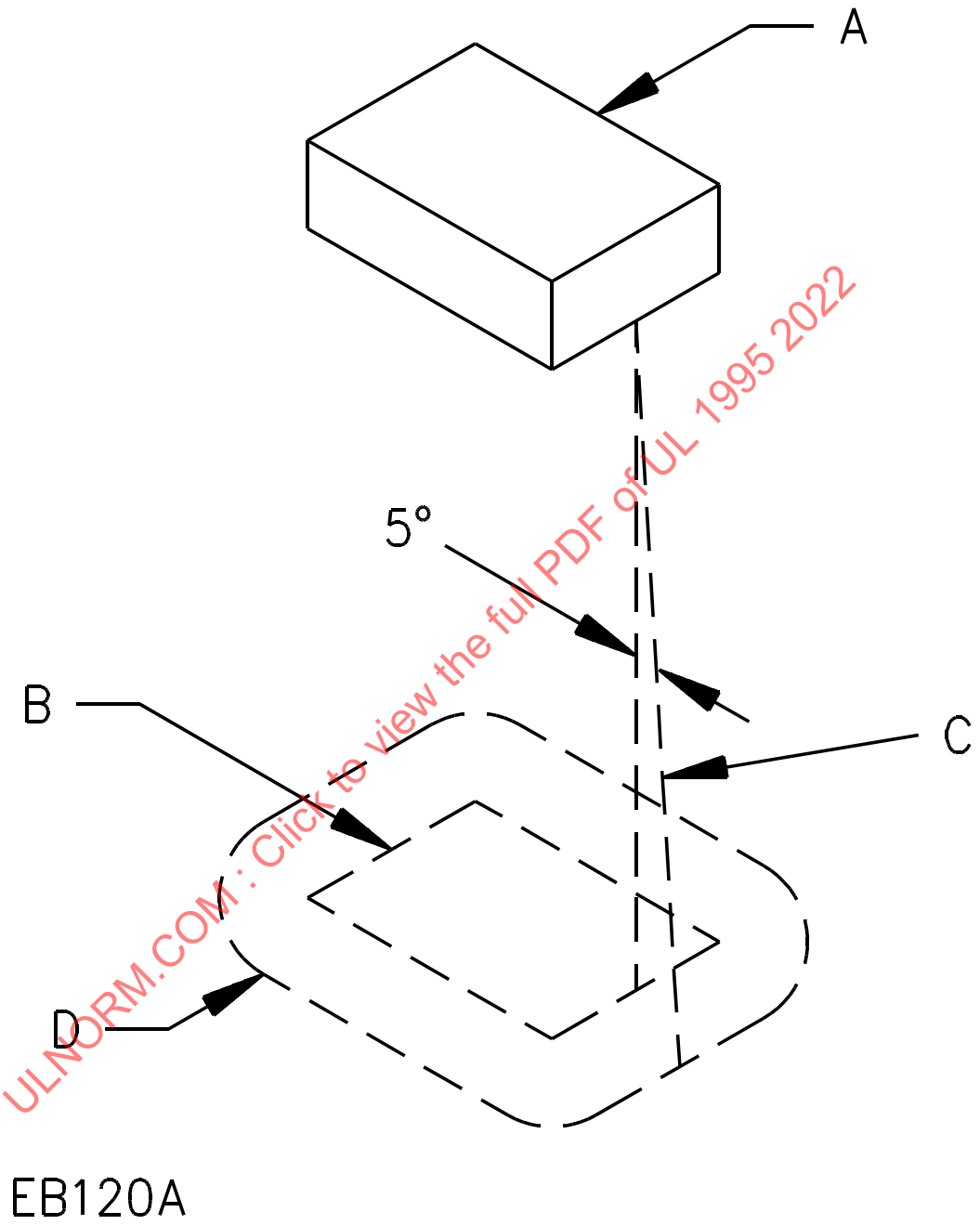
b) the overload protective device provided with the motor allows no burning insulation or molten material to fall to the surface that supports the unit while the motor is energized under each of the following applicable fault conditions: open main winding; open starting winding; starting switch short-circuited; or capacitor shorted (permanent split capacitor type); or

c) the motor incorporates a motor thermal protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from exceeding 125°C (257°F) while the motor is operated at the maximum load that will not cause the protector to cycle; and 150°C (302°F) while the motor is locked.

23.4 The barrier necessary for compliance with Clause 23.3 shall be horizontal and shall have an area extending beneath the motor encompassing the openings in the motor housing and extending at least 5° beyond their area. Openings for drainage and ventilation may be included in the barrier, providing that the openings do not permit molten metal, burning insulation, etc, to fall onto combustible materials. See Figure 23.1.

Figure 23.1

Location and extent of barrier



A – Regions to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. This line is always (1) tangent to the component, (2) 5 degrees from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced by the inclined line C and the horizontal plane of the barrier.

Motor Overload Protection

23.5 All motors other than a hermetic refrigerant motor compressor shall be protected by thermal or by overcurrent protective devices, or a combination of these as follows:

a) A separate device responsive to motor current and rated to set to trip at not more than the percentage of the motor nameplate full-load current rating specified in Table 23.1. If the percentage protection specified in Column A of Table 23.1 does not correspond to the percentage value of an overload relay of a standard size, the device of the next higher size may be used. However, the overload device of the next higher size shall protect against currents exceeding the percentage values specified in Column B of Table 23.1.

b) A separate overload device which combines the functions of overload and overcurrent protection and is responsive to motor current rated or set at values not greater than the percentages of the motor nameplate full-load current rating as specified Table 23.1. Such a device shall be capable of fully protecting the circuit and motor both under overload and short circuit conditions. If the marked service factor of a motor is less than 1.15, or if the service factor or service factor current is not marked on the motor, the rating or setting of separate overload devices, if used, shall not exceed 115% of the full load current of the motor.

c) A protective device integral with the motor that complies with UL 2111, or UL 1004-1 (and CSA C22.2 No. 77) and UL 1004-3 (and CSA C22.2 No. 77). An impedance–protected motor shall comply with UL 1004-1 and UL 1004-2. An electronically protected motor shall comply with UL 1004-1 and UL 1004-7 (and CSA C22.2 No. 77). When an impedance-protected motor is used, it shall not be installed in a compartment handling air for circulation through a duct unless smoke is not generated under any required test condition while the rotor of the motor is locked.

d) Electronic protection that complies with Clause 23.11.

Table 23.1
Protective device activation level

	Maximum percent of full-load current rating protection	
	A	B
Motor with marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 40°C (72°F)	125	140
Any other motor	115	130

23.6 Hermetic refrigerant motor compressors shall be protected by one of the following:

a) A separate overload relay that is responsive to motor compressor current and will trip at not more than 140% of the rated load current of the motor compressor.

b) A thermal protector integral with the motor compressor or protective system that complies with the applicable requirements in CSA C22.2 No. 140.2 and UL 984 or UL 60335-1 and UL 60335-2-34, and will not permit a continuous current in excess of 156% of the rated load current of the motor compressor (or 156% of the branch circuit selection current if the latter is marked, see Clauses 44.10 and 44.11).

Exception: The percentage limitations do not apply if the unit is marked with a single, overall ampere rating in accordance with Clause 44.5.

c) A fuse or circuit breaker responding to motor current, and rated at not more than 125% of the rated load current of the motor compressor. When such a device is used, the product shall start and operate as intended with the fuse or circuit breaker provided.

1) The value of rated load current referred to are those marked on the equipment nameplate.

2) A fuse may be used for motor overload protection, when the highest current rating of fuse that can be inserted into the fuseholder provides the correctly sized motor protection.

d) Electronic protection that complies with 23.11.

23.7 Overload protection of a single-speed, continuous duty fan motor having a marked rating over 746 W output (1 hp) shall be provided as part of the product unless all of the following conditions exist:

a) the motor is located so that it is not affected by an external source of heat;

b) the motor is to be field-wired to an individual branch circuit that does not supply any other loads within the product;

c) the motor overload protection is a part of separate, field-provided motor control equipment that does not require wiring interconnection to the product, except for the motor circuit;

d) energization of electric heating elements does not occur without motor operation or evidence of air flow; and

e) the motor is marked as specified in Clause 45.2.

23.8 A three-phase motor shall be provided with overload protection as specified in Clause 23.5. The protection shall consist of three overcurrent units or the devices as specified in Clause 23.9. If current responsive devices provide the only protection, then such devices shall consist of three current responsive elements that are either connected directly in the motor circuit conductor; or fed by two or three current transformers, and so connected that all three phases will be protected.

23.9 In reference to Clause 23.8, acceptable three-phase protective devices include thermal protectors, a combination of thermal protectors and overcurrent units, or another method of protection, where the specific protective arrangement has been investigated and found to provide protection under primary, single-phase fault conditions when power is supplied from transformers connected wye-delta or delta-wye.

23.10 Equipment employing a direct drive motor in conjunction with a part made of a polymeric material shall comply with the mold stress-relief distortion test and the input to motor test contained in CAN/CSA-C22.2 No.0.17 and UL 746C. Such polymeric parts could include the motor enclosure or housing, the shaft bearing support, the fan/impeller or the blower housing.

Exception: Direct drive motors protected by an integral thermal protector that provides running overload and locked rotor protection in accordance with Clause 23.5 need not comply.

Electronically Protected Motor Circuits

23.11 Electronically protected motor circuits shall comply with either Clause 23.12, 23.13 or 23.14.

Exception: If there is no risk of fire, electric shock or casualty hazard noted during abnormal testing with the motor electronic circuit rendered ineffective (open or short circuited), the evaluation per Clause 23.11 is not required.

23.12 Electronically protected motor circuits shall comply with UL 991 and CSA C22.2 No. 0.8. When the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in the Standard for Tests for Software in Programmable Components, UL 1998 and CSA-ISO/IEC 16085. If software is relied upon to perform a safety function, it shall be considered software class 1.

23.13 Electronically protected motor circuits shall comply with UL 60730-1 and UL 60730-2-9 and CAN/CSA E60730-1 and CAN/CSA E60730-2-9. If the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in Clause H11.12 of UL 60730-1 and CAN/CSA E60730-1. If software is relied upon to perform a safety function, it shall be considered software class B.

23.14 Electronically protected motor circuits shall comply if it is a power conversion controller incorporating overcurrent protection complying with the UL 508C and CSA C22.2 No. 0.14 and the percentage protection is set as indicated in Table 23.1.

23.15 The following shall be considered when evaluating the protective circuit. If the method of Clause 23.14 is employed, all the applicable requirements of UL 508C shall be complied with.

Table 23.2

Application of UL 991 and UL 1998	Application of UL 60730-1 and UL 60730-2-9
Conduct a failure-mode and effect analysis (FMEA.)	
A control becoming permanently inoperative and disconnecting power meets the criteria for electrical supervision of critical components and trouble indication;	
Assumed temperature ranges are as follows: Indoor Use 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F) Outdoor Use −35.0 ±2°C (−31.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F)	
Cycling test duration shall be 14 days	
Endurance test duration shall be 100,000 cycles	
Radio-frequency electromagnetic field immunity: Immunity to conducted disturbances – When applicable test level 3 shall be used Immunity to radiated electromagnetic fields – field strength of 3 V/m shall be used	
For exposure to humidity, the following conditions shall apply: Indoor Use: 21.1 – 26.7°C (70 – 80°F) and minimum 50 percent relative humidity Outdoor Use: minimum 98 percent relative humidity	
	Surge immunity test - Test with installation Class 3 used for other than outdoor use protective devices. Class 4 shall be used for protective devices intended for outdoor use
Electrical fast transient/burst immunity such that a test level 3 shall be used for all equipment other than outdoor use equipment. Test level 4 shall be used for outdoor use equipment	
	Electrostatic Discharge Test with a Security Level of 3 having Control Discharge at 6 kV for accessible metal parts and 8 kV for accessible parts of insulating material

Short Circuit Protection

23.16 Motor overcurrent protective devices and thermal protective devices shall comply with the applicable short circuit requirements for the class of protective device when tested in accordance with the Limited short-circuit test, Clause 64.

23.17 Except as indicated in Clause 23.18, an overcurrent protective device or a thermal protective device employed on equipment having more than one motor, or having a motor and supplementary heater, wired for connection to one supply circuit, shall withstand short circuit and ground fault conditions in accordance with the Limited short-circuit test, as described in Clause 64, without creating a risk of fire or electric shock.

23.18 The short circuit tests specified in Clauses 23.16 and 23.17 may be waived if

a) the thermally protected motor or separately enclosed motor overload protective device is within an outer cabinet of a product or section of a product;

b) the motor or device is intended to be protected by the overcurrent protective device as specified on the unit nameplate, or provided as part of the product, and which is acceptable for the branch circuit protection;

c) the assembly is constructed so that flame and molten metal will be confined within the cabinet; and

d) combustible material, except electrical insulation or an air filter, is not located below the motor.

23.19 Plug fuses shall not be used in circuits exceeding 150 V to ground; screwshells of plug fuses shall be connected to the load side of the circuit.

24 Grounding and bonding

24.1 An exposed metal part that may become energized shall be bonded to the point of connection of the equipment grounding terminal or lead, and to the metal surrounding the knockout, hole, or bushing provided for field power supply connections.

24.2 Except as permitted in Clause 24.3, uninsulated dead metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, control mounting brackets, capacitors and other electrical components, interconnecting tubing and piping, valves and other refrigerant-containing parts, plumbing accessories, etc, shall be bonded for grounding if they may be contacted by the user or by a service person during servicing of the equipment.

24.3 Metal parts, as indicated below, need not comply with the requirements of Clauses 24.1 and 24.2 where:

a) an adhesive attached part such as a metal foil marking, a screw, or a handle that is located on the outside of an enclosure or cabinet and is isolated by grounded metal parts from electrical components or wiring so that it cannot become energized;

b) an isolated metal part, such as a motor controller magnet frame or armature, or a small assembly screw that cannot come in contact with wiring and uninsulated live parts;

c) a panel or cover that does not enclose uninsulated live parts, providing that wiring cannot come in contact with the panel or cover, the panel or cover cannot become energized; and

d) a panel or cover that is insulated from electrical components and wiring by a barrier of vulcanized fibre, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (2/64 in) thick, and that is secured in place.

24.4 The bonding shall be by a positive means, such as by clamping, riveting, brazing, welding, or making a bolted or screwed connection. The bonding connection shall penetrate nonconductive coatings, such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

24.5 A bolted or screwed connection that incorporates a star washer or serrations under the screw head is acceptable for penetrating nonconductive coatings as required by Clause 24.4.

24.6 The use of two or more screws, or two full threads engagement of a single screw in metal, complies with Clause 24.4 if the bonding means depends upon screw threads.

24.7 Metal-to-metal hinge bearing members for doors or covers are considered to be means of bonding the door or cover for grounding if a multiple bearing pin type (piano type) hinge is used.

24.8 The size of a copper or aluminum conductor employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch circuit overcurrent device by which the equipment will be protected. Except as noted below, the size of the conductor shall be as specified in Clause 19.23.

24.9 A bonding conductor to a motor or other electrical component need not be larger than the motor circuit conductors or the conductor supplying the component.

24.10 Bonding conductors in equipment shall have insulation equivalent to that of live conductors, if there is any likelihood of accidental contact with uninsulated live parts.

24.11 Splices shall not be employed in wire conductors used for bonding.

24.12 If more than one size branch circuit overcurrent device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent device intended to provide ground fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor shall be sized on the basis of the overcurrent device intended for ground fault protection of the motor.

24.13 The temperature on any part of the compressor shall not exceed 150° C (302°F).

a) 8 AWG solid copper conductor, or;

b) 6 AWG solid conductor, or;

c) 6 AWG stranded copper conductor.

25 Mounting of components

25.1 Electrical components (for example, switches, fuseholders, lampholders, attachment plug receptacles, motor attachment plugs) shall be mounted securely and, except as permitted by Clause 25.2, shall be prevented from turning. Hazardous voltage or safety circuit (see Clause 32.3) electrical parts shall not be attached to removable covers. Friction between surfaces is not acceptable as the sole means of preventing shifting or turning of a live part, but a properly applied lock washer is acceptable.

25.2 The requirement that a switch be prevented from turning may be waived if the following conditions exist:

a) the switch is of a plunger or other type that does not tend to rotate when operated;

b) the means for mounting the switch is not subject to loosening as the result of operation of the switch;

c) spacings are not reduced below the minimum required values by rotation of the switch; and

d) rotation of the switch cannot apply strain on the conductors or their terminal connections.

26 Switches and controllers

26.1 Except as permitted by Clause 26.3, all units incorporating more than one motor intended for connection to the same power supply shall be equipped with a controller for controlling the loads involved.

26.2 A cord-connected unit equipped with a single phase motor rated greater than 1/3 hp or 7.2 A at 115 V or 3.6 A at 230 V shall be provided with a manually-operable controller that will de-energize all loads. Such a controller shall have a marked OFF position (the international symbol “O” may be used). The controller shall be accessible without the use of tools and shall disconnect all ungrounded conductors. The attachment plug and receptacle may serve as the disconnecting means if the unit has a motor rated at no more than 1/3 hp or 7.2 A at 115 V or 3.6 A at 230 V.

26.3 A motor controller is not required for a unit having more than one motor intended for connection to a single supply line if the marked maximum overcurrent protective device size does not exceed

a) 20 A at 125 V or less; or

b) 15 A at a voltage greater than 125 V but not greater than 600 V; and

c) The unit does not have a compressor motor rated at more than 6 RLA (rated load amperes) in the case of a single-phase motor, or the RLA or LRA (locked rotor amperes) ratings of the compressor motor for a 3-phase motor. See Table 26.1.

Table 26.1
Ampere ratings for 3-phase compressor motors

Electrical supply	Compressor motor rating	
Volts	Rated load amperes	Locked-rotor amperes
208	3.9	23.4
220 – 240	3.6	21.6
440 – 480	1.8	10.8

26.4 A controller shall be provided for controlling the condenser fan motor load on a remote air-cooled condenser.

26.5 A compressor evaporator or liquid chiller assembly may have provision for the connection of the control circuit of a remote condenser fan motor if the assembly is arranged to cause the condenser fan motor supply circuit to be energized when the compressor is operating.

26.6 A switch or other control device shall have a current and a voltage rating of not less than the load that it controls, as determined in the cooling, heating, and temperature operation tests of Clause 46.1.

26.7 A controller for a hermetic motor-compressor shall have a full-load current rating no less than the rated-load current of the motor-compressor marked on the product nameplate, and no less than the branch-circuit-selection current, if the latter value is marked (see Clauses 44.10 and 44.11), plus the additional load controlled.

26.8 A switch or other control device directly controlling a motor and other loads that may be required to break the largest motor load under locked rotor conditions shall have, in addition to the ratings specified in Clause 26.6, a current-interrupting capacity not less than the total of the locked rotor load of the largest motor plus the full load of the other motors, electric heater, and other loads. The load controlled shall include any load external to the unit for which connections in the controller or switch circuit are provided.

26.9 With reference to Clause 26.8, the locked rotor load of a hermetic refrigerant motor compressor shall be determined from the locked rotor current rating of the motor compressor at the normal test voltage. If the motor compressor's rated voltage is less than the normal test voltage, the motor compressor's rated locked rotor current shall be increased by the ratio of the normal test voltage to the rated voltage.

26.10 Motor controllers shall be arranged so that they will simultaneously open the number of ungrounded conductors required to interrupt current flow to the motor. A motor controller that also serves as a disconnecting means shall simultaneously open all ungrounded conductors to interrupt current flow to the motor. This requirement does not apply to an ungrounded conductor connected to a crankcase heating arrangement where current flows through a capacitor connected in series with the start winding of a single-phase motor when the motor is not operating, or any similar arrangements.

26.11 The controller for a motor-compressor employed on a unit in which water is used as the heat exchange medium shall open all ungrounded conductors to the motor-compressor unless:

a) The unit uses double walled heat exchangers that employ a vented interface; or

b) The unit is equipped with a pressure relief valve or a rupture member that will safely relieve pressure generated by heating of the water by uninterrupted current flow.

26.12 Control equipment, including transformers, motors, and heaters of duct-connected units, when located within the discharge or return air space, shall be so designed, enclosed, or protected that dense smoke will not be generated or flame emitted under any conditions likely to occur in service.

26.13 The control system of a unit having an electric heater shall be so designed that the heater cannot operate unless the circulating fan motor circuit is energized. This does not preclude the use of a fan delay control that complies with the applicable requirements for a fan control.

26.14 A component, such as a pilot light, capacitor, or resistor, shall not be connected across the contact terminals of a safety control, such as a temperature- or pressure-limiting control, unless the reliability of the component not to bypass the safety control can be determined.

26.15 The control system of an add-on heat pump shall be provided with a fan interlock designed to prevent operation of the heat pump unless the circulating fan motor circuit is energized. The control system shall include provision for a separate fan relay for use with those furnaces which do not include such a relay. The separate fan relay shall be an integral part of the heat pump, or shall be made available by the heat pump manufacturer, and shall be identified by a marking on the heat pump or wiring diagram.

26.16 An add-on heat pump shall be provided with an interlocking circuit to prevent simultaneous heating operation of the heat pump and installed furnace.

Exception: Simultaneous operation of the heat pump and furnace during a defrost cycle, or during a short transition period from heat pump to furnace operation, or from furnace to heat pump operation, is acceptable provided it can be determined that the compressor motor overload device will not operate during these periods.

26.17 An add-on heat pump shall be provided with a safety control, such as a pressure-limiting device, that will prevent simultaneous operation of the heat pump and installed furnace during heating operation. Compliance shall be determined by the test in Clause 57.

Exception: The safety control is not required in a heat pump with a hazardous voltage interlocking circuit, referred to in Clause 26.16.

26.18 With reference to Clause 26.17, the factory- or field-installed control circuit wiring shall be Class 1, as defined by Rule 16-004 of CSA C22.1 and Article 725-21 of ANSI/NFPA No. 70.

26.19 A low-temperature setting on a thermostat shall not be considered as a true OFF position and shall not be so marked unless the thermostat does not reclose when cooled to a temperature of −35°C (−31°F).

26.20 Where circuit breaker or switch handles are operated vertically, the “UP” position shall be the “ON” position. For multiposition units (eg, upflow, downflow) the installation instructions may be utilized to reposition in the field for compliance.

26.21 **Motors for use with solid-state speed controls**

26.22 A motor intended for use with a remotely located solid-state speed control shall employ overload protection that complies with Clause 23. Such equipment shall include a marking as specified in Clause 45.16.

26.23 A unit that is provided with an integral solid-state speed control shall employ overload protection that complies with Clause 23.

26.24 A solid-state speed control shall comply with the requirements in UL 1917 and CSA 22.2 No. 156.

Exception No. 1: The spacings of an integral factory wired component solid-state speed control shall comply with either UL 1917 or UL 244A. Compliance with UL 60730-1, CAN/CSA E60730-1 and/or the applicable Part 2 standard from the UL or CSA 60730-1 series fulfills these requirements.

Exception No. 2: This requirement does not apply to a motor speed control that complies with UL 991, UL 60730-1, CAN/CSA E60730-1 and/or the applicable Part 2 standard from the UL or CSA 60730-1 series.

26.25 A permanently connected motor employing a factory wired component solid-state speed control shall include a positive marked “off” position provided by an air-gap-type switch that complies with the applicable requirements in UL 20, UL 1054, UL 61058-1A, or the equivalent, and CSA 22.2 No. 14, CSA 22.2 No. 24, and CSA 22.2 No. 55. This marking shall be represented by the word “off”, the symbol “O”, or a visual indicator.

Exception No. 1: An air-gap-type switch is not required when the factory wired solid state speed control de-energizes all circuits that involve open circuit potentials in excess of 30 V ac (42.4 V peak), and where the continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 mA.

Exception No. 2: Electromechanical relays complying with UL 508 and CSA 22.2 No. 14 provide equivalent air gap isolation to meet the above requirement.

27 Transformers

27.1 Transformers intended to supply Class 2 circuits shall have no electrical connection, other than electromagnetic induction, between the Class 2 secondary circuit and the primary circuit.

27.2 A transformer, or combination of transformer and fixed impedance, as the source of supply of a Class 2 circuit, and intended for connection to Class 2 open wiring, shall be subjected to an output test with the primary energized at full rated voltage. Under any noncapacitive conditions of loading from no load to the short circuiting of any or all secondary terminals, and without disturbing internal connections, the secondary output current shall be not greater than that permitted for a Class 2 transformer.

27.3 A transformer (including an autotransformer), other than that described in Clauses 27.9 and 27.10 shall

a) be provided with thermal overload protection in accordance with the requirements of Clause 27.5; or

b) be protected by an overcurrent device in accordance with the requirements of Clause 27.6; or

c) comply with the Transformer burnout test, Clause 65.

Exception No. 1: A transformer rated less than 50 VA that supplies only a motor control circuit and is located in the same enclosure as the motor controller and is protected by primary overcurrent devices, impedance limiting means, or other inherent protective means need not comply with this requirement.

Exception No. 2: A transformer need not comply with items (a) – (c) of Clause 27.3 where the transformer is located in an outdoor section within a double enclosure, e.g. a control box that complies with Clause 6.1, plus an outer cabinet that complies with Clause 5.6, without openings and where any smoke generated cannot enter an indoor section.

27.4 If a transformer (with hazardous voltage primary circuit) incorporates a thermal overload protective device, the device shall be arranged to interrupt primary current, and shall limit the temperatures of the transformer windings to those permitted by the particular class of insulation of the transformer windings when tested in accordance with the Transformer – Overload Test, Clause 66.

Exception: If the thermal overload protective device is a nonrenewable thermal cutoff type, the burnout test of Clause 65 rather than the overload test of Clause 66 shall be conducted to determine compliance with this requirement.

27.5 A thermal cutoff shall comply with CSA C22.2 No. 209 and UL 60691. A manual or automatic resetting thermal protector shall have an endurance rating of not less than 6000 cycles, and shall comply with CSA C22.2 No. 24 and UL 873 or with the UL 60730-1 and UL 60730-2-9 or with CSA E60730-1, and CSA E60730-2-9, pertaining to the calibration of temperature-limiting controls.

27.6 If a transformer having a hazardous voltage primary is protected by an overcurrent device, such protection shall comply with the requirements specified in Clauses 27.7, 27.8, 27.11, and 27.13.

27.7 Except as noted in Clause 27.8, a transformer having a hazardous voltage primary shall be protected by an overcurrent device (or devices) located in the primary circuit, and rated or set as indicated in Table 27.1. See Clause 27.11.

Exception: If the rated primary current of the transformer is 9 A or more, and 125% of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used.

Table 27.1
Rating of overcurrent device

Rated primary current, A	Maximum rating of overcurrent device, percent of transformer primary current rating
Less than 2	300[a]
2 or more, less than 9	167
9 or more	125

[a] Does not apply to autotransformer; may be increased to 500% if transformer supplies a motor control circuit.

27.8 If the circuit supplying a transformer other than an auto transformer is provided with overcurrent protection rated or set at not more than 250% of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit, provided that the secondary circuit is protected at not more than 125% of the rated secondary current of the transformer. See Clause 27.12.

Exception No. 1: If the rated secondary current of the transformer is 9 A or more, and 125% of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used in the secondary circuit.

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

27.9 Except as indicated in Clause 27.10, a transformer having a rated output of not more than 30 V and 100 VA shall be protected by an overcurrent device located in the primary circuit. The overcurrent device shall be rated or set at not more than 167% of the primary current rating of the transformer. See Clause 27.11.

27.10 If the transformer is Class 2, compliance with Clause 27.9 is not required.

27.11 Overcurrent protection in the primary circuit of a transformer, as described in Clauses 27.7 and 27.9, need not be provided if, based on the marked ratings of the equipment, the rating of the branch circuit overcurrent protective device does not exceed the values specified in Clause 27.7 or 27.9, as applicable.

27.12 Overcurrent protection in the secondary circuit of a transformer, as required by Clause 27.8, shall be provided as part of the equipment.

27.13 A required transformer overcurrent protective device shall be provided as specified in Clause 32.7.

27.14 With reference to Clause 27.13, the fuses need not be provided when the fuseholder is factory-installed in the product and if the fuse ratings are marked as specified in Clause 45.3(a).

27.15 The secondary of a transformer supplying power to extra-low-voltage circuits shall be grounded if (see Clause 32.4)

a) the primary is energized from a source rated at more than 150 volts-to-ground; or

b) it supplies power to a control circuit that is a safety circuit.

28 Capacitors

28.1 Capacitors shall be within a suitable enclosure or container made of sheet metal or some other suitable material.

28.2 Oil filled motor running capacitors and dry-film protected type running capacitors shall comply with the testing requirements of UL 810 and CSA 22.2 No. 190.

28.3 Electrolytic types of motor starting capacitors shall comply with the requirements of supplement SA of UL 810.

28.4 A separate enclosure for a capacitor is not required if the capacitor is adequately protected against damage by the outer enclosure of the unit. If the metal shell of a capacitor complies with the applicable

requirements of Table 6.1 or Table 6.2, an additional enclosure is not required, provided that the terminals are suitably enclosed.

28.5 Paper capacitors shall be impregnated or otherwise enclosed to exclude moisture.

28.6 A capacitor employing a liquid dielectric medium shall be protected against expulsion of the dielectric medium when tested in accordance with Clause 46.1, including faulted overcurrent conditions based on the circuit in which it is used. (See Clause 64.1.)

Exception: If the available fault current is limited by other components in the circuit, such as a motor-start winding, the capacitor may be tested using a fault current less than the value specified in Table 64.1 but no less than the current found by dividing the rated circuit voltage by the impedance of the other components.

29 Electric crankcase heaters

29.1 An electric crankcase heater assembly shall be constructed of materials suitable for the temperatures to which it may be subjected in the unit.

29.2 The heater element may be enclosed in metallic sheathing or may be resistance wire insulated to comply with these requirements, so as to be protected against damage in its intended, normal use. Metallic enclosed heater elements may be insulated from the sheath with magnesium oxide, porcelain beads, or other materials having heat-resisting properties.

29.3 To comply with Clause 29.1, a heater case or a terminal seal of rubber or thermoplastic materials shall have suitable aging properties for temperatures measured during heating tests.

29.4 If moulded seal caps are provided, the wall thickness of material covering splice connections shall be equivalent to the required minimum thickness of insulation on the heater leads.

29.5 Metal tubing forming a heater element enclosure shall be constructed of corrosion-resistant material, or shall be plated, dipped, coated, or otherwise treated to resist external corrosion, and shall be suitable for the temperatures to which it is subjected.

29.6 Uncoated copper tubing may be used for temperatures of 200°C (392°F) and lower; metallic coated copper tubing is acceptable for temperatures below the melting temperatures of the coating. Uncoated or oxide-coated steel tubing is not acceptable as a crankcase heater sheath. Plated steel tubing may be employed if the plating is determined to be corrosion resistive, and will withstand the temperatures to which it may be subjected. Aluminum tubing may be employed if the alloy withstands a burnout test without melting or other breakdown. Stainless steel tubing such as ASTM type 304 is acceptable for crankcase heater sheaths.

30 Electric heaters

30.1 An electric heater intended to be used with a unit shall be tested with the unit in accordance with these requirements.

30.2 A heating element shall be supported in its intended position in a substantial and reliable manner and shall be protected against mechanical injury and contact with outside objects. In determining if a heating element complies with this requirement, consideration shall be given to sagging, loosening, and other similar conditions resulting from

a) continuous heating of the element; and

b) flexing of the element supports or related wiring due to alternate heating and cooling of the element.

30.3 Heating elements shall be so supported that, even if heaters are subjected to extreme conditions of operation, including the tests specified in Clause 54, short circuits cannot occur between turns, between sections of the heating elements, or between uninsulated live parts and non-current-carrying metal parts, and the spacings of Table 33.2 and Table 33.3 are maintained.

30.4 Coiled wire heating elements may be supported on porcelain, hook type insulators depending upon the stiffness of the coil, the spacing between hooks, and the shape of the hook, etc. Porcelain insulators of all types will normally be required to be retained in place by means other than the heating element.

30.5 Heating elements shall be securely fastened to terminals (under the heads of terminal binding screws) in such a manner that the wire is not be likely to become loosened during the lifetime of the heater.

30.6 If an auxiliary control device, such as a thermostat, or a combination thermostat and control switch in a product with electric heat or remote control assembly, has a marked ON or OFF position, or is marked with another wording or symbol, such as “NO HEAT, COLD, O,” or similar wording, that conveys the same meaning as “OFF”, it shall disconnect the element or elements and controls from all ungrounded conductors of the supply circuit when placed in that position. This requirement applies to a thermostat in a remote control assembly that is referred to on the product nameplate, but does not apply to a remote auxiliary control device in a Class 2 circuit such as a room thermostat.

30.7 An auxiliary control is considered to be one that is intended primarily for regulating time, temperature, etc, under conditions of intended operation, but is not intended for protection against overload or excessive temperature conditions, etc.

30.8 Electric heaters employing resistance-type heating elements intended for comfort heating shall be protected at not more than 60 A, and the protected circuit shall not have a concurrent load exceeding 48 A. These heating elements shall be connected in protected subdivided circuits if any total concurrent load of the unit exceeds 48 A based on nameplate ratings. If the overcurrent protective devices are in a separate assembly for independent mounting, as described in Clause 30.9, the rating of the overcurrent protective devices also shall not exceed 1.5 times the current rating of the connected load, if such rating is more than 16.7 A.

Exception: If a heater assembly is provided with means for field connection to a power supply for only the resistance-type elements, with or without their control circuit, in a wiring enclosure having a separate cover and physically separated from the power supply for other loads, the rating of the other loads need not be considered in applying this requirement.

30.9 The overcurrent protective devices for subdivided circuits, as required by Clause 30.8, may be provided by the product manufacturer as a separate assembly for independent mounting.

30.10 The overcurrent protection specified in Clauses 30.8 and 30.9 shall be circuit breakers, cartridge fuses, or type S plug fuses, of a type and rating appropriate for branch circuit protection, in accordance with the requirements of CSA C22.1 and ANSI/NFPA No. 70.

30.11 An electric heater shall be equipped with one or more automatically resetting temperature-limiting controls that will disconnect the heating element or elements from the supply circuit to prevent temperatures from exceeding the limits specified in Table 46.5. These temperature-limiting controls shall be factory-installed as an integral part of the heater.

30.12 The temperature-limiting controls shall comply with the applicable requirements of CSA C22.2 No. 24 and UL 353.

30.13 A safety control or a temperature-limiting control intended to prevent heater operation that can result in risk of fire, electric shock, or injury to persons shall be operative whenever the heater is connected to its power supply, and shall interrupt operation of a sufficient number of heating elements to prevent temperatures from exceeding applicable temperature limits.

30.14 A unit employing an automatically resetting temperature-limiting control shall interrupt the power supply to the heater by direct means or by means of a single magnetically operated relay device or contactor that complies with the requirements for the endurance test for the limit control.

30.15 Contactors and sequence controls, such as thermal relays or mechanical step controls, used to control one or more sections of the heater element load, shall be able to withstand 100,000 cycles of making and breaking the load controlled.

30.16 All contactors and sequence controls that are used on open electric heaters shall break all ungrounded conductors. Phase break on three phase heaters shall not be permitted. Where silicon controlled rectifiers (SCR's) are used, the safety contactor shall break all ungrounded conductors.

30.17 A unit employing electric heaters shall be provided with one or more manually resettable or replaceable backup protective devices of the type specified in Clause 30.18 that will, with the contacts of the automatically resetting temperature-limiting control permanently closed, limit the temperatures to comply with the requirements specified in the Backup protection tests – Clause 55.

30.18 The manually resettable or replaceable protective devices specified in Clause 30.17 shall be functionally independent of the automatically resetting temperature-limiting control. The following types of controls comply with this requirement:

a) One or more thermal cutoffs, nonresettable temperature-limiting controls, or manually resettable limit controls connected to open a sufficient number of ungrounded conductors to permit the unit to comply with the specified temperature limits.

b) A combination consisting of one or more normally open switching device(s) and thermal cutoffs, nonresettable limit controls, or manually resettable limit controls. The thermal cutoff or limit control shall be connected in the coil circuit of the switching device. The combination shall be integral with the product; be able to open a sufficient number of ungrounded supply conductors to permit the product to comply with the specified temperature limits; and be independent of control by an automatic cycling device with the unit.

30.19 The backup protection specified in Clause 30.17 is required for a product employing an electric heater that incorporates a switching device whose coil circuit is controlled by both the automatically resetting temperature-limiting control and a temperature-regulating control for the heater

30.20 A thermal cutoff or nonresettable limit control shall be secured in place and located so that it will be accessible for replacement without damage to other connections or internal wiring, in compliance with Clauses 30.22 and 30.24.

30.21 A thermal cutoff or nonresettable limit control shall comply with the requirements of the Backup protection tests, specified in Clause 55.

30.22 Replacement of a thermal cutoff or nonresettable limit control shall not necessitate any of the following:

a) Removal of the unit or heater assembly from its installation, except as specified in Clause 30.23;

b) Disconnection of the field wiring systems;

c) Stretching or similar displacement of the heater element wire that could cause permanent displacement or distortion to the extent that the performance of the heater could be affected; or

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

Exception: A thermal cutoff or nonresettable limit control that is not required in order to comply with any of the requirements in this standard need not comply with Items (a) and (b).

30.23 With reference to the requirements of Item (a) of Clause 30.22, removable heating elements or an element assembly may be withdrawn, or a heater may be partially withdrawn, to replace a thermal cutoff or nonresettable limit control, if withdrawal will not result in noncompliance with the requirements of Items (b), (c), and (d) of Clause 30.22.

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

30.25 A thermal cutoff or nonresettable limit control shall not function during any test performed on a product employing electric heaters, when the automatically resettable limit control is connected in the circuit.

30.26 Sequence controls, such as thermal relays or mechanical step controls, used to control one or more sections of the heater element load, shall be able to withstand 100,000 cycles of making and breaking the load controlled, unless the unit is capable of withstanding required tests without sequence controls.

31 Receptacles

31.1 Unless intended to be connected to a power supply separate from that supplying other loads, each receptacle intended for general use shall be rated at 15 or 20 amperes, 125 or 250 volts. Each general or special use receptacle shall be of the grounding type and shall comply with the applicable requirements of CSA-C22.2 No. 42 and UL 498.

31.2 Overcurrent protection shall be provided as part of the equipment for each receptacle included in the equipment unless:

a) The receptacle is intended to be connected to a power supply separate from that supplying the equipment;

b) The equipment can be connected to a branch circuit rated at not more than 15A or 20A in accordance with CSA C22.1 or ANSI/NFPA No. 70; or

c) The receptacle is intended for use only with specific accessories.

31.3 Receptacles connected to the line side of a unit disconnect shall have a separate disconnect

31.4 When installed on equipment for outdoor use, in addition to complying with the rain test in Clause 74 the service receptacle shall comply with installation requirements in CSA C22.1 and ANSI/NFPA No. 70 insofar as they apply, including:

a) A 125 or 250 V, single-phase, 15 or 20 A receptacle intended for general use shall have a ground-fault circuit-interrupter (GFCI). The GFCI shall comply with C22.2 No. 144 and UL 943.

b) Unless subjected to the rain test of Clause 74 125 or 250 V, single-phase, 15 or 20 A receptacles installed in wet locations shall have an enclosure that is weatherproof whether or not the attachment plug is inserted, and all 125 or 250 V, single-phase, 15 or 20 A non-locking receptacles shall be weather-resistant types.

32 Control circuits

32.1 For the purpose of these requirements, a direct connected, hazardous voltage control circuit is one 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 of the controlled circuits within the equipment.

32.2 For the purpose of these requirements, a control circuit is one that carries electric signals directing the performance of a controller which, in turn, governs power delivered to a motor or other load in the equipment. A control circuit does not carry main power current. A tapped, hazardous voltage control circuit is one that is tapped within the equipment from the load side of the overcurrent device for the controlled load.

32.3 A control circuit is considered to be a safety circuit if it includes contacts of any controls integral with, or external to, the equipment that are intended to prevent unsafe operation of the equipment due to circuit wiring becoming grounded, open circuited, or short circuited, such as

a) a device to prevent overheating of a motor due to overload (including locked rotor);

b) a temperature limit switch, the failure of which to operate might result in an unsafe operation; or

c) a pressure-limiting device in a refrigerating system, the failure of which to operate might result in an unsafe condition.

Exception: A control circuit having a pressure-limiting device is not considered to be a safety circuit unless the pressure-limiting device is required by Clauses 34.29 through 34.32 and all parts of equipment subjected to refrigerant pressures have sufficient strength as required by Clause 34.4.

32.4 In a control circuit that is a safety circuit, the contacts of a safety device shall be connected in the ungrounded side of the control circuit. If the control circuit is derived from an external voltage source the control circuit shall

a) be grounded within the unit; or

b) be marked to caution that the side of the control circuit employing the safety device shall not be grounded.

32.5 Conductors of hazardous voltage control circuits shall be provided with overcurrent protection. The rating of the overcurrent protective device or devices shall not exceed the applicable values specified in Table 32.1.

Exception No. 1: Conductors of 18, 16, and 14 AWG that do not exceed 1.2 m (4 ft) in length between points of opposite polarity may be protected by overcurrent protective devices rated 60 A or less.

Exception No. 2: An overcurrent protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in the Limited Short-Circuit Test, Clause 64.

Exception No. 3: A lead 305 mm (12 in) or less in length need not be provided with overcurrent protection.

Exception No. 4: A control circuit conductor supplied from the secondary of a single-phase transformer that is connected so that only a two-wire (single voltage) secondary is used may be protected by an overcurrent device located on the primary side of the transformer, provided that this protection is in accordance with requirements specified in Clause 27, Transformers, and that the rating of the device does not exceed the applicable values specified in Table 32.1 multiplied by the ratio of secondary to primary rated transformer voltage.

Exception No. 5: A control circuit conductor that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Tables 1 through 4 in CSA C22.1 and Column A of Table 430-72(b) of ANSI/NFPA No. 70. The correction factors of the referenced Tables need not be applied.

Table 32.1
Overcurrent protective device rating for control circuit conductors

Maximum rating of overcurrent protective device, A				
Tapped control circuit conductor size, mm² (AWG)	Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
	Copper	Aluminum[a]	Copper	Aluminum[a]
0.82 (18)	25	–	5	–
1.3 (16)	40	–	10	–
2.1 (14)	100	–	45	–
3.3 (12)	120	100	60	45
5.3 (10)	160	140	90	75
Larger than 5.3 (10)	b	b	c	c

[a] Includes copper-clad aluminum.

[b] 400% of value specified for 60°C conductors in Table 1 of CSA C22.1 and Table 310-17 of ANSI/NFPA No. 70. The correction factors of the referenced Table need not be applied.

[c] 300% of value specified for 60°C conductors in Table 2 of CSA C22.1 and Table 310-16 of ANSI/NFPA No. 70. The correction factors of the referenced Table need not be applied.

32.6 Overcurrent protection for a conductor of a hazardous voltage control circuit, as required by Clause 32.5, shall be provided as part of the equipment, if, based on the marked rating of the equipment, the rating of the branch circuit overcurrent protective device exceeds the applicable values specified in Table 32.1.

Exception: If the unit employs a direct-connected hazardous voltage circuit, and the overcurrent protective devices are not provided as part of the unit, the unit shall be marked to specify the maximum size of overcurrent device for the unit. The type of overcurrent protection shall be specified in the marking.

32.7 Overcurrent protective devices shall be provided for all ungrounded conductors, and have a voltage rating not less than the circuits in which they are used.

The devices shall be either a circuit breaker or a fuse suitable for branch circuit protection such as HRCI-J, -R,-T,-L, or HRCII-C, or Class CC, G, H, J, K, L, R, T,or a Type S plug fuse.

Exception: If the control circuit is tapped from a circuit supplying other loads in the equipment, a device used for overcurrent protection may be of the supplementary type (a type other than indicated for branch circuit protection), provided that it has a interrupting rating acceptable as specified on Table 64.1 for the circuit in which it is used. See Clause 45.3 for fuse replacement marking.

32.8 Fuses shall comply with UL 248-1 Low-Voltage Fuses – Part 1, General Requirements and CAN/CSA-C22.2 No. 248.1-00 Low-Voltage Fuses – Part 1, General Requirements and one of the following standards:

a) UL 248-2 Low-Voltage Fuses – Part 2, Class C Fuses and Low-Voltage Fuses – Part 2, Class C Fuses CAN/CSA-C22.2 No. 248.2 or;

b) Low-Voltage Fuses – Part 3, Class CA and CB Fuses UL 248-3 Low-Voltage Fuses – Part 3, Class CA and CB Fuses and CAN/CSA-C22.2 No. 248.3 or;

c) Low-Voltage Fuses – Part 4, Class CC Fuses UL 248-4 Low-Voltage Fuses – Part 4, Class CC Fuses and CAN/CSA-C22.2 No. 248.4 or;

d) UL 248-5 Low-Voltage Fuses – Part 5, Class G Fuses and CAN/CSA-C22.2 No. 248.5 Low-Voltage Fuses – Part 5, Class G Fuses or;

e) UL 248-6 Low-Voltage Fuses – Part 6, Class H Non-Renewable Fuses and CAN/CSA-C22.2 No. 248.6 Low-Voltage Fuses – Part 6, Class H Non-Renewable Fuses or;

f) UL 248-7 Low-Voltage Fuses – Part 7, Class H Renewable Fuses and CAN/CSA-C22.2 No. 248.7 Low-Voltage Fuses – Part 7, Class H Renewable Fuses or;

g) UL 248-8 Low-Voltage Fuses – Part 8, Class J Fuses and CAN/CSA-C22.2 No. 248.8 Low-Voltage Fuses – Part 8, Class J Fuses or;

h) UL 248-9 Low-Voltage Fuses – Part 9, Class K Fuses and CAN/CSA-C22.2 No. 248.9 Low-Voltage Fuses – Part 9, Class K Fuses or;

i) UL 248-10 Low-Voltage Fuses – Part 10, Class L Fuses and CAN/CSA-C22.2 No. 248.10 Low-Voltage Fuses – Part 10, Class L Fuses or;

j) UL 248-11 Low-Voltage Fuses – Part 11, Plug Fuses and CAN/CSA-C22.2 No. 248.11 Low-Voltage Fuses – Part 11, Plug Fuses or;

k) UL 248-12 Low-Voltage Fuses – Part 12, Class R Fuses and CAN/CSA-C22.2 No. 248.12 Low-Voltage Fuses – Part 12, Class R Fuses or;

l) UL 248-13 Low-Voltage Fuses – Part 13, Semiconductor Fuses and CAN/CSA-C22.2 No. 248.13 Low-Voltage Fuses – Part 13, Semiconductor Fuses or;

m) UL 248-14 Low-Voltage Fuses – Part 14, Supplemental Fuses and CAN/CSA-C22.2 No. 248.14 Low-Voltage Fuses – Part 14, Supplemental Fuses or;

n) UL 248-15 Low-Voltage Fuses – Part 15, Class T Fuses and CAN/CSA-C22.2 No. 248.15 Low-Voltage Fuses – Part 15, Class T Fuses or;

o) UL 248-16 Low-Voltage Fuses – Part 16, Test Limiters and CAN/CSA-C22.2 No. 248.16 Low-Voltage Fuses – Part 16, Test Limiters

32.9 Where the equipment has part of a control circuit included within it, and is intended to have the circuit completed at the time of installation by external wiring to a safety device located outside the equipment, the equipment shall be marked to show that the external wiring is to comply with the requirements for a Class 1 circuit. See Clause 26.19.

32.10 Fuseholders shall comply with the UL 4248 Series of Standards for Fuseholders or the CSA CAN/CSA-C22.2 No. 4248 Series of Standards for Fuseholders.

32.11 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures, UL 489, or CAN/CSA-C22.2 No. 5.

33 Spacings

Hazardous Voltage Circuits

33.1 In circuits up to and including 750 V, the spacings between an uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded part other than the outer enclosure, an exposed metal part that is isolated (insulated), or the outer enclosure shall be not less than as specified in Table 33.2 and Table 33.3.

33.2 The spacings between uninsulated live parts of opposite polarity, and between uninsulated live parts and grounded non-current-carrying metal parts, of circuits greater than 750 V shall be not less than those specified in Table 33.1.

Table 33.1
Spacings for hazardous voltage circuits

Voltage range, V	Minimum spacing, mm (in)	
	Through air	Over surface
751 – 1000	10 (3/8)	13 (1/2)
1001 – 2000	19 (3/4)	34 (1-3/8)
2001 – 3000	25 (1)	50 (2)
3001 – 5000[a]	63 (2-1/2)	75 (3)
3001 – 5000[b]	82 (3-1/4)	100 (4)
5001 – 7200[a]	75 (3)	88 (3-1/2)
5001– 7200[b]	100 (4)	125 (5)

[a] Between uninsulated live parts and grounded non-current-carrying metal parts.

[b] Between uninsulated live parts of opposite polarity.

33.3 The spacings on the components in the control system, which are derived from a current transformer sensing the motor compressor current, shall be judged on the basis of the maximum available voltage at the component with the motor-compressor operating at rated load current. See Clause 33.4.

33.4 Provision shall be made for limiting the voltage in the control assembly (see Clause 33.3) resulting from an open secondary circuit of a remote current transformer to a voltage for which the control components in this circuit are acceptable. The open secondary circuit may result from an open remote shunt resistor or from a disconnected or broken conductor at the connection to the control circuit.

Table 33.2
Minimum spacings at locations other than electric heating elements

Rating[d]		Minimum spacing mm (in)					
		Through air,		Over surface[e]		To enclosure[a]	
VA	Volts	mm	in	mm	in	mm	in
0 – 2000	0 – 300[b]	3.2	1/8	6.3	1/4	6.3	1/4
More than 2000	0 – 150	3.2[c]	1/8	6.3	1/4	12.5	1/2
	151 – 300	6.3	1/4	9.5	3/8	12.5	1/2
	301 – 750	9.5	3/8	12.5	1/2	12.5	1/2

[a] These spacings do not apply to an individual enclosure of a component part within an outer enclosure or cabinet.

[b] If over 300 V, the spacings in the last line of the Table apply.

[c] The spacings between wiring terminals of opposite polarity or between a wiring terminal and ground shall be not less than 6.3 mm (1/4 in), except that if short circuiting or grounding of such terminals will not result from projecting strands of wire, the spacing need not be greater than that given in the above Table. Wiring terminals are those connected in the field and not factory-wired.

[d] The spacings at an individual component part shall be judged on the basis of the total measured volt-ampere consumption of the load or loads which the components control. For example, a component that controls the compressor motor shall be judged on the basis of the measured volt-amperes of the compressor motor. A component that controls loads in addition to the compressor motor shall be judged on the basis of the sum of the volt-amperes of the loads so controlled, except that in a component that independently controls separate loads shall be judged on the basis of the volt-amperes of the larger load. The volt-ampere values for the load referred to above shall be determined by the marked rating of the load; except that for loads that are not required to have a marked rating, the measured input shall be used in determining the volt-ampere values.

[e] The over surface spacings for glass-insulated terminals of motors may be 3.2 mm (1/8 in) where 6.3 mm (1/4 in) is specified in the Table; and may be 6.3 mm (1/4 in) where 9.5 mm (3/8 in) is specified.
Exception No. 1: The spacings of motor terminals inside a hermetic motor enclosure may be one-half of those indicated in the Table, except that the over surface spacings may be 2.4 mm (3/32 in) where 6.3 mm (1/4 in) is specified.
Exception No. 2: The above spacing requirements do not apply to the inherent spacings (internal) of a component part of the unit for which spacing requirements have been judged on the basis of the component standard.
Exception No. 3: At closed-in points only, such as the screw and washer construction of an insulated terminal mounted in metal, a spacing of not less than 1.2 mm (3/64 in) is acceptable, if the potential involved is 300 V or less, and a spacing of not less than 6.4 mm (1/4 in) is acceptable if the potential is 300–750 V.
Exception No. 4: The spacings "to enclosure" shall not be applied to an individual enclosure of a component within an outer encounter or cabinet.

Table 33.3
Minimum spacings at electric heating elements[a,c]

Description of spacing	Potential involved, V	Spacing	
		mm	in
Between uninsulated live parts of opposite polarity; and between an uninsulated live part and a dead metal part, other than the enclosure, that either is exposed to contact by persons or may be grounded	0 – 250	1.6	1/16
	251 – 600	6.4[b]	1/4[b]
Between a live part and the enclosure	0 – 600	6.4	1/4

[a] These spacings are applicable only to parts of the heating element and its terminals located inside the conditioned (heated or cooled) air handling compartment. If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum spacing is maintained under all operating conditions and under all normal conditions of handling. Spacings at a thermal cutoff shall comply with Table 33.2.

[b] A spacing of not less than 1.6 mm (1/16 in) is permissible at a heating element rated for 300 V or less.

[c] Metal-sheathed heater elements that have spacings at terminations between live parts and noncurrent-carrying metal parts less than 3.2 mm (0.13 in) (6.3 mm (0.25 in) for 300 – 600 V), but not less than 1.6 mm (0.06 in) (3.2 mm (0.13 in) for 300 – 600 V) shall be sealed against moisture.

33.5 If higher than rated potential is developed in a motor circuit through the use of capacitors, the rated voltage of the system shall be assumed for the evaluation of spacings. However, if the developed steady state potential determined under normal operating conditions exceeds 500 V, the developed potential shall be used in evaluating spacings for the parts affected.

33.6 An insulating liner or barrier of vulcanized fibre, varnished cloths, mica, phenolic composition, or similar material employed where spacings would otherwise be insufficient shall be not less than 0.7 mm (0.028 in) thick.

Exception No. 1: A liner or barrier not less than 0.3 mm (0.013 in) thick may be used in conjunction with an air spacing of not less than 1/2 of the through air spacing required. The liner shall be located so that it will not be oxidized or otherwise deteriorated by arcing.

Exception No. 2: Insulating material less than 0.7 mm (0.028 in) thick may be used, if it has insulating, physical, and flammability properties equivalent to those of the materials specified in the above Clause.

Extra-Low-Voltage Safety Circuits

33.7 For an extra-low voltage safety circuit (including Class 2), if operation of the product with a short circuit or grounded circuit may result in unsafe operation of the controlled device, spacings shall be as follows:

a) The spacing between uninsulated live parts and the walls of a metal enclosure, including conduit fittings, etc, shall not be less than 3.2 mm (1/8 in);

b) The spacing between wiring terminals intended for connection of hazardous voltage circuit wiring, irrespective of polarity, and between wiring terminals and metal parts (including the enclosure) that may be grounded when the device is installed, shall be not less than 6.3 mm (1/4 in); and

c) The spacing between uninsulated live parts, irrespective of polarity, and between uninsulated live parts and metal parts, other than the enclosure, which may be grounded when the device is installed, shall be not less than 0.8 mm (1/32 in) provided that the parts are constructed in such a way that spacings are maintained.

33.8 No spacings are specified for Class 2 circuits not used as safety circuits.

34 Refrigerant, hot water, and steam coils

General

34.1 Refrigerant-containing components shall comply with the following:

a) they shall be constructed of corrosion-resistant material, or shall be plated, dipped, coated, or otherwise treated to resist external corrosion and;

b) except as stated in Item (c), tubing used to connect refrigerant-containing components shall comply with the minimum wall thickness requirements of Table 34.1 and with the strength requirements of Clause 34.3 and;

c) tubing used in the construction of refrigerant-containing components, such as an evaporator or condenser coil, that is adequately protected by the inherent construction shall comply with the strength requirements specified in Clause 34.3.

34.2 Refrigerant-containing components that comply with the Standard for Nonelectrical Refrigerant-Containing Components and Accessories, UL 207, and the Standard for Refrigerant-Containing Components for Use in Electrical Equipment, CSA C22.2 No. 140.3, meet the requirements of (a), (b), and (c).

Table 34.1
Tubing wall thickness

Minimum wall thickness,[a] mm (in)							
Outside diameter		Copper				Steel	
		Protected		Unprotected			
4.76	(3/16)	0.62	(0.0245)	0.67	(0.0265)	0.64	(0.025)
6.35	(1/4)	0.62	(0.0245)	0.67	(0.0265)	0.64	(0.025)
7.94	(5/16)	0.62	(0.0245)	0.72	(0.0285)	0.64	(0.025)
9.53	(3/8)	0.62	(0.0245)	0.72	(0.0285)	0.64	(0.025)
12.70	(1/2)	0.62	(0.0245)	0.72	(0.0285)	0.64	(0.025)
15.88	(5/8)	0.80	(0.0315)	0.80	(0.0315)	0.81	(0.032)
19.05	(3/4)	0.80	(0.0315)	0.98	(0.0385)	0.81	(0.032)
22.23	(7/8)	1.04	(0.0410)	1.04	(0.0410)	1.17	(0.046)
25.40	(1)	1.17	(0.0460)	1.17	(0.0460)	1.17	(0.046)
28.58	(1-1/8)	1.17	(0.0460)	1.17	(0.0460)	1.17	(0.046)
31.75	(1-1/4)	1.28	(0.0505)	1.28	(0.0505)	1.17	(0.046)
34.93	(1-3/8)	1.28	(0.0505)	1.28	(0.0505)	1.17	(0.046)
38.10	(1-1/2)	1.41	(0.0555)	1.41	(0.0555)	1.58	(0.062)
41.3	(1-5/8)	1.410	(0.0555)	1.410	(0.0555)	1.58	(0.062)
54.0	(2-1/8)	1.626	(0.0640)	1.626	(0.0640)	–	–
66.7	(2-5/8)	1.880	(0.0740)	1.880	(0.0740)	–	–

[a] Nominal wall thickness of tubing shall be greater than the thickness indicated to maintain the minimum wall thickness.

Note: "Protected" implies that the tubing is shielded by the cabinet or assembly, to the extent that unintended damage caused by objects such as tools falling on or otherwise striking the tubing during handling and after installation of the unit is prevented. This protection may be provided in the form of baffles, channels, flanges, perforated metal, or equivalent means. If a cabinet is employed for the intended installation of a unit, the tubing is considered shielded. Tubing not so shielded is considered to be unprotected with respect to Table 34.1.

34.3 All parts of equipment subject to a refrigerant pressure shall have sufficient strength to withstand the pressure test requirements specified in the Strength test, Clause 70. The test pressure shall be the higher of:

a) Three times the maximum normal working pressure, see Clause 34.8,

b) Three times the maximum abnormal pressure, see Clause 34.10, or

c) Three times the minimum design pressure specified in Table 85.1.

Exception No. 1: Pressure vessels that comply with Clause 34.6.

Exception No. 2: Pressure gauges and control mechanisms.

Exception No. 3: A part or a complete system that complies with Clause 71.

Exception No. 4: Liquid chillers employing centrifugal motor compressors shall have sufficient strength to withstand without failure a pressure equal to not less than three times the maximum normal working pressure, or three times the minimum design pressure specified in Table 85.1, whichever is greater.

Exception No. 5: High-side parts in a carbon dioxide (R-744) transcritical refrigeration system equipped with a pressure relief or pressure limiting device set at no higher than the design pressure, shall have an

ultimate strength not less than 3 times the high-side design pressure if the high-side design pressure of a carbon dioxide (R-744) transcritical refrigeration system equipped with a pressure relief or pressure limiting device in accordance with 34.2 is not less than 140 Bar (2030 psig).

34.4 A water coil operating at more than 93°C (200°F) and a steam coil shall withstand a hydrostatic pressure equal to three times the marked operating pressure, without leakage or rupture, when tested as described in Clause 70.

34.5 A water coil operating equal to or less than 93°C (200°F) shall withstand a hydrostatic pressure equal to 1035 kPa (150 psig) or two times the marked operating pressure, whichever is higher, without leakage or rupture, when tested as described in Clause 70.

34.6 If the equipment includes pressure vessels having an inside diameter over 152 mm (6 in), and having an internal or external design pressure greater than 15 psig (103.4 kPA gauge), they shall comply with CSA B51, and shall be designed, tested, and stamped in accordance with the ASME Unfired Pressure Vessel Code for a design pressure in compliance with the requirements of the Strength test specified in Clause 70.

34.7 The tubing connections of dissimilar metals, such as aluminum and copper, shall be protected against moisture to minimize galvanic action.

34.8 For the purpose of Clause 34.3, the maximum normal working pressure shall be the following:

a) For high side parts, the highest of the following:

1) The maximum condensing pressure when the equipment is operated under the most severe condensing conditions for which it is intended, but in any case for equipment with an air-cooled condenser, at a condenser air inlet temperature of not less than 40°C (104°F), and for equipment with a water-cooled condenser, at condenser water temperatures not less than 26.7°C (80°F) at the inlet and 37.8°C (100°F) at the outlet; and at the most severe evaporator condition for which it is intended, but in any case with air inlet conditions of not less than 26.7°C (80°F) dry bulb, and 19.4°C (67°F) wet bulb;

2) The marked design pressure; or

3) The condensing pressure of water-cooled equipment that does not have a pressure-limiting device if the water flow is stopped; and

b) For low side parts, the highest of the following:

1) The evaporator pressure when the equipment is operated as specified in Item (a)(1); or

2) The vapour pressure of the refrigerant at 21.1°C (70°F); or

3) The evaporator pressure when it is exposed to some temperature above 21°C (70°F) for which it is designed; or

4) The marked design pressure.

c) For intermediate pressure parts on transcritical systems, the marked intermediate design pressure.

34.9 For transcritical systems the maximum normal working pressure is the marked design pressures for each system pressure range.

34.10 The maximum abnormal working pressure shall be as follows:

a) for high side parts, the pressure developed in the fan motor and water failure tests;

Note: This includes any intermediate pressure ranges within a transcritical system.

b) for low side parts, the highest of the following:

1) the pressure that developed in the motor and water failure test(s), including the pressure that results when the compressor is stopped;

2) the rating or setting of a pressure relief or rupture member fitted in the low side; or

3) if the high side operating pressure is limited by a pressure relief valve that is vented into the low pressure side of the system, the value of the low side pressure that results from the action of the pressure relief valve.

34.11 Pressure vessels with a design pressure not exceeding 103 kPa (15 psig) are not required to be designed, tested, and stamped in accordance with CSA B51 and the ASME Unfired Pressure Vessel Code.

34.12 ASME pressure vessels bearing the code U or UM symbol with a working pressure not less than that required by Clause 34.3 are acceptable without test.

Refrigerant Pressure Relief

34.13 Equipment shall have protective means such as a fusible plug, a rupture member, soldered or brazed tubing joints, special terminals, or pressure relief valves, or shall be so constructed that some part of the system will safely relieve the pressure in case of fire.

Exception: A means for relieving pressure is not required on a forced air-cooled condenser in which the only refrigerant-containing component is tubing, and which is not equipped with shutoff valves.

34.14 A pressure vessel having an inside diameter greater than 76 mm (3 inches) but not exceeding 152 mm (6 inches) and having a gross internal volume not exceeding 0.085 m^3 (3 cubic feet) shall be protected by a pressure-relief device(s) that complies with Clause 34.16 if it contains or may contain liquid refrigerant.

34.15 A pressure vessel having an inside diameter greater than 76 mm (3 inches) but not exceeding 152 mm (6 inches) and having a gross internal volume greater than 0.085 m^3 (3 cubic feet) but less than 0.170 m^3 (6 cubic feet) shall be protected by a pressure-relief device(s) that complies with Clause 34.17 if it contains or may contain liquid refrigerant. Fusible plugs shall not be used.

34.16 The requirements for the pressure relief indicated in Clauses 34.14 and 34.15 are:

a) a rupture member or pressure relief valve that will relieve the pressure at not more than 40% of the pressure defined in Clause 34.3, or 40% of the pressure it is capable of withstanding, as determined by the test in Clause 70; or

b) a fusible plug, provided that the critical pressure of the refrigerant used does not exceed the relieving pressure specified in Item (a), and that the saturation pressure of the refrigerant used, at the temperature marked on the plug, does not exceed the relieving pressure specified in Item (a) above. However, the pressure-relief device required in accordance with Clause 34.15 shall not be a fusible plug.

34.17 A pressure vessel having an inside diameter greater than 152 mm (6 inches) mentioned in Clauses 34.6 and 34.12 shall have pressure relief in accordance with ANSI/ASHRAE 15 and CSA B52.

34.18 Constructions that may be acceptable for relieving pressure in case of fire include those indicated in Clause 34.13, as well as gasketed joints and elastomeric insulators for terminals of hermetic compressors.

34.19 A stop valve or shutoff valve shall not be located between any pressure relief device or fusible plug, etc, and the part or parts of the system protected thereby.

34.20 All pressure relief means on pressure vessels shall be connected adjacent to or directly to the pressure vessel or parts of the system protected. Pressure relief devices shall be connected above the liquid refrigerant level and installed to make them accessible for inspection and repair and to protect them from conditions that could cause them to malfunction.

Exception: Fusible plugs may be located either above or below the liquid refrigerant level.

34.21 Rupture members shall burst at a pressure within 5% of the nominal pressure marked on the device, at the temperature with which it is marked, when tested in accordance with Clause 72, Rupture member test.

34.22 Fusible plugs shall operate at a temperature within 5.6°C (10°F) of the marked temperature rating, when tested in accordance with Clause 73.

34.23 A pressure vessel that has an inside diameter greater than 76 mm (3 in) and that cannot contain liquid refrigerant shall be protected by a pressure relief device or fusible plug having sufficient discharge capacity to relieve the pressure developed in the vessel, under fire conditions, and prevented from exceeding a value corresponding to one-third the ultimate strength of the vessel.

34.24 A positive displacement compressor operating at pressures exceeding 103 kPa (15 psig) and having a displacement exceeding 0.02 m^3/s (50 cfm) shall be equipped with a pressure relief device having the capacity and the pressure setting necessary to prevent rupture of the compressor. The pressure relief device shall be located between the compressor and stop valve on the discharge side. Discharge from the device may be vented to the atmosphere or into the low pressure side of the system.

34.25 Pressure relief devices may discharge into the low pressure side of the system, provided that they are not appreciably affected by back pressures, and provided that the low pressure side of the system is equipped with its own pressure relief device. The low side pressure relief devices shall have capacity to protect either the pressure vessels that are relieved into the low pressure side of the system, or all pressure vessels on the low side of the system, whichever relieving capacity is the largest.

34.26 On liquid chillers employing centrifugal motor compressors, the pressure relief device for the high-side pressure vessels may be in the low-side of the system, provided

a) it can be established that the clearances between the capacity control vanes and their housings and other fixed openings between the high-side and low-side are sufficient to provide the relief capacity required for high-side pressure vessels; and

b) the low-side pressure relief device has a relief capacity at least equal to the sum of the capacities required for all pressure vessels on high-side and low-side.

34.27 Calculation of the discharge capacity of a rupture member or fusible plug shall be in accordance with CSA B52 and ANSI/ASHRAE 15.

34.28 A pressure relief valve shall be sealed at a start-to-discharge pressure not exceeding the marked working pressure of the pressure vessel it protects.

Exception: A pressure relief valve for a pressure vessel that does not have a marked working pressure shall be sealed at a start-to-discharge pressure that corresponds to no more than one-fifth of the ultimate strength of the pressure vessel.

34.29 A pressure-relief valve used on equipment intended to utilize carbon dioxide (R744) in a secondary loop or a cascade system and provided with a pressure vessel shall be sealed at a value not less than 3448 kPa (500 psig).

Exception: If the equipment on which the pressure vessel is located does not use a hot gas defrost system, then the pressure-relief valve on the low side may be sealed at not less than 2069 kPa (300 psig).

34.30 A pressure relief valve used on equipment intended to utilize carbon dioxide (R744) in a transcritical system shall be sealed at a value not less than 8273 kPa (1200 psig) on the high side of the system, and a value not less than 3448 kPa (500 psig) on the intermediate pressure side of the system.

34.31 Where the pressure relief means is provided by a rupture member, the nominal rated rupture pressure of the member shall not exceed the marked design pressure of the vessel protected, or one-fifth of the ultimate strength of pressure vessels that do not have a marked design pressure.

34.32 Equipment intended to utilize carbon dioxide (R744) in a secondary loop, cascade, or transcritial system and that may contain a pressure vessel within the R744 loop or system shall be furnished with the following items which are installed as part of the equipment:

a) a pressure-relief valve set to open as indicated in Clause 34.29, and

b) a pressure-regulating relief valve set to operate at no higher than 90 percent of the marked setting of the pressure relief valve.

34.33 Equipment that may contain a pressure vessel within the R744 loop or system is not required to be provided with the pressure-relief or the pressure-regulating relief valve as part of the equipment if the instructions provide the information indicated in item (c) of Clause 4.4 and the equipment is marked according to item (b) of Clause 45.13.

34.34 Equipment intended to utilize carbon dioxide (R744) in a transcritical system is not required to be provided with a pressure regulating relief valve.

34.35 The pressure-regulating relief valve covered by item (b) of Clause 34.32 shall:

a) Be factory set and sealed to prevent changing the relief setting,

b) Be mounted to minimize the likelihood of removal and plugging the opening (e.g., use of a threaded fitting other than the NPT type),

c) Comply with the Regulating Relief Valve Endurance Test, Clause 74, and

d) Have a discharge capacity not less than 20 percent of the marked discharge capacity of a required pressure-relief valve.

34.36 Pressure-regulating relief valves shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII. Valves of 1/2 inch iron pipe size and larger shall bear the authorized code “UV” symbol together with the set pressure and capacity. Valves of less than 1/2 inch iron pipe size shall be similarly marked, except that where the size does not permit a nameplate, the code symbol may be omitted and the set pressure and capacity may be stamped on the valve or on a metal plate attached to it. Manufacturers of valves that do not bear the code symbol shall provide evidence of certification of the valve and its pressure and capacity rating by appropriate code authorities.

Refrigerant Pressure-Limiting Device

34.37 A pressure-limiting device shall be installed on

a) All units that are designed for use in systems containing 10 kg (22 lbs) or more of refrigerant or that employ a receiver or condenser-receiver with a capacity to accept 10 kg (22 lbs) of refrigerant without the liquid occupying more than 90 per cent of the volume when the refrigerant temperature is 32.2°C (90°F);

b) All condensing units that are not subjected to operational tests (where the refrigerant circuit is operated to obtain pressure – See Table 46.1) with a compressor motor rated at more than 1 horsepower (746 W output).

Exception: A pressure-limiting device need not be provided if the condensing unit

1) Is intended for air-conditioning use; and

2) Contains a hermetic refrigerant motor-compressor having a steel shell that is provided with an internal bleeder valve that relieves discharge pressure into the low-pressure side of the refrigerant system.

34.38 A pressure-limiting device shall be installed on all compressor units and compressor-evaporator units.

34.39 The adjustable cutout pressure setting of a pressure-limiting device shall not exceed

a) One-third of the ultimate strength of high side refrigerant containing parts provided this setting does not exceed 90 percent of the setting of the pressure relief device; or

b) 110 percent of the design pressure marking on the unit name plate for units that are (1) not subjected to operational tests (where the refrigerant circuit is operated to obtain pressure – See Table 46.1) or (2) water cooled.

Exception: On liquid chillers employing centrifugal motor compressors, if the pressure relief device is set in the low side of the system, the maximum cutout pressure to which a pressure-limiting device may be readily adjusted by the adjusting means provided may be more than 90 percent but not more than 100 percent of the following, whichever is lowest:

a) Except for ASME Code U-symbol pressure vessels, see Item (b), one-third of the pressure corresponding to the ultimate strength of high-side refrigerant-containing parts; and

b) The marked design pressure of high-side pressure vessels.

34.40 There shall be no stop valves between the pressure-limiting device and the compressor.

34.41 A contactor provided to comply with Clause 34.32 or Clause 34.33, shall be rated for 100,000 endurance cycles.

35 Condensing and compressor units employing flammable refrigerants.

35.1 Condensing units and compressor units intended to be used in a refrigeration system and employing a flammable refrigerant shall comply with Supplement SA of the Standard for Household Refrigerators and Freezers, UL 250, or Supplement SB of the Standard for Commercial Refrigerators and Freezers, UL 471, depending on the application of the product.

36 Heat pump water heating and heat recovery equipment

General

36.1 The following additional requirements apply specifically to heat pump water heating and heat recovery equipment. Such equipment shall also comply with all of the applicable requirements of this Standard.

Heat Exchanger

36.2 Heat exchangers intended for connection to a potable water system shall be of double wall construction and marked in accordance with Clause 45.12(a). Such design shall incorporate either a vented interface or redundant construction to prevent the leakage of refrigerant into potable water.

36.3 Heat exchangers may be of single wall construction provided they are not intended for connection to a potable water system, and shall be marked in accordance with Clause 45.12(b).

36.4 In accordance with Clause 36.2, a vented interface shall be maintained at near atmospheric pressure, with the venting path continuous over the entire length of the heat exchanger. The continuity of the venting path is determined by use of water at a pressure not higher than 62 kPa (10 psig).

36.5 In accordance with Clause 36.2, heat exchangers shall have sufficient strength to withstand a pressure of not less than three times the maximum rated refrigerant design pressure for the refrigerant side, with the water side maintained at atmospheric pressure.

36.6 Heat exchangers shall have sufficient strength to withstand not less than 1-1/2 times the maximum rated design pressure for the refrigerant side, in accordance with a vented interface (Clause 36.2). See Clause 79.15.

36.7 Heat exchangers employing a redundant double wall construction per Clause 36.2 shall have sufficient strength for each separate wall to withstand a pressure of not less than three times the maximum rated refrigerant design pressure with the outer side maintained at atmospheric pressure.

36.8 The water side of a heat exchanger shall have sufficient strength to withstand a pressure of not less than 2.1 MPa (300 psig). See Clause 79.15.

Storage Tank

36.9 Storage tanks shall meet the requirements of CSA C22.2 No. 110 and UL 174.

Water Temperature Control

36.10 A heat pump water heater, desuperheater or heat recovery unit shall be equipped with a water-temperature-regulating control, so that the water in the tank, if supplied by the manufacturer as part of the water heating system, or at the outlet, will not attain a temperature of more than 85°C (185°F).

36.11 In addition to the temperature-regulating control required by Clause 36.10, a water-temperature-limiting control shall be provided to interrupt the electrical supply to the water heating system to prevent the temperature in the tank or at the outlet from exceeding 99°C (210°F), when the equipment is tested under the applicable conditions of Clause 79. This control shall not function under normal conditions as specified in Clauses 79.5 and 79.6.

36.12 Controls limiting water temperature for the heat pump water heater or heat recovery unit shall be temperature- or pressure-actuated and located electrically as specified in Clauses 36.15 and 36.16.

Exception: If the unit complies with the water temperature test as noted in Clause 79.8 when all operating, regulating and limiting controls are bypassed, and the compressor motor is provided with a direct line break overload protector, the construction need not comply with the above.

36.13 Controls shall comply with the applicable requirements for their intended function(s), shall have an endurance rating of not less than 30,000 cycles, and shall comply with CSA C22.2 No. 24 and UL 873 or with UL 60730-1 and UL 60730-2-9 or with CSA E60730-1 and CSA E60730-2-9.

36.14 Controls shall be integral with the equipment, and shall not be designed to be installed in an existing water storage tank that is not supplied as part of the packaged heat pump water heater or desuperheater, or heat recovery unit.

36.15 The temperature-limiting control shall have no operating part in common with the temperature-regulating control mentioned in Clause 36.10.

36.16 If the temperature-limiting control is in the control circuit of a magnetic contactor or relay, such a contactor or relay shall be so wired that it is not actuated by a temperature-regulating control.

36.17 Heat recovery units shall be marked to identify the locations of the water and refrigerant inlet and outlet connections.

36.18 The name and rating plate of a unit that is intended for use with a field-installed auxiliary equipment referred to in Clause 16.11 shall include provisions for marking the current of the field-installed auxiliary equipment.

37 Power supplies

37.1 Power supplies, charge controllers, inverters, converters or other components intended to have a direct PV input or be part of the PV system shall additionally comply with the applicable portions of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741 and CSA C22.2 No. 107.1.

38 Components and subsystems of solar photovoltaic systems

38.1 Electrical components of PV systems shall comply with the relevant requirements for such components described in this standard. In addition, PV components and subsystems shall comply with the requirements below.

38.2 PV modules and cells on heating and cooling equipment or on a frame or other support they have in common shall comply with the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703 and CSA C22.2 No. 61730-1 and CSA C22.2 No. 61730-2 or ULC ORD C1703.

38.3 For units that are provided with crystalline and multicrystalline silicon PV module(s) or cells, the dc voltage correction factor of 1.20 shall be applied to determine maximum PV system voltage.

38.4 Specific open-circuit voltage temperature coefficients for the supplied PV modules or cells may be substituted in place of the 1.20 factor.

38.5 For units with a PV input circuit intended for connection to PV module(s) that are not provided with the unit, the input circuitry and components shall be rated for the maximum input voltage rating of the unit.

38.6 A switch, circuit breaker, or other device shall not be installed in a grounded conductor of a PV system if operation of that device leaves the marked, grounded conductor in an ungrounded and energized state.

38.7 A switch, circuit breaker, or other device, that is part of a ground-fault detection system may be installed in the grounded conductor.

39 Photovoltaic system grounding

39.1 Modules that individually or collectively supply a PV system voltage over 50 volts shall have one conductor solidly grounded at any single point on the PV source output circuit.

39.2 PV systems need not have a grounded conductor if the inverter or charge controller is rated for use with an ungrounded PV array in accordance with UL 1741 and CSA C22.2 No. 107.1.

40 Photovoltaic system ground fault protection

40.1 Inverters, converters or charge controllers with direct photovoltaic dc inputs from an integral module(s) shall be provided with ground-fault protection in accordance with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources, UL 1741 and CSA C22.2 No. 107.1.

40.2 A utility-interactive inverter supplied by a grounded module(s) shall be marked in accordance with Clause 45.20.

40.3 Batteries charged by the PV system supplied by a grounded module(s) shall be marked in accordance with Clause 45.20.

41 Photovoltaic system overcurrent protection

41.1 The PV system shall be provided with overcurrent protection, sized per the PV module over current protection rating, suitable for branch circuit protection, for conductors, inverters, charge controllers, converters and the connected heating and cooling equipment.

41.2 Overcurrent protection is not required for circuit conductors of module(s) integral to the heating and cooling equipment where there are no external sources such as parallel-connected source circuits, batteries, or backfeed from inverters.

41.3 The overcurrent protective device size shall not exceed following:

a) The ampacity of PV source conductors;

b) The PV module over current protection rating; and

c) The maximum overcurrent protective device ratings specified for any charge controllers, converters, inverter harness/cabling systems or inverter.

41.4 The circuit supplying power from the modules or cells shall be considered a branch circuit with respect to control circuits requirements of Clause 32.

41.5 Energy storage device output circuits shall be provided with overcurrent protection rated for the output conductors and load equipment to which it provides energy, including but not limited to inverters, charge controllers, converters and the connected heating and cooling equipment.

42 Photovoltaic system disconnection means

42.1 A means shall be provided to disconnect all current-carrying conductors of a PV system and any additional source (e.g., batteries) from all other conductors within the heating and cooling equipment. The disconnecting means shall be readily accessible and provided with the marking in Clause 45.17. If two or more disconnecting means are provided (e.g. for the PV system and the branch circuit), they shall be grouped and marked.

42.2 Equipment intended to receive input power from a utility interactive inverter shall be provided with a:

a) Dedicated and marked field wiring termination means of connection through distribution equipment such as a switchboard or panelboard. This means shall include the branch circuit overcurrent protective device as required by Clause 42.1,

b) Means to disconnect and isolate the inverter from all other circuitry within the equipment and,

c) Secondary, independent means of controlling the battery charging process when the utility is not present or when the primary charger controller fails or is disabled.

42.3 Equipment that includes an internal utility interactive inverter or performs utility interactive inverter functions to export power by back-feeding the branch circuit input power shall be provided with a means to disconnect and isolate the utility interactive inverter circuit from the heating and cooling equipment circuitry. Connection to the heating and cooling equipment load through dedicated and marked distribution equipment such as a switchboard or panelboard and that include branch circuit over current protection as required by ratings of the inverter fulfills this requirement.

42.4 When a panelboard is provided as part of the equipment it may be installed in place of the required disconnect if the panelboard includes separate branch circuit overcurrent protection for the utility interactive inverter and for the equipment.

42.5 The separate panel board need not be supplied with the equipment if the installation instructions specify that it is to be provided in the end installation, provides details that fulfill the requirements for disconnection and the heating and cooling equipment and /or a common frame or support accommodates the panelboard.

42.6 A panelboard shall:

a) Comply with the Standard for Panelboards, UL 67 and CSA C22.2 No. 29 or, if factory-built integral to or as a listed accessory for the HVAC system, shall meet the construction requirements for enclosures, spacings and field wiring provisions of this standard;

b) Not be rated less than the sum of the ampere rating of all overcurrent devices supplying it;

c) Have the load connection positioned at the opposite end from the supply circuit conductor entry location;

d) Have its bus or conductor rating sized for the load connected or shall be marked in accordance with Clause 45.22; and

e) Be installed on the heating and cooling equipment, on a common frame or support for the panelboard and heating and cooling equipment, or integral with or within the heating or cooling equipment.

UNIT MARKINGS

43 General

43.1 All markings required for compliance with this Standard may need to be in other languages to conform with local language requirements where the product is to be sold.

Note: In Canada there are two official languages, English and French. Annex A lists some examples of French translations.

44 Equipment markings

44.1 The markings in Clause 44 may consist of one or more labels, located in a place where readily visible after installation, without the use of tools. The markings shall not be affixed to any panel that can be removed without the use of tools except that,

a) A marking may be located on a panel that would be removed for installation or service, providing that the panel must be in place for the intended operation of the equipment;

b) If the nameplate is located on a removable cover, a second nameplate with the electrical rating, model designation, and a note to see marking on the cover shall be secured on the inside of the unit;

c) The markings on a unit intended for built-in installation may be located behind a louvred panel or grille that requires tools for removal to gain access to the field wiring compartment.

44.2 The material for the labels shall be of metal or of a type suitable for outdoor or indoor use, as applicable.

44.3 The equipment shall be plainly marked, in a permanent manner, with the following:

a) The manufacturer's or private labeler's name, trademark, tradename, or other identifying symbol;

b) The catalogue number, style, model, or other type designation;

c) Voltage;

d) Number of phases, unless for single-phase operation;

e) Frequency in hertz;

f) The horsepower (see Clause 44.17) and full load amperes of each motor, except for hermetically sealed compressor motors, which shall be rated in locked rotor and rated load amperes (see Clause 44.10), and motors smaller than 1/8 horsepower, which may be rated in watts or amperes;

Exception No. 1: Motors controlled by an adjustable speed drive shall be marked with either the motor's MOC or the rated input current to the power conversion equipment. When there is bypass utilized, it shall be the larger of the motor's MOC, the rated input current to the power conversion equipment or the full load amperes of the motor.

Exception No. 2: Motor-compressors controlled by an adjustable speed drive shall be marked with either the compressors MRC or the rated input current to the power conversion equipment. If an MRC rating is not available for a compressor, the tests of Annex AA of UL 60335-2-34 or CAN/CSA C22.2 No. 60335-2-34 shall be conducted on the compressor or complete unit.

g) Heater input amperes or watts at marked voltage. See also Clause 44.3(t) for separable heater element assemblies;

h) Minimum power supply circuit ampacity for each hazardous voltage circuit which powers more than one motor or a motor and other loads rated 1.0 A. or more as shown in Figure 44.1 (see Clause 44.14);

i) For each hazardous voltage circuit which powers more than one motor or a motor and other loads rated 1.0 A. or more as shown in Figure 44.2 (see Clause 44.15) “MAX. FUSE_____”, or “MAX. CKT. BKR._____ ”, or “Maximum overcurrent protective device.”

j) The type of refrigerant for operation, and the weight of factory refrigerant charge (self-contained units only), if the equipment is intended to employ refrigerant. The kind and quantity of refrigerant employed in the system shall be a type that is classified in ANSI/ASHRAE 34;

Exception: Unit coolers that do not contain a compressor (such as fan coil units or forced air cooled condensers) need not be marked with the kind of refrigerant if a tag is provided indicating that the design pressure(s) marked on the unit shall not be less than the design pressures marked on the compressor or condensing unit or as outlined in Clause 6.8 of CSA B52 and Clause 8.2 of ANSI/ASHRAE 15 for the refrigerant used in the system. The marking shall also indicate that after charging, the equipment shall be marked with the refrigerant and the oil used. Compatibility with an alternate refrigerant may need to be determined if the unit contains any gaskets.

k) The design pressures for the high and low pressure sides, if intended to employ refrigerant. Intermediate design pressure shall be marked on transcritical systems employing an intermediate pressure section;

l) The date or other dating period of manufacture not exceeding any consecutive three months. For example, date coding, serial numbers, or equivalent means may be used;

m) The maximum outlet air temperature for units with electric resistance heaters;

n) The range of external static pressures, or maximum external static pressure at which the unit was tested (add-on heat pumps and units with electric resistance heaters only);

o) The minimum spacing to combustible surfaces for units with electric resistance heaters;

p) The minimum refrigerant design pressure and the type of the remote condenser (air-, water-, or evaporatively-cooled), if the unit is intended to be used with a remote condenser;

q) The marking “OUTDOOR USE” or equivalent, if the equipment is intended to be used and meets the applicable requirements for outdoor use;

r) “WARNING: RISK OF ELECTRIC SHOCK. CAN CAUSE INJURY OR DEATH: DISCONNECT All REMOTE ELECTRIC POWER SUPPLIES BEFORE SERVICING”, in letters not less than 3.2 mm (1/8 in) high, or the equivalent. For equipment with multiple hazardous voltage power supplies, this marking shall be located on all panels providing access to hazardous voltage uninsulated live parts;

s) “CAUTION: MOUNT WITH THE LOWEST MOVING PARTS AT LEAST 2.4 m (8 ft) ABOVE FLOOR OR GRADE LEVEL”, or the equivalent, if required under Clause 11.2;

t) The name and rating plate of a unit with a field-installed element assembly referred to in Clause 15.4 shall include the following or the equivalent:

1) List all of the manufacturer's name(s) and model designations of all of the heater elements that can be installed in the unit;

2) Have provision for:

i) Checking off the model designation of the heater that is installed; and

ii) Indicating the electrical ratings (volts, phase (if three phase only), and amperes or watts) of the unit with the heater installed; and

3) Iif the actual heater element rating is not included on the equipment nameplate and if the heater element nameplate is not accessible for viewing after installation of the elements, the following additional marking shall appear, and should be applied on the exterior of that section of the unit that houses the field-installed heater elements: “FOR ACTUAL HEATER ELEMENT RATING SEE ELEMENT MARKING INSIDE”, or the equivalent;

u) A distinctive marking to identify the place of manufacture, if produced at more than one factory;

v) Units with hot water coils shall be marked with the maximum inlet water temperature;

w) Units with hot water or steam coils shall be marked with the maximum pressure at which a water coil employing heated water at a temperature exceeding 93°C (200°F) or a steam coil is intended to be used;

x) Where required by Clause 76.1, the following marking or equivalent, “CAUTION: USE TIME DELAY FUSES”; and

y) The short-circuit current rating of the motor controllers, equipment control panel, overall equipment panel, or industrial control panel when employed with multimotor and combination-load equipment.

Exception: Equipment intended for use in one- and two-family dwellings, cord-and-attachment-plug connected equipment, or equipment supplied from a branch circuit protected at 60 A or less is not required to be marked with a short-circuit current rating.

z) As required by Clause 19.35, “CAUTION - RISK OF FIRE AND ELECTRIC SHOCK. REPLACE ONLY WITH MANUFACTURER'S CORD SET, PART NO. XXX”, or the equivalent.

z1) The name and rating plate of a unit with a factory specified field-installed Ultraviolet (UV) lamp assemblies shall include the following or the equivalent:

1) List all of the manufacturer's name(s) and model designations of all of the ultraviolet (UV) radiation lamp systems that can be installed in the unit;

2) Have provision for checking off the model designation of the Ultraviolet (UV) lamp assembly that is installed;

3) Have provision for indicating the electrical ratings (volts, and amperes or watts) of the unit with the ultraviolet UV lamp assembly installed; and

4) If the actual ultraviolet (UV) lamp assembly rating is not included on the equipment nameplate and if the UV lamp assembly nameplate is not accessible for viewing after installation of the unit, the following additional marking shall appear, and should be applied on the exterior of that section of the unit that houses the ultraviolet (UV) lamp assembly: “FOR ACTUAL ULTRAVIOLET (UV) Lamp ASSEMBLY RATING SEE LAMP MARKING INSIDE”, or the equivalent;

z2) The ratings of the ultraviolet (UV) radiation lamp system lamps, maximum lamp rating in watts and voltage.

Exception: For individual loads rated at less than 1 A, the electrical ratings need not be marked on the unit.

44.4 For cord-connected units, the total input current in amperes shall be marked on the unit.

44.5 A single overall ampere rating, rather than individual ratings for the various loads, may be marked on the unit nameplate provided that

a) The unit is rated single phase, ac; and

b) The single ampere rating does not exceed 12 A at 208-240 V or 16 A at 120 V, with the corresponding maximum ratings of the power supply overcurrent protective devices and minimum power supply circuit ampacities of 15 A and 20 A, respectively.

44.6 Unless it is otherwise obvious, equipment that depends upon a proper location or position for acceptable operation shall be marked (for example, “TOP” or “BOTTOM”), to indicate the position in which it shall be installed.

44.7 The high-side, if applicable, and low-side design pressures indicated on the nameplate of the unit shall be as follows:

a) No less than the values shown in Table 85.1 for the type of refrigerant used; and

b) No more than the pressures at which the assembled unit or components or both are tested for leakage (see Clause 85.1).

44.8 Units with star-delta start motor-compressors shall include the locked rotor current for the star and delta connections.

44.9 With reference to Clause 10.5, if the motor-compressor controller and overload protection are not provided by the chiller manufacturer, the nameplate shall so indicate. The nameplate shall include the designation of the chiller manufacturer's specification for these remote components.

44.10 For a hermetic motor compressor, the branch circuit selection current in amperes shall also be marked, if required, in accordance with Clause 44.11 and provided that it meets the requirements of the Canadian Electrical Code, Part I, CSA Standard C22.1, and Article 440-4(c) of the National Electrical Code, ANSI/NFPA No. 70.

44.11 A branch circuit selection current rating in amperes shall be marked on the product nameplate if a thermal protector or protective system allows a continuous current greater than 156 percent of the rated load current:

a) Of the motor compressor as marked on the product nameplate; or

b) Of the product when marked with a single overall ampere rating per Clause 44.5. The marked value of the rating shall be at least 64 percent of the compressor maximum continuous current rating.

Determination of Rating

44.12 The ratings of motors and other loads marked on the equipment shall be used to determine minimum circuit ampacity (Clause 44.14) and rating of the hazardous voltage supply circuit overcurrent protective device (Clause 44.15). Remote loads, such as motors and heaters supplied from the unit, shall also be included in the determination. If the product nameplate is marked with a branch circuit selection current rating, the branch-circuit selection current is the value in amperes that shall be used instead of the rated-load current.

44.13 The minimum rated currents marked on the equipment shall be as follows:

a) For motor loads, no less than

1) 95 per cent of the input measured during the heating and cooling operation tests or the input measured during the input tests, Clause 47.1; and

2) 64 per cent of the compressor maximum continuous current rating;

b) For electric resistance heaters, the ampere or wattage rating marked on the unit nameplate shall not differ from that measured during the input test (see Clause 47.2) by more than ± 5 percent.

c) 64 per cent of the motor-compressors maximum current rating (MRC).

Minimum Circuit Ampacity

44.14 The minimum circuit ampacity (MCA) required by Clause 44.3(h) shall be determined as follows. All concurrent load conditions shall be considered in the determinations; see Figure 44.1. Whichever load condition provides the highest value shall be used.

a) For a motor group only, a load consisting of two or more motors, the rated current of the largest motor or branch circuit selection current, if marked (see Clauses 44.11 and 44.12), or the MOC and MRC required by item (f) of 44.3, multiplied by 125 per cent, added to the rated currents of all of the other motors.

b) For a combination load, a load consisting of one or more motors, electric heaters, and any other loads, that incorporates one or more compressor motors, the rated current of the largest motor or branch circuit selection current, if marked (see Clauses 44.11 and 44.12), or the MOC and MRC required by item (f) of 44.3, multiplied by 125 per cent, added to which shall be the value obtained by multiplying the rated current of the electric heaters by 125 per cent, and adding to that total the sum of the ratings of all other loads.

c) For a combination load, a load consisting of one or more motors, electric heaters, and any other loads, not involving a hermetic refrigerant motor compressor, the sum of the rated currents multiplied by 125 per cent.

Exception: The rated current of the heater load may be multiplied by 100 percent, rather than 125 per cent, provided that

1) The rated heater load at a field wiring terminal is 50 kW or more;

2) Minimum circuit ampacity or the minimum conductor size that may be field-connected to such terminal is still to be marked; and

3) The heater element circuits connected to the field wiring terminals are subdivided as specified in Clause 30.8 and are arranged to be controlled by one or more temperature-actuated devices to reduce the likelihood of continuous simultaneous operation of all of the element circuits.

Figure 44.1
Minimum circuit ampacity calculation

On equipment with multiple modes of operation, every mode shall be considered for each individual field wired hazardous voltage circuit. Whichever load condition provides the highest value shall be used for Clause 44.14, in the applicable circuit.

(Clause 44.14(a))

MCA = (1.25 × LOAD1) + LOAD2

(Clause 44.14(b))

MCA = (1.25 × LOAD1) + (1.25*× LOAD3) + LOAD2 + LOAD4

(Clause 44.14(c))

MCA = 1.25 × (LOAD1 + LOAD2 + LOAD4) + (1.25* × LOAD3)

where

MCA = Minimum circuit ampacity per Clause 44.14. The MCA may be increased to allow a higher value.

LOAD1 = Current of largest motor (compressor or other motor), or branch circuit selection current, if marked, (see Clauses 44.11 and 44.12) and Exceptions 1 and 2 of item (f) of 44.3,

LOAD2 = Sum of currents of all motors (compressor or other motor), not including largest motor (See Exceptions 1 and 2 of item (f) of 44.3.)

LOAD3 = Current of electric resistance heater

LOAD4 = Any other load rated 1.0 A or more

*If exception in Clause 44.14 applies, use 1.0 instead of 1.25.

Rating of Overcurrent Protective Devices

44.15 The maximum current rating of overcurrent protection for each hazardous voltage circuit, as required by Clause 44.3(i), for units having more than one motor, or one or more motors and other loads, operated from a single supply source, shall be determined as follows. All concurrent load conditions shall be considered in the determinations.

The rated current of the largest motor, compressor or other motor or branch circuit selection current, if marked (see Clauses 44.11 and 44.12) shall be multiplied by 2.25. To that shall be added the rated current of any other concurrent loads involved in the circuit. Whichever load condition provides the highest value shall be used for Clause 44.3(i). See Figure 44.2.

Figure 44.2
Maximum rating of overcurrent protective device calculation

On equipment with multiple modes of operation, every mode shall be considered for each individual field-wired hazardous voltage circuit. Whichever load condition provides the highest value shall be used for Clause 44.15, in the applicable circuit.

MOP = (2.25 × LOAD1) + LOAD2 + LOAD3 + LOAD4

where

LOAD1 = Current of largest motor (compressor or other motor), or branch circuit selection current, if marked, (see Clauses 44.11 and 44.12) and Exceptions 1 and 2 of item (f) of 44.3.

LOAD2 = Sum of currents of all motors (compressor or other motor), not including largest motor (See Exceptions 1 and 2 of item (f) of 44.3.)

LOAD3 = current of electric resistance heater

LOAD4 = any other load rated 1.0 A or more

MOP = maximum rating of overcurrent protective device

44.16 If the value of the rating determined by applying Clause 44.15 does not equal a standard current rating of overcurrent protective device, the marked maximum rating shall be the next lower standard rating.

Exception No. 1: The marked maximum rating of the overcurrent protective device shall be the standard rating next higher than the computed value, if the next lower standard rating is less than 125 percent of the current rating of an electric heater load, when such a heater is involved.

Exception No. 2: If the computed value of the overcurrent protective device is less than the minimum ampacity of the supply circuit, as determined in accordance with Clause 44.14, the marked rating of the device shall be increased to the largest standard overcurrent protective device rating appropriate for the marked minimum circuit ampacity.

Exception No. 3: If the marked minimum circuit ampacity does not correspond to a standard protective device rating, the next higher standard rating of the protective device may be marked, if this rating does not exceed 800 A.

44.17 The horsepower rating for motors other than hermetically sealed compressors is not required on the unit nameplate, provided the nameplate is marked with a minimum disconnect size rating. The current rating in amperes of the disconnect size shall be at least 115% of the sum of the following unit nameplate marked loads (see Clause 44.13):

a) motor-compressor rated load current or branch-circuit selection current, whichever is greater; and

b) the rated current for other controlled loads.

44.18 A marking on, or in addition to, the nameplate shall be provided on a cord-connected unit as follows: if a unit with a power supply cord has a marked ampere rating which exceeds 50 percent of the rating of the branch circuit to which it may be connected in accordance with ANSI/NFPA 70, it shall have a permanent marking in letters not less than 4.8 mm (3/16 inch) high located adjacent to the cord entrance on the exterior of the room side enclosure. This marking shall read: “Use on Single Outlet Circuit Only.”

44.19 Notwithstanding Clause 44.18, the marking on a unit with a 15 ampere attachment plug may read: "Use on Single Outlet Circuit or 20 Ampere circuit," if the marked rating of the unit does not exceed 10 amperes.

Short-Circuit Current Rating of Motor Controllers, Overall Equipment Panel, Equipment Control Panel or Industrial Control Panels

44.20 The short-circuit current rating of Item (y) of Clause 44.3 shall include the following marking or the equivalent as specified for the motor controllers, equipment control panel, overall equipment panel or industrial control panel: "Short-circuit current: _____kA rms symmetrical, ___V maximum".

Short-Circuit Rating of the Overall Equipment Panel, Equipment Control Panel or Industrial Control Panel

44.21 The short-circuit current rating of the equipment control panel, overall equipment panel or industrial control panel shall be determined based upon:

a) establishing the short-circuit current ratings of individual power circuit components as specified in Clauses 44.22 to 44.24, and

b) determining the overall panel short-circuit current rating as specified in Clauses 44.25 and 44.26.

Short-Circuit Current Rating of Individual Power Circuit Components

44.22 All power circuit components, including disconnect switches, branch circuit protective devices, branch circuit fuseholders, load controllers, motor overload relays, terminal blocks, and bus bars, shall have a short-circuit current rating expressed in amperes or kiloamperes and voltage.

Exception No. 1: Power transformers, reactors, current transformers, dry-type capacitors, resistors, varistors, and voltmeters are not required to have a short-circuit current rating.

Exception No. 2: The "S" contactor of a wye-delta motor controller is not required to have a short-circuit current rating.

Exception No. 3: An electrically commutated motor and its controls that are dedicated to the control of a single motor where the primary function of the control is to provide commutation and the control does not make or break motor circuit current is not required to have a short-circuit current rating.

44.23 The short-circuit current rating of a component shall be established by one of the following methods:

a) the short-circuit current rating marked on the component, or

b) the short-circuit current rating for a load controller, motor overload relay, or combination motor controller that has been investigated in accordance with the performance requirements, including short-circuit test requirements, as specified in CSA C22.2 No. 14 or UL 508, or

c) The short circuit current rating determined by the voltage rating of the component and the assumed short circuit current from Table 44.1.

Table 44.1
Assumed maximum short circuit current rating for unmarked components

Component	Short circuit current rating, kA
Bus bars	10
Circuit breaker (including GFCI type)	5
Current meters	a
Current shunt	10
Fuseholder	10
Industrial control equipment:	
a. Auxiliary devices (overload relay)	5
b. Switches (other than mercury tube type)	5
c. Mercury tube switches	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2 kVA	3.5
Rated 250 volts or less and 2 kVA or less	1
Motor controllers, rated in horsepower (kW)	
a. 0 – 50 (0 – 37.3)	5[c]
b. 51 – 200 (38 – 149)	10[c]
c. 201 – 400 (150 – 298)	18[c]
d. 401 – 600 (299 – 447)	30[c]
e. 601 – 900 (448 – 671)	42[c]
f. 901 – 1500 (672 – 1193)	85[c]
Meter socket base	10
Miniature or miscellaneous fuse	10[b]
Receptacle (GFCI type)	2
Receptacle (other than GFCI type)	10
Supplementary protector	0.2
Switch unit	5
Terminal block or power distribution block	10

[a] A short circuit current rating is not required when connected via a current transformer or current shunt. A directly connected current meter shall have a marked short circuit current rating.

[b] The use of a miniature fuse is limited to 125-volt circuits.

[c] Standard fault current rating for motor controller rated within specified horsepower range.

[d] Short circuit current rating values are taken from UL 508 and are shown here as a reference. For most up-to-date information, see UL 508.

44.24 A short-circuit current rating for a motor controller, an overload relay, or a combination motor controller, as specified in items (a) or (b) of Clause 44.23, shall only be used as the short-circuit current rating of the component when the specified branch circuit protective device is provided.

Exception No. 1: When the specified branch circuit protection related to short circuit current rating is a Class CC, G, J, L, RK1, RK5, or T fuse, a fuse of a different class can be used at the same fault rating where the peak let-through current and I^2t of the new fuse is not greater than that of the specified fuse.

Exception No. 2: When the specified branch circuit protection related to the short-circuit current rating is a circuit breaker marked "current limiting," a different current-limiting circuit breaker may be used at the same fault rating where the peak let-through current and I^2t of the new current-limiting circuit breaker is not greater than that of the specified circuit breaker.

Determination of the Overall Short-Circuit Current Rating of a Equipment Control Panel, Overall Equipment Panel or Industrial Control Panel

44.25 For each circuit within the equipment control panel, overall equipment panel or industrial control panel, the smallest short-circuit current rating of all power circuit components on the load side of an overcurrent protective device and any control circuit overcurrent protection shall be determined and compared with the short-circuit current rating of the branch circuit protective device. The smaller of the two ratings shall be assigned to the line side of the overcurrent protective device.

44.26 The overall short-circuit current rating of the equipment control panel, overall equipment panel or industrial control panel shall be one of the following:

a) For a control panel fed by a single branch circuit without overcurrent protection within the panel, the lowest short circuit current rating for any power circuit component and the control circuit overcurrent protection;

b) For an control panel consisting of a single branch circuit including overcurrent protective devices and power circuit components within the equipment control panel, overall equipment panel or industrial control panel, the short-circuit current rating shall be in accordance with Clause 44.25; or

c) For a control panel fed by multiple branch circuits, power circuit components within the equipment control panel, overall equipment panel or industrial control panel, such as disconnecting switches, bus bars, terminal blocks, the short-circuit current rating shall be the lowest short-circuit current rating of any branch circuit.

Short-Circuit Current Rating of an Industrial Control Panel, Equipment Control Panel, or Overall Equipment Panel

44.27 The short-circuit current rating of an industrial control panel, equipment control panel or overall equipment panel shall be as determined by CSA C22.2 No. 14 and UL 508A.

45 Other markings

45.1 The markings in Clause 45 may appear on label(s) or on wiring diagram(s). Material may be paper or the equivalent.

45.2 A unit requiring field-provided motor overload protection, under the provisions of Clause 23.6, shall have markings readily visible stating this fact, and indicating that the motor overload protective devices shall be rated or selected in compliance with the applicable installation code, as specified by the authority having jurisdiction.

45.3 A replacement marking shall be provided for a replaceable fuse or overload protective heater element provided as a part of a product or remote control assembly. It shall be visible when the cover or door of the compartment is opened. This marking shall specify

a) The rating of the fuse in amperes and voltage, and the fuse class, if marked;

b) For supplementary type fuses (see Clause 32.7) the fuse manufacturer's or private labeller's name and catalogue number; and

c) The manufacturer and model designation of the overload protective heater element.

45.4 All connection points where field connections are to be made shall be clearly marked, unless these are apparent.

45.5 Connection points intended for Class 2 connections shall be marked “CLASS 2” or the equivalent.

45.6 If the unit includes a motor that is installed remote from its controller, the rating of the remote motor, the size of the conductors supplying it, and reference to the location of the disconnect device for the remote motor shall be shown.

45.7 If provisions are made for the connection of an external load such as a cooling tower or evaporator motor, the maximum load to be connected shall be shown. If provisions are made for the connection of an external hazardous voltage switching device such as a thermostat or control switch, the minimum required rating for the switching device shall be shown.

45.8 If a unit is controlled by a specific use controller that is not installed on the assembly, a marking shall show the identifying designation of the controller. The rating of the overcurrent (heater) element to be used shall be shown when a thermal overload relay is part of the controller.

45.9 If a unit is intended to be connected to an extra-low-voltage source, the minimum rating of the supply transformer shall be shown if a transformer rated 5 VA or more is required.

45.10 Units shall be marked, in the vicinity where field wiring terminates, “USE COPPER SUPPLY WIRES” or the equivalent.

If the product is intended for field connection with aluminum wires, the marking shall additionally so state.

45.11 If the temperature in the terminal box or the compartment intended for the supply connections exceeds 75°C (167°F) during the operational tests, a value suitable for the temperature measured shall be marked.

The marking shall state, “USE CONDUCTORS SUITABLE FOR AT LEAST _____ °C (_____ °F)” or the equivalent.

45.12 The following applies to heat pump water heating equipment only:

a) Equipment having a heat exchanger complying with Clause 36.2 and 36.4 shall be marked with the following, or the equivalent: “CAUTION: DOUBLE WALL HEAT EXCHANGER, SUITABLE FOR POTABLE WATER CONNECTION”.

b) Equipment having a heat exchanger complying with Clause 36.3 shall be marked with the following, or the equivalent: “CAUTION: SINGLE WALL HEAT EXCHANGER, NOT SUITABLE FOR POTABLE WATER CONNECTION”.

45.13 Equipment intended to utilize carbon dioxide (R744) in a secondary loop, cascade, or transcritial system shall be marked to indicate:

a) That the equipment is for use with R744 (carbon dioxide) system components where the design pressure of the equipment is not higher than the design pressure of the associated components.

b) If the equipment contains a pressure vessel within the R744 loop or system, but pressure-relief and pressure-regulating relief valves are not provided as part of the equipment as permitted by Clause 34.33, a marking shall be located where visible to the installer indicating that pressure-relief or pressure-regulating relief valves are not installed on the equipment and that a sufficient number of valves having capacity deemed adequate shall be field-installed on the system.

45.14 The marking covered by Clause 45.13 shall refer to the installation instructions provided by the equipment manufacturer.

45.15 Pressure-regulating relief valves shall be provided with the following or equivalent marking: “Do not defeat, cap, add piping to the outlet of the valve or attempt to change the relief setting.”

45.16 Motors intended for use with remotely located solid-state speed controls and that comply with the requirements specified in Clause 59 must be marked with the following statement, “SUITABLE FOR USE WITH ANY SOLID-STATE SPEED CONTROLS” or equivalent wording.

Exception: If a speed control is specified by the manufacture, the marking is not required.

45.17 Heating and cooling equipment with a solar PV system shall be provided with a marking to identify each solar PV system and inverter disconnecting means. The marking shall be located adjacent to or near the disconnecting means.

45.18 Heating and cooling equipment with a stand-alone solar PV system shall be marked to indicate that it has a stand-alone system.

45.19 Heating and cooling equipment with an interactive solar PV system shall be marked to indicate that it has a utility-interactive system.

45.20 Heating and cooling equipment with a PV interactive system shall be permanently marked on the utility-interactive inverter or near the ground-fault indicator (see Clause 41) with the following or equivalent wording:

“Warning – Electrical Shock Hazard if a Ground Fault is Indicated. Normally Grounded Conductors May Be Ungrounded and Energized.”

45.21 Where all terminals of a disconnecting means may be energized in the open position, a permanent marking shall be provided adjacent to the disconnecting means and state the following or equivalent:

“Warning – Electric shock hazard. Do not touch terminals. Terminals on both the line and load sides may be energized in the open position.”

45.22 Inverter output connection of the distribution equipment shall be marked with the following or equivalent wording:

“Warning – Inverter Output Connection. Do Not Relocate This Overcurrent Device”

45.23 An ungrounded photovoltaic power source accessible to service persons shall be labeled with the following or equivalent wording at each junction box, combiner box, disconnect and device where energized, ungrounded circuits may be exposed during service per Clause 39.2.

“Warning – Electric Shock Hazard. The DC Conductors of this Photovoltaic System are Ungrounded and May Be Energized.”

Ultraviolet radiation markings

45.24 All removable Ultraviolet (UV) radiation doors or barriers shall be marked with the following or equivalent. The marking shall be on, or adjacent to the door or barrier.

If interlocks are required by Clause 8.5 or 8.6 the doors or openings incorporating an interlock to reduce the risk of UV exposure shall be marked with the words “WARNING UV LIGHT SOURCE” and the following or equivalent: “This cover is provided with an Interlock to reduce the risk of ultraviolet radiation exposure”

If interlocks are not required by Clause 8.6 the doors or openings shall be marked with the words "WARNING UV LIGHT SOURCE" and the following or equivalent: "Disconnect power before servicing".

Removable barriers shall be marked with the words "Caution" and the following or equivalent: ***"UV LIGHT SOURCE – KEEP PROTECTIVE BARRIER IN PLACE"***

TESTS

46 General test parameters

46.1 The tests specified in Table 46.1 and Table 46.2, denoted by "yes" in the tabulations, apply to the type of unit indicated. Table 46.1 applies to units, either self-contained equipment or matched systems, that involve compressors. Table 46.2 applies to all other equipment, such as central heating furnaces, where compressors are not involved. Only those tests that apply to the intended application of the unit are required.

46.2 For the tests specified in Table 46.1, except as otherwise indicated, the inlet air and water temperatures maintained during the respective tests shall be as shown in Table 46.4. If ambient temperatures are not specified, the device may be tested at any ambient.

46.3 For the tests specified in Table 46.2, the air inlet temperature maintained during the respective tests shall be 26.7°C (80°F), ±1.1°C (±2°F) dry bulb. The wet bulb temperature is not specified.

If the inlet air temperature is maintained at other than 26.7°C (80°F), ±1.1°C (±2°F), the temperatures in Table 46.5 shall be adjusted accordingly. The temperatures shall not be within 5 percent of the adjusted maximum temperatures.

46.4 Temperatures shall be determined either by thermocouples or the rise of resistance method. A temperature shall be considered to be constant when three successive readings taken at 10 min intervals indicate that stabilized temperatures have been established (no more than a 1 percent net increase between the last two readings). If the temperatures measured are within 5 percent of the values specified in Table 46.5, the test shall be continued until two successive 10 min readings indicate constant temperatures.

46.5 Components shall not be overheated, there shall be no risk of electrical shock hazard, and refrigerant shall not be released when the unit is tested in accordance with Clause 46.1. See Table 46.5. The temperatures in Table 46.5 are based on a unit ambient of 26.7°C (80°F).

Table 46.1
Operation tests (units with compressors)

Type of test	Air conditioner[a]	Air conditioner with electric heaters[c]	Air conditioner with hot water or steam	Heat pump[b]	Heat pump with electric heater[c]	Condensing unit[d]	Liquid chiller
Input (47.1)	yes	yes	yes	yes	yes	yes	yes
Input (47.2)	–	yes	–	–	yes	–	–
Temperature operation (48)	–	–	–	–	–	yes	–

Table 46.1 Continued on Next Page

Table 46.1 Continued

Type of test	Air conditioner[a]	Air conditioner with electric heaters[c]	Air conditioner with hot water or steam	Heat pump[b]	Heat pump with electric heater[c]	Condensing unit[d]	Liquid chiller
Temperature operation (49)	–	–	yes	–	–	–	–
Cooling operation (50)	yes	yes	yes	yes	yes	–	yes
Heating operation (51)	–	–	–	yes	yes	–	–
Abnormal operation (52)	–	–	–	yes	yes	–	–
Continuity of operation (53.2)	–	–	–	–	yes	–	–
Continuity of operation (53.8)	–	yes	–	–	yes	–	–
Limit control cutout (53.11)	–	–	–	–	yes	–	–
Limit control cutout (53.16)	–	yes	–	–	yes	–	–
Heating operation (53.17)	–	yes	–	–	yes	–	–
Abnormal operation (54)	–	yes	–	–	yes	–	–
Backup protection (55)	–	yes	–	–	yes	–	–
Fan delay (56)	–	yes	–	–	yes	–	–
Control system failure (57)	–	–	–	yes	yes	–	–
Fan motor failure (58)	yes	yes	yes	yes	yes	–	–
Condenser water failure (60)	yes	yes	yes	yes	yes	–	yes
Dielectric voltage withstand (61)	yes	yes	yes	yes	yes	yes	yes
Condensate drain blockage (62)	yes	yes	yes	yes	yes	–	–
Loading (63)	yes	yes	yes	yes	yes	yes	yes
Rain (67)	yes	yes	yes	yes	yes	yes	yes
Ultraviolet (UV) leakage (89.2)	yes[e]	yes[e]	yes[e]	yes[e]	yes[e]		

[a] Unit intended for operation without electric heaters or any other heating means.

[b] See Clause 79 for test on heat pump water heating equipment.

[c] This includes units having provision for simultaneous operation with other supplementary means for heating (hot water or steam).

[d] Condensing unit is not required to be tested as part of a complete system.

[e] Only required on units with ultraviolet (UV) radiation lamp systems or that are marked in accordance with item (z1) of Clause 44.3.

Table 46.2
Operation tests[a] (units without compressors)

Type of test	Without supplementary heat	With electric heat	With hot water or steam
Input (47.1)	Yes	–	Yes
Input (47.2)	–	Yes	–
Temperature Operation (48)	Yes	–	–
Temperature Operation (49)	–	–	Yes
Continuity of operation (53.8)	–	Yes	–
Limit control cutout (53.16)	–	Yes	–
Heating operation (53.17)	–	Yes	–
Abnormal operation (54)	–	Yes	–
Backup protection (55)	–	Yes	–
Dielectric voltage withstand (61)	Yes	Yes	Yes
Condensate drain blockage (62)	Yes	Yes	Yes
Loading (63)	Yes	Yes	Yes
Rain (67)	Yes	Yes	Yes
Ultraviolet (UV) leakage (89.2)	yes[b]	yes[b]	yes[b]

[a] These tests apply to fan units, fan coil units, room fan heater units, central heating furnaces, and similar fixed electric space heating equipment. Such assemblies, tested as part of matched systems (see Table 46.1), need not be individually tested as noted in this Table.

[b] Only required on units with ultraviolet (UV) radiation lamp systems or that are marked in accordance with item (z1) of 44.3.

Table 46.3
Polymeric material tests

Type of tests	Cabinet	Structural parts	Functional parts	Thermal or accoustical material
Flammability:[a,b]				
Source of Ignition				
Internal	Yes	Yes	Yes	Yes
External	Yes	Yes	No	Yes
Mold Stress-Relief distortion[c]	Yes	Yes	Yes[c]	No
Accelerated Aging(68.5)	Yes	Yes	No	No
Ultraviolet Light Exposure(80)	Yes[e]	Yes[e]	No	No
Water Exposure and Immersion(81)	Yes[e]	Yes[e]	No	No
Tensile Strength[d]	Yes	Yes	No	No
Flexural Strength[d]	Yes	Yes	No	No
Izod Impact[d]	Yes	Yes	No	No
Tensile Impact[d]	Yes	Yes	No	No
Impact(69)	Yes	Yes	No	No
Loading(63)	Yes	Yes	No	No

Table 46.3 Continued on Next Page

Table 46.3 Continued

Type of tests	Cabinet	Structural parts	Functional parts	Thermal or accoustical material

[a] *Exception: A material having a flame spread rating of not more than 25 when tested as specified in CAN/ULC-S102, and the requirements in UL 723.*

[b] See Clause 5.10.1.

[c] See Clause 23.10.

[d] See Clauses 68.5, 80 and 81.

[e] On units marked for outdoor use, where exposed to the effects of ultraviolet light, water, or immersion.

Table 46.4
Air and water temperatures °C (°F)[acd]

	Input tests		Temperature test	Temperature and pressure tests	
	Heating	Cooling	Heating	Heating	Cooling
Air to outdoor coil[l]	8.3 (47) DB[f]	35 (95) DB	7.2 (45) DB	21.1 (70) DB	40 (104)
	6.1 (43) WB[g]	23.9 (75)WB[b]	6.1 (43) WB	14.7 (58.5)WB	26.7(80)WB[b]
Air to indoor coil[m]	21.1 (70) DB	26.7 (80) DB	26.7 (80)	26.7 (80)	26.7 (80) DB
		19.4 (67) WB			19.4 (67) WB
Water-cooled condenser					
entering	21.1 (70)	29.4 (85)	23.9 (75)	23.9 (75)	29.4 (85)
leaving	[e]	35 (95)	Rated flow	Rated flow	38 (100)
Evaporatively-cooled condenser	–	23.9 (75)	–	–	26.7 (80)
Water-cooled evaporator					
entering	–	12.2 (54)	–	–	maximum rated[h]
leaving	–	6.7 (44)	–	–	10.0 (50)
Unit without condenser compressor					
refrigerant-saturated	–	49.0 (120)	–	–	[i]
discharge temperature	–	40.6 (105)[k]	–	–	
refrigerant liquid temperature	–	43.3 (110)	–	–	[j]
entering expansion device	–	35.0 (95)[k]	–	–	

[a] The test room ambient is not specified.

[b] When condensate is rejected to the condenser air stream and for evaporatively cooled air conditioners.

[c] All DB temperatures are ±1.1°C (±2°F).

[d] All WB temperatures are ±0.6°C (±1°F).

[e] This temperature is not specified; however, the water flow rate shall be the same as obtained during the input (cooling cycle) test.

[f] Dry bulb.

[g] Wet bulb.

[h] Water temperature entering the evaporator shall be 10.0°C (50°F) plus the maximum temperature drop for which the unit is rated by the manufacturer.

[i] The temperature corresponding to the saturated vapour temperature at a pressure of 90% of the maximum adjustable setting of the pressure-limiting device, but no less than 49°C (120°F).

[j] 5.6°C (10°F) below the temperature indicated for the saturated discharge temperature.

[k] Refrigerant temperature conditions for a liquid chiller without a condenser intended for use with a remote water or evaporatively cooled condenser.

[l] The outdoor coil is the coil through which the outdoor air passes.

[m] The indoor coil is the coil through which the indoor air passes.

Table 46.5
Maximum acceptable temperatures

Materials and components	Column 1		Column 2	
	°C	°F	°C	°F
A. Motors[g]				
1. Class A insulation on coil windings of alternating-current motors having a frame diameter of 178 mm (7 in) or less (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple or resistance method	102	215	142	287
(b) In totally enclosed motors –				
Thermocouple or resistance method	107	224	142	287
2. Class A insulation on coil windings of alternating-current motors having a frame diameter of more than 178 mm (7 in) and of direct-current motors (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple method	92	197	142	287
Resistance method	102	215	142	287
(b) In totally enclosed motors –				
Thermocouple method	97	206	142	287
Resistance method	107	224	142	287
3. Class E insulation on coil windings of motors having a frame diameter of 178 mm (7 in) or less (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple or resistance method	112	233	142	287
(b) In totally enclosed motors –				
Thermocouple or resistance method	117	242	147	296
4. Class E insulation on coil windings of motors having a frame diameter of more than 178 mm (7 in) (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple method	102	215	142	287
Resistance method	112	233	142	287
(b) In totally enclosed motors –				
Thermocouple method	107	224	142	287
Resistance method	117	242	147	296
5. Class B insulation on coil windings of alternating-current motors having a frame diameter of 178 mm (7 in) or less (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple or resistance method	122	251	152	305
(b) In totally enclosed motors –				
Thermocouple or resistance method	127	260	157	314
6. Class B insulation on coil windings of alternating-current motors having a frame diameter of more than 178 mm (7 in) and of direct-current motors (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple method	112	233	142	287
Resistance method	122	251	152	305

Table 46.5 Continued on Next Page

Table 46.5 Continued

Materials and components	Column 1		Column 2	
	°C	°F	°C	°F
(b) In totally enclosed motors –				
Thermocouple method	117	242	147	296
Resistance method	127	260	157	314
7. Class F insulation on coil windings of motors having a frame diameter of 178 mm (7 in) or less (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple or resistance method	147	296	177	350
(b) In totally enclosed motors –				
Thermocouple or resistance method	152	305	182	359
8. Class F insulation on coil windings of motors having a frame diameter of more than 178 mm (7 in) (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple method	137	278	167	332
Resistance method	147	296	177	350
(b)In totally enclosed motors				
Thermocouple method	142	287	172	341
Resistance method	152	305	182	359
9. Class H insulation on coil windings of motors having a frame diameter of 178 mm (7 in) or less (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple or resistance method	162	323	192	377
(b) In totally enclosed motors –				
Thermocouple or resistance method	167	332	197	386
10. Class H insulation on coil windings of motors having a frame diameter of more than 178 mm (7 in) (not including hermetic motor-compressors)[a, b]				
(a) In open motors –				
Thermocouple method	152	305	182	359
Resistance method	162	323	192	377
(b) In totally enclosed motors –				
Thermocouple method	157	314	187	368
Resistance method	167	332	197	386
11. Hermetic motor-compressor enclosure[c]	150	302	150	302
B. Components[g]				
1. Capacitors[e]				
Electrolytic type[d]	67	152	(not specified)	
	92	197	(not specified)	
2. Field wiring	77	170	92	197
3. Relay, solenoid, and other coils with[b]				
(a) Class A insulated windings –				
Thermocouple method	92	197	142	287
Resistance method	112	233	142	287
(b) Class B insulated winding –				

Table 46.5 Continued on Next Page

Table 46.5 Continued

Materials and components	Column 1		Column 2	
	°C	°F	°C	°F
Thermocoouple method	112	233	142	287
Resistance method	132	269	152	305
(c) Class F insulated winding –				
Thermocouple method	137	278	167	332
Resistance method	147	297	172	341
(d)Class H insulated winding –				
Thermocouple method	152	305	182	359
Resistance method	162	323	192	377
(e) Class E insulated winding –				
Thermocouple method	102	215	142	287
Resistance method	122	251	152	305
4. Solid contacts	92	197	117	242
5. Transformer enclosures –				
(a) Class 2 transformers	87	188	112	233
(b) Power and ignition transformers	92	197	117	242
6. Fuse bodies[h]	92	197	122	251
C. Insulated Conductors[f, g]				
1. Flexible cords and wires with rubber, thermoplastic, or neoprene insulation	62	143	87	188
Temperature Rating[i]				
Degrees C Degrees F				
60 140	62	143	87	188
75 167	77	170	102	215
90 194	92	197	117	242
105 221	107	224	132	269
D. Electrical Insulation – General[f, g]				
1. Fibre used as electrical insulation on cord bushings	92	197	122	251
2. Phenolic composition used as insulation or as parts where failure will result in a hazardous condition	152	305	177	350
3. Thermoplastic material	temperature rating of material			
E. General[g]				
1. Surfaces of product, discharge plenum, and duct at points of specified zero clearance to test enclosure	92	197	124	255
2. Surfaces of test enclosure where clearance more than zero to combustible material is specified	92	197	124	255

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

[b] If the coil is inaccessible for mounting thermocouples (for example, a coil immersed in sealing compound) or if the coil wrap includes thermal insulation or more than two layers, 0.8 mm (1/32 in) maximum, of cotton, paper, rayon, or the like, the resistance method shall be used. For a thermocouple measured temperature of a coil of an alternating-current motor, other than a hermetic motor compressor, the thermocouple shall be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by a thermocouple may be (not including hermetic motor compressors):

(1) 5°C (9°F) for Item A1(a) of this Table;

(2) 10°C (18°F) for Item A3(a) of this Table;

Table 46.5 Continued on Next Page

Table 46.5 Continued

Materials and components	Column 1		Column 2	
	°C	°F	°C	°F
(3) 15°C (27°F) for Items A2(a) and B3(a) of this Table;				
(4) 20°C (36°F) for Items A4(a), B3(b), and B3(c) of this Table; or				
(5) 30°C (54°F) for Item B3(d) of this Table;				
more than the indicated maximum, provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in this Table.				
[c] For the exposed surface of the motor-compressor enclosure including the surface of a wrap-around crankcase heater (see Clauses 52.4 and 60.2).				
[d] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature on insulating material integral with the capacitor enclosure may be not more than 92°C (197°F) in tests where Column 1 applies.				
[e] A capacitor may operate at a temperature higher than 92°C (197°F) but not higher than its marked temperature rating.				
[f] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to be acceptable for higher temperatures than those specified in this Table.				
[g] See Clauses 54.2 and 54.4.				
[h] Includes both casing and ferrule. However, a temperature not more than 20°C (36°F) higher than the values indicated in this Table is acceptable on the casing (not ferrule) of a Class G, J, T, or L fuse.				
[i] Cords and wires that are marked with or otherwise found to be acceptable at higher temperature ratings may be used if both Column 1 and Column 2 temperatures are within the cord and wire temperature ratings.				

Test Voltage

46.6 Unless otherwise specified, products shall be tested at the appropriate potential indicated in Table 46.6.

Table 46.6
Test voltages

Unit rated voltage	Test voltage[a, b]
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600
Other	Rated

[a] Tolerance shall be ±2%.

[b] Input testing shall be conducted at nameplate rated voltage.

Air Flow

46.7 If the conditioned air flow is adjustable, the initial air flow in all heating tests shall be adjusted to deliver the minimum air quantity (volume per unit time) specified by the manufacturer. For cooling tests, the air flow shall be adjusted to deliver the maximum air quantity specified by the manufacturer. The static pressure shall be as indicated in Clause 46.11.

46.8 The air quantity across an air-cooled condenser shall be as specified by the manufacturer if the fan drive is adjustable. However, if the fan drive is direct-connected, the air quantity may be that which results when all inherent resistance elements are in place.

46.9 The condenser air system shall be operated to deliver minimum rated air flow at the maximum rated static pressure if an air-cooled condenser is intended to be duct-connected.

46.10 If multispeed or multiple condenser fan motors are employed, and if the speed, or the number of motors operating, can be changed automatically by the use of a temperature or pressure-operated control device, the electrical input to the motor compressor shall be measured when stabilized conditions are obtained at the maximum condenser inlet air temperature (not exceeding 40°C (104°F)), which is just under the temperature at which the fan speed starts to increase or an additional fan motor starts to run.

Static Pressure

46.11 For units with heating means (supplementary or inherent), the static pressure in the duct system shall be initially adjusted to the maximum static pressure specified by the manufacturer, or to the static pressure of Table 46.7, whichever is the greater, at the start of the test sequence.

For units without heating means, the static pressure in the duct system shall be initially adjusted to the minimum static pressure specified by the manufacturer, or to the static pressure of Table 46.8, whichever is the smaller, at the start of the test sequence.

46.12 For units without a duct system (free air discharge) the requirements of Clauses 46.11, 46.14, and 46.15 are not applicable.

46.13 If filters are factory-provided with the unit, or specified for field installation, they shall be in place during all of the tests.

46.14 External static pressure shall be measured by a manometer or pressure transducer. One side of the instrument shall be connected to the discharge plenum. For units utilizing an inlet duct, the other side of the instrument shall be connected to the inlet duct. For units without an inlet duct, the other side of the instrument shall be open to the surrounding atmosphere.

Table 46.7
Operating conditions[a]; relation of total static pressure to total heat output

Total rated heating, kW	Minimum total static pressure, mm (in) water column
0 – 19.99	3.1 (0.12)
20 – 29.99	3.8 (0.15)
30 – 44.99	5.1 (0.2)
45 and over	6.35 (0.25)

[a] For equipment not tested with an air filter, add 2 mm (0.08 in) to the applicable pressure in the Table. For units intended for use with refrigerant coils that are tested without the coils in place, add 1.27 mm (0.05 in) to the applicable pressure.

Table 46.8
Operating conditions; relation of total static pressure to cooling ratings

Standard cooling rating	Minimum total static pressure, mm (in) water column	
Btu/h (in thousands)	mm of water	in of water
0 through 17	1.27	(0.05)
18 through 28	2.54	(0.10)

Table 46.8 Continued on Next Page

Table 46.8 Continued

Standard cooling rating	Minimum total static pressure, mm (in) water column	
Btu/h (in thousands)	mm of water	in of water
29 through 42	3.81	(0.15)
43 through 70	5.08	(0.20)
71 through 105	6.35	(0.25)
106 through 140	7.62	(0.30)
141 through 210	8.89	(0.35)
211 through 280	10.16	(0.40)
281 through 350	11.43	(0.45)

46.15 For the connections to the manometer or pressure transducer, a metal tube having an internal diameter of approximately 6.4 mm (0.25 in) shall be centred at a specified location (see Figure 46.1) and soldered to the surface of the discharge plenum. Then a hole, 1.0 mm (0.04 in) in diameter, shall be drilled through the wall of the discharge plenum at this location; the inner surface of this wall adjacent to the hole shall be smooth and free from irregularities. Connection of these tubes to the manometer or pressure transducer shall then to be made by means of a suitable length of rubber tubing or the equivalent. Instead of the above, a static pitot tube or the equivalent may be used.

Unit Setup

46.16 The unit shall be connected to an electrical supply source with wire sized as required for wire rated 75°C (167°F) except that, if the product is marked for use with a higher temperature in accordance with Clause 45.11, wire of the temperature rating specified in the marking may be used. The supply wires shall be sized in accordance with Table 2 of CSA C22.1 and Table 310-16 of ANSI/NFPA No. 70. The correction factors from the referenced tables shall not be considered.

46.17 Adjustable limit controls shall be set at maximum cutout and minimum differential permitted by the control adjusting means.

46.18 For units that include electric resistance heating means, the limit controls used shall be calibrated samples that have cutout temperatures as close as possible to the nominal setting with the tolerances not exceeding ±2.8°C (5°F) of the nominal cutout temperature.

46.19 For the cooling operation test and temperature operation test (Clause 48), an inlet duct is not required. For heating tests, an inlet duct shall be connected to the return air opening of the unit (assuming that the unit is intended to be so applied). The duct shall be the same size as the flanges, if flanges are provided. If flanges are not provided, the duct shall be the same size as the inlet opening.

46.20 The inlet duct shall be provided with an adjustable restricting means by which the air flow can be reduced. The restriction should be uniform across the duct cross-sectional area, so that the full heating coil surface will be exposed to the air flow except when the restriction is closed.

46.21 A unit that has provision for the attachment of an outlet duct or plenum shall be fitted as described below for tests in which an outlet duct is specified. The duct shall be the same size as the flanges, if flanges are provided. If flanges are not provided, the duct shall be the same size as the outlet opening.

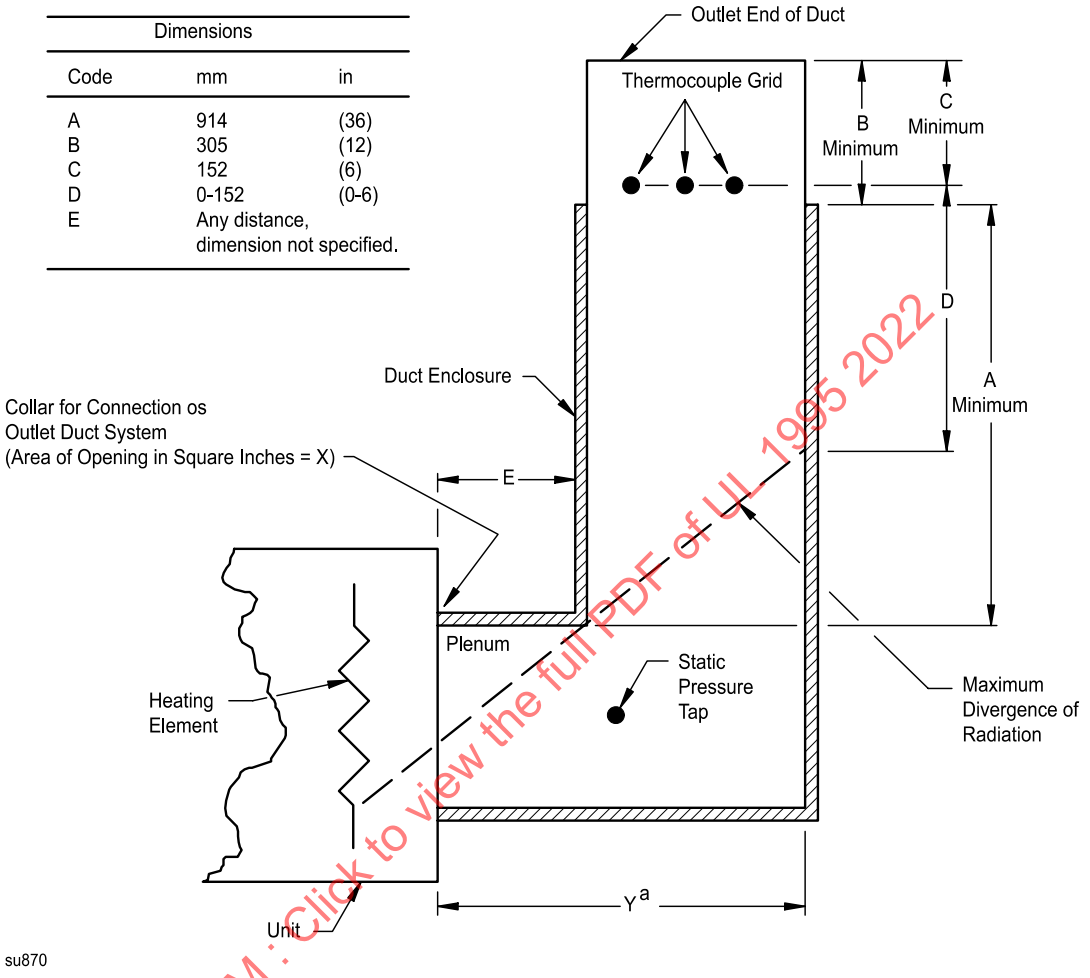
46.22 A unit that does not include electric heating means shall be fitted with an outlet duct sized to fit the casing flanges, or openings without flanges, or locations marked for flanges, and arranged to discharge away from the return air inlet.

46.23 A unit that includes or has provision for field installation of electric heating means shall be fitted with a metal plenum and an outlet duct in accordance with Figure 46.1.

Figure 46.1

Warm Air Outlet

Dimensions		
Code	mm	in
A	914	(36)
B	305	(12)
C	152	(6)
D	0-152	(0-6)
E	Any distance, dimension not specified.	



Notes to Figure 46.1:

1) The enclosure illustrated represents a plan view for a horizontal discharge unit, and a side view (rotated 90°) for an upflow or downflow unit. The outlet duct of an upflow or downflow unit shall extend at a right angle to the discharge air flow direction, and shall discharge away from the return air inlet.

2) Plenum dimension Y is determined as follows:

a) Horizontal flow unit: Y shall be no more than square root of X.

b) Upflow unit: Same as for horizontal flow unit, except that height of unit plus Y shall be no more than 2.3 m (7 ft, 6 in) or per the manufacturer's installation instructions minus specified clearance to combustible material for a unit other than a mobile home unit, or 2.1 m (7 ft) minus that clearance for a mobile home unit.

3) Downflow unit: Y shall be no more than 305 mm (12 in) plus square root of X for a unit other than a manufactured (mobile) home unit, or 25.4 mm (1 in) plus square root of X for a manufactured (mobile) home unit. However, in either case, the spacing may be increased if necessary, to obtain the specified clearance to combustible material from the upper surface of the outlet duct.

4) The thermocouple grid shall consist of nine thermocouples of identical length, wired in parallel to form a grid with a thermocouple located centrally in each of nine equal duct areas in a plane perpendicular to the axis of air flow.

5) The outlet duct system shall be provided with means for restricting the air flow.

6) Dimensions of this Figure are not to scale.

46.24 Thermostats intended for control of room temperature, outdoor thermostats, or other temperature regulating controls whose functioning during the normal operation of the equipment could tend to reduce the temperatures, shall be shunted out of the circuit, except as allowed in Clause 53.7.

Test Enclosure

46.25 The requirements in Clauses 46.26 to 46.29 apply only to a product that includes, or has provision for field installation of, electric heating means.

46.26 When zero clearance is specified, insulation 25.4 mm (1 in) thick and having a density no less than 16 kg/m^3(1 lb/ft^3) shall be wrapped closely around the plenum, outlet duct, and other heated surfaces.

For units that meet the zero clearance temperature test requirements, clearances greater than zero may be specified on the unit nameplate.

46.27 For units for which other than zero clearance is specified, a wood test enclosure shall be installed so as to encase the plenum, outlet duct, and heated surfaces of the unit which includes electric heating means.

The wood test enclosure shall consist of 25.4 mm (1 in) nominal thickness wood boards, or 19.1 mm (3/4 in) plywood, with inside surfaces painted flat black, and with all joints sealed. It shall be completely encased, and shall be spaced from the heated surfaces according to the clearance from combustible surfaces specified by the manufacturer.

46.28 If the unit is intended to be installed on a noncombustible floor, the floor of the partial enclosure shall be of noncombustible material such as stone, brick, or concrete. If the unit is intended to be installed on a combustible floor, the floor of the partial enclosure shall consist of unpainted plywood, 19 mm (3/4 in) thick.

46.29 Temperatures shall be measured on the metal surfaces, if zero clearance is specified. Temperatures shall be measured on the inside surfaces of the wood enclosure, if a clearance of more than zero is specified.

Instrumentation

46.30 Temperatures shall be measured by thermocouples, except that the change of resistance method may be used to measure the temperature of motor windings or of coils. The thermocouples shall consist of wires not larger than 24 AWG and not smaller than 30 AWG.

46.31 A thermocouple junction shall be securely held in good thermal contact with the surface of the material whose temperature is being measured. Adequate thermal contact may be obtained by taping, cementing, brazing, or soldering the couple in place.

46.32 Pressure gauges as applicable shall be attached using minimum lengths of 3.2 mm (1/8 in) outside diameter tubing.

47 Input test

Circuits – Other than Electric Heaters

47.1 The electrical input shall be measured when stabilized thermal conditions are obtained. The electrical input to compressor motors and other electrical loads shall be measured under the following conditions:

a) Load conditions – as specified in Table 46.4 or Clause 46.3, as applicable;

b) Voltage – at unit nameplate marked voltage; tolerances as specified in Table 46.6.

Exception: This test may be waived, if

1) The rated load amperes marked on the product nameplate is not less than 5 per cent below the input amperes as measured during the heating, cooling, and temperature operation tests, Clauses 48 through 51; or

2) The unit is provided with a current-limiting control system.

Electric Heater Circuits

47.2 The input to the electric heater circuits shall be measured when the product is operating under the following conditions:

a) Sample – as specified in Clause 46.16. Any inlet temperature between 15.5°C (60°F) and 35°C (95°F) dry bulb is acceptable for this test. (The wet bulb air temperature is not specified.)

b) Voltage – as specified in Table 46.6.

48 Temperature operation test – without any supplementary heating means

48.1 Motor protective devices shall not trip during the test. The maximum temperature measured shall not exceed the values specified in Column 1 of Table 46.5.

48.2 The test arrangement and conditions shall be as follows:

a) Voltage – as specified in Table 46.6.

b) Inlet air conditions – 26.7°C (80°F), ±1.1°C (±2°F) DB, wet bulb is not specified.

48.3 The unit shall be operated continuously until temperatures are constant. The electrical input to the motor(s) and other electrical loads shall be measured during the test.

49 Temperature operation tests – with hot water or steam heating

49.1 For a unit employing a hot water coil, the temperature of the entering water shall be the maximum inlet temperature marked on the unit. The rate of flow shall be so adjusted that the temperature of the water at the outlet is 11°C (20°F) lower than that of the entering water, except that a lower temperature differential may be employed if recommended by the manufacturer.

49.2 For a unit employing a steam coil, the pressure of the entering steam shall be the maximum steam pressure marked on the unit.

49.3 The temperature of the discharge air shall not exceed 93°C (200°F) during the test.

49.4 Motor protective devices shall not trip during the test. The maximum temperatures measured shall not exceed the values specified in Column 1 of Table 46.5.

49.5 The test voltage shall be as specified in Table 46.6. The inlet air temperature maintained during the test shall be 26.7°C (80°F) ±1.1°C (±2°F) dry bulb. Wet bulb temperature is not specified.

49.6 The unit shall be operated continuously until temperatures are constant. The electric input to the motor(s) and other electrical loads shall be measured during the test.

50 Cooling operation test – temperature and pressure

50.1 This test shall be conducted on all units having provision for cooling that employ refrigerant coils for evaporating and condensing. Pressure-limiting devices and motor protective devices shall not trip during the test. The maximum temperatures measured shall not exceed the values specified in Column 1 of Table 46.5, except that electrical components in an air handling compartment tested with 40°C (104°F) inlet air may exceed these values by 13.3°C (24°F). The test shall not result in refrigerant leakage or rupture of parts.

50.2 The test arrangement and conditions shall be as follows:

a) Load conditions – as specified in Table 46.4;

b) Voltage – as specified in Table 46.6.

During the temperature and pressure test on liquid chillers employing centrifugal motor-compressors, the motor-compressor shall be loaded to its marked rated load current. See Exception in Clause 47.1.

50.3 The unit shall be operated continuously until temperatures are constant and the maximum pressures are determined. The electrical input to the compressor motor and other electrical loads shall be measured during the test.

51 Heating operation test – temperature and pressure

51.1 This test shall be conducted on all units that have provision for refrigerant heating without any supplementary means for heating (for example, electric heaters, hot water, steam, gas, or oil). During this test, the maximum temperatures measured shall not exceed the values specified in Column 1 of Table 46.5. There shall be no refrigerant leakage or rupture of parts.

51.2 The test arrangement and conditions shall be as follows:

a) Load conditions – as specified under “Temperature and pressure tests – heating” of Table 46.4;

b) Voltage – as specified in Table 46.6.

After the air flow and static pressure are initially set, the inlet air opening shall be restricted to approximately 50 per cent of the opening area. The test shall continue until temperatures are constant, and the maximum pressure has been determined.

Exception: For heat pumps not provided with an indoor fan motor and intended to operate in conjunction with an installed furnace, the indoor air quantity shall be adjusted to a value 10 percent less than the specified minimum value in the manufacturer's instructions.

51.3 With reference to Clause 51.2, if operation is interrupted by a limit control or motor overload protective device, when the inlet air is restricted, the restriction shall be eased slowly until the heat pump operates without interruption. The test shall continue until temperatures are constant and the maximum pressure has been determined.

52 Abnormal temperature and pressure tests – refrigerant heat only

52.1 If the equipment has a pressure-limiting device that is in compliance with Clauses 34.32 to 34.35, the tests described in Clauses 52.2 and 52.3 may be waived.

Indoor Fan Failure and Water Failure

52.2 The unit shall be operated under the conditions of Clause 51 until constant temperatures have been attained. All indoor fan motor(s) shall then be disconnected, and the unit permitted to function as it will until maximum temperatures and pressures are attained, or until representative maximum temperatures and pressures are reached under cycling load. The compressor motor overload device and/or the fan motor overload device may operate during this test. The room ambient shall be approximately 26.7°C (80°F). The test voltage shall be as specified in Table 46.6.

52.3 The unit shall be operated with the water shut off, and also with the water restricted until maximum stabilized temperatures are reached or until representative maximum temperatures are attained under cycling load. If the unit cycles on a motor overload protective device, the test shall continue until the maximum pressure during the protective device operation is obtained. The room ambient shall be approximately 26.7°C (80°F).

52.4 The equipment tested as specified in Clauses 52.2 and 52.3 is considered to comply if all of the following conditions are met:

a) The refrigerant system does not rupture or develop leaks during the test. The maximum pressure recorded shall be used to determine the strength of all parts in the equipment;

b) The maximum temperature of the hermetic motor compressor enclosure including the surface of a wrap around crankcase heater does not exceed 150°C (302°F);

Exception: An enclosure including the surface of a wrap around crankcase heater subjected to discharge gas shall not exceed 200°C (392°F). The equipment shall then be subjected to the Dielectric voltage withstand test of Clause 61.

and

c) there is no damage to any electrical components or refrigerant-containing parts.

53 Electric heater tests

General

53.1 The tests in this Clause shall be conducted on any unit that employs electric resistance heaters. For a heat pump the capacity of the refrigerant heat source or an alternate heating source shall be equal to the heat pump's capacity when operated under the load conditions specified under temperature test-heating or Input test-heating in Table 46.4. This capacity shall be maintained throughout the test, unless and until, during the abnormal temperature tests, the high pressure switch functions to shut off the refrigeration unit.

Continuity of operation – simultaneous electric resistance heat and refrigerant heat

53.2 This test shall be conducted on any heat pump that includes electric heating means. The unit shall operate continuously without opening any limit control or overload protective device. Also see Clause 53.1.

53.3 The test arrangement and conditions shall be as follows:

a) Load conditions – as specified under "Temperature test-heating" in Table 46.4;

b) Voltage – as specified in Table 46.6.

53.4 The product shall be placed in heating operation with all electric heaters energized. There shall be no inlet air restriction except as inherent in the device, with air filters in place.

53.5 The test shall continue until the outlet air and surface temperatures have stabilized.

53.6 A temperature- or pressure-limiting device, or a motor overload protective device, shall not open during the test.

53.7 An air-to-air heat pump so designed that all supplementary heaters cannot be energized if operated at the outdoor temperature specified in Table 46.4 may be tested at the maximum outdoor air temperature that permits the heaters to be energized. Any control that controls the operation of electric heaters shall comply with Clause 30.12.

Continuity of operation – electric resistance heat only

53.8 This test shall be conducted on any unit that can have only the electric resistance heaters operate without any other heating means, except hot water or steam heating. The unit shall be operated as specified in Clause 53.2, except that any refrigeration unit shall be inoperative and the ambient temperature is not specified. The voltage shall be as specified in Table 46.6. If hot water or steam heating can be simultaneously energized with the electric heaters, this additional heating means shall be operating during the test. See Clauses 49 and 53.1.

53.9 For equipment, such as makeup air units with electric heat, designed and intended to be utilized at entering air temperatures less than 80°F and employing one of the following control schemes, the inlet air temperature will be as per the manufacturer's specifications and not per Clause 46.3.

a) A functional limit control (that meets the requirements in Clauses 30.11 – 30.14) to operate to de-energize the appropriate number of heaters. This functional limit control shall have to have the same construction as the primary limit controls, but shall be set at a temperature 3°C (5.4°F) lower so the functional limit control would always function first - before the primary limit controls (that meets the requirements in Clauses 30.11 – 30.14 and 53.9).

b) A regulating control to control the heaters, if the heaters also have primary limit controls and back-up protection limit controls as described in Clause 55.

Limit control cutout test – simultaneous electric resistance heat and refrigerant heat

53.10 A limit control, when adjusted to the maximum setting allowed by a fixed stop, shall prevent a unit from delivering air at a temperature exceeding 93.3°C (200°F).

53.11 The test arrangement and conditions shall be as described for the continuity of operation test, Clause 53.2. The unit shall be operated as described in that Clause until the outlet air temperature is constant.

53.12 The inlet opening shall be slowly and uniformly restricted at the rate indicated in Clause 53.15, with no other readjustment of the system, until a limit control opens, at which point the outlet air temperature shall be measured.

53.13 When a heat source other than refrigerant heat is used, it shall be de-energized when its temperature rise reaches the value calculated using the following equation: [3]

For temperature rise measurements in °C:

$$\Delta t = \dot{q} \div (k \times Q)$$

where

Δt = the temperature rise in °C,

$\dot{q}$ = the heat capacity determined in Clause 53.1 (kW),

Q = the minimum air flow rate from Clause 51.3 (m^3 / sec),

k = 1.2 [kJ / (m^3 – °K)]

For temperature rise measurements in °F:

$$\Delta t = \dot{q} \div k \times Q)$$

where

Δt = the temperature rise in °F,

$\dot{q}$ = the heat capacity determined in Clause 53.1 (Btu / hr),

Q = the minimum air flow rate from Clause 51.3 (ft^3 / min),

k = 1.085 [(Btu-min) / (ft^3 – hr – °R)]

53.14 If the heat pump and/or heater circuits are not fully deenergized by the first limit control operation, the test shall be continued by further restricting the inlet air until either all limit controls trip or the outlet air temperature stabilizes.

53.15 The outlet air temperature rise caused by the restriction of the air inlet opening shall be approximately 1.1°C/min (2°F/min). If more than 10 min is required before the first limit control opens, the specified rate of restriction need only apply to the final 10 min period prior to functioning of that limit control.

Limit control cutout test – electric resistance heat only

53.16 The requirements of Clauses 53.11 to 53.15 shall also apply to equipment with any refrigeration unit inoperative with the outdoor temperature not specified.

Heating operation test – unit with electric resistance heaters

53.17 The requirements of this Clause shall be applied to equipment operating in the electric heat only mode, simultaneous electric resistance heat with hot water or steam mode, or in the simultaneous electric resistance heat and refrigerant heat mode of operation.

53.18 This test shall be conducted immediately following the Fan delay test, Clause 56, if performed, and the Limit control cutout tests, Clauses 53.11 to 53.16.

53.19 The test arrangement and conditions are the same as for the limit control cutout tests, except that the limit controls shall be shunted out of the circuit. The inlet air restriction shall be eased until the output air temperature is 3°C (5.4°F) less than the outlet air temperature measured at the time of operation of the first limit control during the Limit Control Cutout Test.

53.20 The unit shall be operated continuously until constant temperatures and maximum pressures are determined. The electrical input shall be measured at intervals during the test.

53.21 The maximum temperatures measured shall not exceed the values specified in Column 1 of Table 46.5.

53.22 The test shall not result in refrigerant leakage or in rupture of parts. The maximum pressure shall be recorded as a basis for the strength test requirements.

54 Abnormal temperature and pressure tests

General

54.1 These tests shall be conducted on any unit with supplementary heating means and all those specified in Table 46.2.

54.2 The tests described in this Clause shall not result in refrigerant leakage or rupture of parts. The maximum pressure shall be recorded as a basis for the strength test requirement. A unit employing a pressure-limiting device complying with Clause 34.34 as applicable is considered to comply with the high side pressure requirement.

54.3 For units intended to be connected to a duct system, the maximum temperatures measured during the tests described in this Clause shall not exceed

a) The value specified in Column 2 of Table 46.5 during 1 h after the first operation of a limit control or motor overload protective device; and

b) The value specified in Column 1 of Table 46.5 thereafter; except that a motor may attain the temperature specified in Column 2 during any part of the test.

54.4 For units without a duct system (free air discharge), the requirements of Clause 54.3 are not applicable. See Clause 54.5.

54.5 During the tests described in this Clause there shall be no

a) Emission of flame or molten metal; or

b) Risk of electric shock hazard; or

c) Glowing or flaming of the felt, cheesecloth, or drape (for units without a duct system, free air discharge only).

54.6 The test arrangement and conditions are unchanged from the continuity of operation test for the type of unit under test. The unit shall be operated to constant outlet air temperature, with the bypass removed from the limit controls.

54.7 Unless it is a required backup control, a manually resettable supplementary control that is a limit control may function during the tests specified in Clauses 54.11 to 54.16.

54.8 Units with multiple voltage ratings shall be tested as follows:

a) All abnormal tests shall be conducted at the voltage that results in the highest limit cutout temperature. See Clauses 53.10 to 53.16.

b) The abnormal test that results in the highest temperature shall be repeated at the other voltages. The remaining abnormal tests may be waived on the basis of the results.

54.9 For units without a duct system (free air discharge), when tested per Clauses 54.11 to 54.13, a layer of cheesecloth shall be placed over the outlet air opening. During the blocked outlet test, the cheesecloth shall be covered with a 25 mm (1 in) thick felt pad.

54.10 The felt mentioned in Clause 54.9 shall be standard weight, animal hair, punched felt with centre reinforcement consisting of burlap having a mass of 170 g/m^2 (5 oz/sq. yd). Felt 25 mm (1 in) thick has a mass of 3.56± 0.51 kg/m^2(105 ± 15 oz/sq. yd) or SAE J314, Grade F-11, one inch-thick wool felt, or made with felt strips each having a width of 100 mm and lined with a single layer of textile material. The felt has a specified mass of 4 kg/m^2 and thickness of 25 mm. The textile material consists of a prewashed double-hemmed cotton sheet having a mass between 140 g/m^2 and 175 g/m^2 in the dry condition. The cloth shall be bleached cheesecloth, 914 mm (36 in) wide, approximately 28 to 30 m/kg mass (14 to 15 yd/lb), and having for any 25.4 × 25.4 mm (1 × 1 in) square, 32 threads in one direction and 28 threads in the other.

Restricted inlet

54.11 The test shall be conducted under the same conditions as in the continuity of operation test for the type of unit under test and may be a continuation of the limit control cutout test. The inlet shall be uniformly restricted at such a rate that the outlet air temperature increases approximately 1.1°C (2°F) per min, but not faster, until operation is interrupted by a temperature limit control. The equipment shall be permitted to function without any further adjustment until temperatures become stabilized; the increase in restriction shall then be resumed until a second temperature limit control (if any) functions. Conditions shall then be allowed to become stable, and the restriction shall then be resumed. This procedure shall be continued until the resulting temperatures and pressures are the maximum that occur with any amount of restriction.

Fan failure

54.12 The unit shall be restored to operation temperatures, as in the continuity of operation test. All blower motors shall be deenergized. The assembly shall be permitted to function as it will until maximum temperatures are reached under stable or cycling conditions.

Blocked outlet

54.13 The equipment shall be allowed to resume normal temperatures as in the continuity of operation test, with the blower motor operating. The air outlet shall then be blocked completely, and operation continued until the limit control functions to interrupt the heater element circuit. The system shall then be permitted to function without any further adjustment until maximum stabilized temperatures are reached or until representative maximum temperatures are attained under cycling load.

54.14 This test shall not be conducted on any unit without a duct system (free air discharge) with any air discharge openings located more than 1.22 m (4 ft) above the floor level when the unit is installed as intended.

Curtain drape

54.15 This test shall not be conducted on a ceiling-mounted, or on a top or bottom discharge wall or floor mounted unit without a duct system (free air discharge).

This test may be waived if during the continuity of operation test the curtain drape is blown away from the discharge openings of the unit.

54.16 The upper edge of a simulated curtain, a minimum of 0.9 m (3 ft) high vertically and a minimum of 2.4 m (8 ft) long horizontally, shall be continuously attached to a vertical wall above the unit. The curtain shall consist of 8 oz white duck plus an overlay of cheesecloth as described in Clause 54.10 on the side facing the heater, and shall be hung loosely in folds so that a 2.4 m (8 ft) length covers a 1.8 m (6 ft) length of the unit, completely blocking the air discharge openings. The bottom edge of the curtain shall be located so that it will barely touch the floor. During the test, the curtain shall be draped to conform as closely as possible to the contour of the surface of the unit.

55 Backup protection tests

General

55.1 The tests described in this Clause shall be conducted on a product provided with, or having provision for field addition of, electric heaters and which is provided with a backup protective device (see Clause 30.17). If the unit is a heat pump, the unit shall operate the electric heaters simultaneous with the refrigerant heat.

55.2 When tested in accordance with this Clause, the temperature at the points mentioned in Clause 55.3 shall not exceed 100°C (212°F) except that the temperature shall not exceed 130°C (266°F) during the 30 min period following the initial imposition of the test condition. The temperature following the functioning of one or more of the manually resettable or nonresettable limit controls or thermal cutoffs shall be no more than 175°C (347°F); however, at the end of the 30 min period following the functioning of the first control or cutoff, the temperature shall not exceed 100°C (212°F).

55.3 The temperature limit mentioned in Clause 55.2 applies to the metal duct and the product itself, where suitable for zero clearance installation, and the inside surface of the wooden test enclosure, of any product employing electric heaters.

55.4 The test arrangement and conditions are unchanged from those described in the Abnormal temperature and pressure tests, Clause 54. The product shall be operated as described in the continuity of operation tests until the outlet air temperature is constant, with the automatically reset temperature-limiting control of the electric heaters bypassed.

55.5 A pressure-limiting device or other control may operate to deenergize the compressor motor during the tests described in Clauses 55.7 to 55.10. If a manually reset pressure or temperature-limiting device also deenergizes the electric heater circuits, the latter function shall be

a) Bypassed if the device controls the heater through a contactor or equivalent control that also operates in the normal temperature-regulating circuit of the heater; and

b) Allowed to control the heater if such control is accomplished through a backup contactor.

55.6 Clause 54.8 shall apply for multiple voltage rated units.

Restricted inlet

55.7 This test shall be conducted as described in Clause 54.11, except that the rate of restriction of the inlet duct shall be such that the opening is totally blocked at the end of 30 min.

55.8 If a manually reset pressure- or temperature-limiting device that is not bypassed for heater control, as indicated in Clause 54.6, operates to deenergize the product and the electric heaters, the tests indicated in Clauses 55.9 and 55.10 may be waived.

Fan failure

55.9 This test shall be performed in accordance with Clause 54.12.

Blocked outlet

55.10 This test shall be performed in accordance with Clause 54.13.

56 Fan delay test – duct-connected downflow and horizontal units

56.1 During the normal operation of horizontal or downflow equipment provided with a fan delay control, starting with the equipment at room temperature, the fan control shall operate to prevent the air in the inlet and on the air filter, if provided, from attaining a temperature higher than 90°C (194°F). A limit control, thermal cutoff, or motor overload device shall not open before the fan control functions.

56.2 For downflow equipment, a duct having a cross-section the same size as the inlet air opening of the unit shall be attached to the return inlet air opening, and extended vertically, using a 90° elbow if the unit has only a side inlet air opening, to a distance of 2.3 m (7-1/2 ft) above the base of the unit. For horizontal equipment, a duct having a cross-section the same as the inlet air opening in the unit shall be attached to the air inlet, and extended vertically by means of a 90° elbow for a distance of 1.8 m (6 ft) above the top of the return air opening. The sample shall be arranged to operate against an external static pressure as specified in Clause 46.11. Any fan or limit control, if adjustable, shall be adjusted to the maximum temperature setting allowed by a fixed stop and minimum differential.

56.3 The temperature of the air in the inlet duct shall be measured by means of three thermocouples located in the plane of the return air (inlet air) opening of the unit. For a downflow unit, the thermocouples shall be on the horizontal centre line of the return air opening. For a horizontal unit, the thermocouples shall be on a horizontal line 1/3 of the distance below the top of the return air opening. One thermocouple shall be located 25.4 mm (1 in) from one side of the opening, one at the centre, and the other 25.4 mm (1 in) from the opposite side of the opening. None of the three thermocouples shall indicate a temperature higher than 90°C (194°F) prior to the operation of the fan control.

56.4 The conditions shall be as described in the continuity of operation test, see Clause 53.3 or 53.8, as applicable.

57 Control system failure test

57.1 The test described in Clauses 57.2 and 57.3 shall be conducted on any heat pump that is not provided with an indoor fan motor assembly (and hence is intended to be used with the fan motor assembly of an installed air handling unit).

Exception: a unit provided with a hazardous voltage interlocking circuit to prevent simultaneous operation of the heat pump and installed air handling unit need not be tested.

57.2 The heat pump shall be operated as described in the heating operation test without supplementary electric heaters, Clause 51, except that the inlet air temperature to the heat pump indoor coil shall be adjusted to 71.1°C (160°F). The indoor air quantity shall be adjusted to a value 10 percent less than the specified minimum value in the manufacturer's instructions.

The heat pump shall be operated to establish that the control specified in Clause 26.17 stops operation of the compressor motor before the compressor motor overload protective device operates. The heat pump shall be operated to constant temperatures as described in Clause 51, Heating operation test–temperature and pressure.

Note: The motor overload protective device may operate if the device is in a manual reset circuit that prevents automatic restarting of the compressor motor.

57.3 The maximum temperatures measured shall not exceed the values specified in Column 1 of Table 46.5. The test shall not result in refrigerant leakage or rupture of parts. The maximum pressure shall be recorded as a basis for the strength test requirements.

58 Fan motor failure test

58.1 If the equipment has a pressure-limiting device that is in compliance with Clauses 34.32 to 34.35, the test described in Clause 58.2 may be waived.

58.2 The unit shall be operated under the conditions of Clause 50 except the room ambient shall be approximately 26.7°C (80°F), until temperatures and pressures become constant. All outdoor fan motor(s) shall then be locked or deenergized, and the unit allowed to operate until maximum stabilized temperatures and pressures are reached or until representative maximum temperatures and pressures are attained under cycling load. The compressor motor overload device and/or the fan motor overload device may operate during this test. The unit shall comply with Clause 60.2.

59 Motors for use with wave chopping solid-state speed controls

59.1 In addition to the condition described in Clause 46.11, a motor that includes or that is intended for use with a solid-state speed control shall be operated under the following condition in Clause 59.2.

59.2 With the motor connected to an ac supply modified to produce half-wave output. The supply shall be switched from sinusoidal to half-wave output after the motor is operating at maximum speed. If after the supply is switched from sinusoidal to half-wave operation, the motor shaft does not continue to rotate in a manner that is a normal condition, the locked-rotor temperature requirements described in Clause 59.3 shall be used instead of the maximum temperature specified in Table 46.5. See Figure 59.1. For the requirements in this Clause and Clause 59.3, “normal” is defined as operation in excess of 10% of the measured maximum RPM.

59.3 When the motor shaft does not rotate or rotates in a manner not determined to be normal after the supply is switched from sinusoidal to half-wave operation as described in Clause 59.2 or the motor does not restart when operated from a half-wave source after the motor is de-energized, the motor shall comply with the applicable temperature requirements as follows:

a) The temperature of an impedance-protected motor shall comply with the locked-rotor temperature test requirements in CSA 22.2 No. 77 or UL 2111 or UL 1004-1 and UL 1004-3.

b) The temperature of a thermally-protected motor shall comply with the locked-rotor temperature test requirements in CSA 22.2 No. 77 or UL 2111 or UL 1004-1 and UL 1004-3, except:

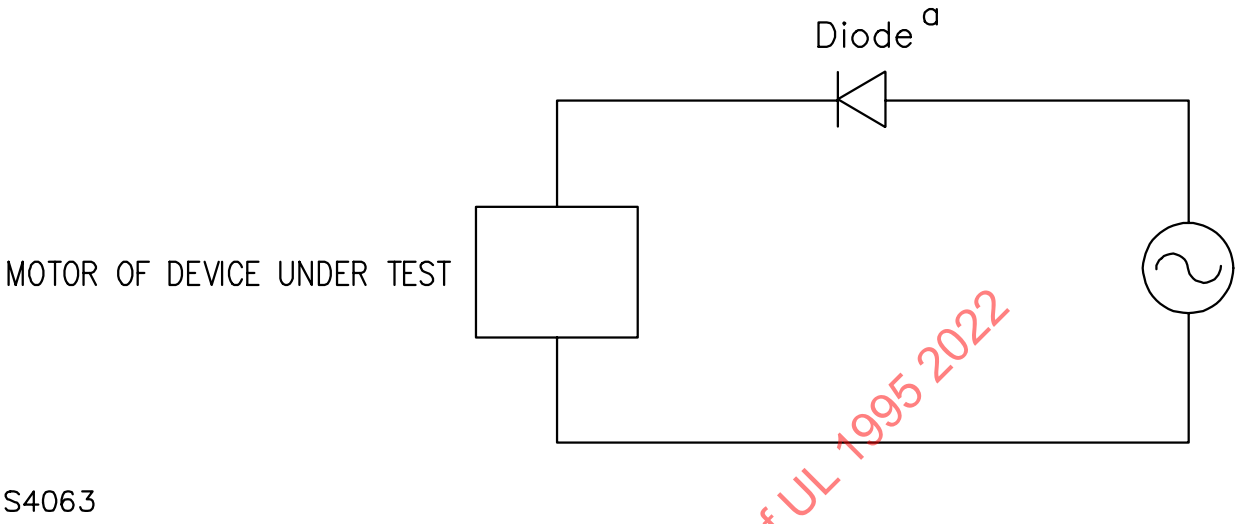
1) For a motor with an automatic reset type protective device, the temperature criteria shall not be applied during the initial cycle of the thermal protector operation and there shall be no emission of flame or molten metal, or

2) For a motor with a non-replaceable thermal cutoff, the temperature criteria shall not be applied when the thermal cutoff opens within the first hour and there shall be no emission of flame or molten metal.

c) The duration of the test shall be for 15 days. The power supply shall be modified to provide half-wave output directly to the motor and bypassing the integral solid-state speed control.

Figure 59.1

Half-wave test circuit



Footnote –

[a] A standard rectifier diode shall be used to produce the half-wave input to the motor of the device under test. The diode shall be sized for the rating of the device under test (at least twice the rating of the motor).

60 Condenser water failure test

60.1 For those units having water-cooled refrigerant heat exchangers, the unit, while operating in the cooling mode, shall be operated as in Clause 50 until temperatures and pressures become constant, whereupon the water shall be shut off or the condensing water restricted, until the maximum stabilized temperatures and pressures are reached or until they are attained under cycling load. If the unit cycles on a motor overload protective device, the test shall be continued until the maximum pressure during the protective device operation is obtained. The room ambient temperature shall be approximately 26.7°C (80°F).

60.2 The equipment is considered to comply if all of the following conditions are met:

a) The refrigerant system does not rupture or develop leaks during the test. The maximum pressure recorded shall be used to determine the strength of all parts in the equipment. A unit employing a pressure-limiting device complying with Clause 34.34, as applicable, is considered to comply with the high-side pressure requirement; and

b) The maximum temperature of the hermetic compressor motor enclosure does not exceed 150°C (302°F);

Exception: An enclosure subjected to discharge gas shall not exceed 200°C (392°F). The equipment shall then be subjected to the Dielectric voltage withstand test of Clause 61.
and

c) there has been no damage to the electrical components and refrigerant-containing parts.

61 Dielectric voltage-withstand test

61.1 The equipment shall withstand without breakdown the following:

a) A potential, as specified below, applied between live parts of hazardous voltage circuits, and dead (grounded) metal parts, for a period of 1 min. AC test potentials are 40 – 70 Hz and DC test potentials represent the peak value of the AC test potentials. For the test, the unit may be in a heated or unheated condition.

1) 1000 V ac or 1414 dc for units rated 250 V or less, and which include a motor rated at less than 1/2 hp.

2) 1000 V ac plus twice rated voltage or 1414 V dc plus 2.818 times rated voltage for units rated more than 250 V or which include a motor rated 1/2 hp or larger.

For units employing extra-low-voltage circuits, the test shall be conducted with this circuit connected to the cabinet, chassis, or other dead (grounded) metal parts, so that the potential that is applied between the live hazardous voltage parts and dead (grounded) metal parts will simultaneously be applied between the live hazardous voltage parts and the extra-low-voltage circuits.

61.2 There are two methods for subjecting the extra low voltage circuit to the dielectric test:

a) For units employing extra-low-voltage circuits, the test shall be conducted with this circuit connected to the cabinet, chassis, or other dead (grounded) metal parts, so that the potential that is applied between the live hazardous voltage parts and dead (grounded) metal parts will simultaneously be applied between the live hazardous voltage parts and the extra-low-voltage circuits; or

b) The extra-low-voltage circuit shall withstand, without breakdown, a minimum test potential of 500 volts applied for 1 minute between extra low-voltage live parts and dead metal parts. The test potential shall be at any frequency between 40 and 70 hertz. If protective devices of the type indicated in Clause 33.7 are employed in the extra low-voltage circuit, the test shall also be conducted between live parts of opposite polarity.

61.3 The test between extra-low-voltage parts of opposite polarity shall be conducted on magnet coil windings of the transformer after breaking the inner coil lead where it enters the layer. This opposite polarity test may be waived on the complete assembly provided that the components have been separately subjected to this test.

61.4 The test equipment used to determine compliance with Clause 61.1 shall include a transformer having an essentially sinusoidal output with a rating sufficient to maintain the required test potential. It shall also include an audible or visual indication of breakdown.

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

62 Condensate drain blockage test

62.1 The equipment shall be installed as intended, with the indoor fan motor energized. All condensate drain lines except overflow lines shall be blocked, and water added to the drain pan at a rate of not less than 500 mL (1 pint) per minute for each 472 L/s (1000 CFM) of air flow, until water overflows onto the floor.

During this test, water shall not impinge on uninsulated hazardous voltage parts and extra-low-voltage safety circuits, and shall not be retained within the enclosure for electrical parts or wiring.

A motor winding may be wetted; however, it shall be subjected to the Dielectric voltage-withstand test, Clause 61.

62.2 If the drain pan is located below all electrical parts, the test described in Clause 62.1 may be waived.

63 Loading test

63.1 A substantially horizontal plane on the top of equipment shall be capable of sustaining a static load of 91 kg (200 lbs), applied in a vertical direction, in the most unfavourable location, over an area of 152 mm (6 in) diameter. This load shall not result in:

a) A deflection that causes the structure to contact a moving part, and

b) A permanent deformation of the structure so as not to comply with Clause 11.2.

The structure shall comply with the requirements of this Standard following the loading test in the as received condition.

Polymeric cabinets and structural parts shall comply with the requirements of this Standard following the loading test in the as received condition.

63.2 Guarding shall have sufficient strength to withstand a force of 111 N (25 lbs) applied anywhere in a direction normal to the surface by the end of a rod 38.1 mm (1.5 in) in diameter. The application of this force shall not result in deflection that causes the guarding to contact a moving part, and shall not result in a permanent deformation of the guarding so as not to comply with Clause 11.2. The structure, including polymeric cabinets and structural parts, shall comply with the requirements of this standard following the loading test in the as received condition.

63.3 Equipment intended to be suspended from the wall or ceiling shall withstand the test described in Clause 63.4 without falling from its intended mounting location.

63.4 The equipment shall be installed as per the manufactures instructions. A load equal to three times the weight of the unit but not exceeding 181.6 kg (400 lbs) mass, acting vertically downwards, shall be applied uniformly to the unit for minimum of 1 minute.

64 Limited short-circuit test

64.1 Devices and conductors, as referenced in Clauses 20.19, 23.18, and Exception 2 of Clause 32.5, shall withstand short-circuit and ground-fault conditions when protected by either a device that is suitable for branch-circuit protection and located in the product, or a branch-circuit protective device of the type and rating specified in Clause 23.18. There shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing the components under test, and no arc over between hazardous voltage and extra-low-voltage circuits.

64.2 Each device and each conductor shall be connected in a circuit having a capacity based on the rated current and voltage of the product; see Table 64.1. The product rated current shall be determined by adding the rated motor currents and the other rated currents. The circuit capacity shall be measured without the devices or conductors in the circuit.

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

Table 64.1
Limited short-circuit test currents

Product ratings, A				
	Single phase			Circuit capacity,
110 – 120 V	200 – 208 V	220 – 240 V	254 – 277 V	A
9.8 or less	5.4 or less	4.9 or less		200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
	3 phase			Circuit capacity,
200 – 208 V	220 – 240 V	440 – 480 V	550 – 600 V	A
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

65 Transformer – burnout test

65.1 There shall be no emission of flame or molten metal from the product enclosure or emission of smoke in an indoor air handling compartment when a transformer having a hazardous voltage primary is operated under the conditions described in Clauses 65.2 and 65.3.

This test does not apply to a transformer having a hazardous voltage primary that is provided with thermal overload protection of other than the nonrenewable thermal cutoff type (see Clause 27.4), or that is protected by an overcurrent device in accordance with the requirements of Clause 27.6.

65.2 Three samples of the transformer shall be operated continuously at the normal test voltage indicated in Table 46.6 and rated frequency with the enclosure grounded. The test ambient temperature shall be 26.7°C (80°F), and operation shall be continued until constant temperature is indicated by a thermocouple on the enclosure or until burnout occurs. The circuit on which the transformer is tested shall be protected by fuses rated not less than that required for the product.

65.3 The load connected to the output terminals shall be the highest of the following, and shall be readjusted to the specified value after 2 min of operation, if necessary, with no further readjustment during the test:

a) A resistance load to provide a current equal to three times the full rated transformer secondary current; or

b) If the transformer supplies a motor with or without additional loads, a resistance load to provide a current equal to the motor locked rotor current plus any additional load; or

c) Iif the transformer supplies an inductive load (other than a motor) such as the coils of relays, solenoids, and the like, a resistance load to provide a current equal to the sum of such loads with the armature of the largest blocked open.

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

66 Transformer – overload test

66.1 This test applies to a transformer having a hazardous voltage primary provided with thermal protection of other than the nonrenewable thermal cutoff type. See Clause 27.4.

66.2 Temperatures of a thermally protected transformer having a hazardous voltage primary, measured on the surface of the windings, shall not exceed the insulation temperature rating when the transformer is tested as indicated in Clauses 63.3 and 63.4. Insulation temperature rating is defined as the rating for the class of insulation.

66.3 A variable resistance load shall be connected to the output terminals, and the transformer operated continuously at the normal test voltage indicated in Table 46.6. If the protective device controls a switching device that, in turn, interrupts primary current to the transformer, the switching device shall be in the circuit. The test ambient temperature shall be approximately 26.7°C (80°F). The resistance load shall be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 10°C (18°F) below its insulation rating. The load shall then be gradually increased until operation of the protector occurs.

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

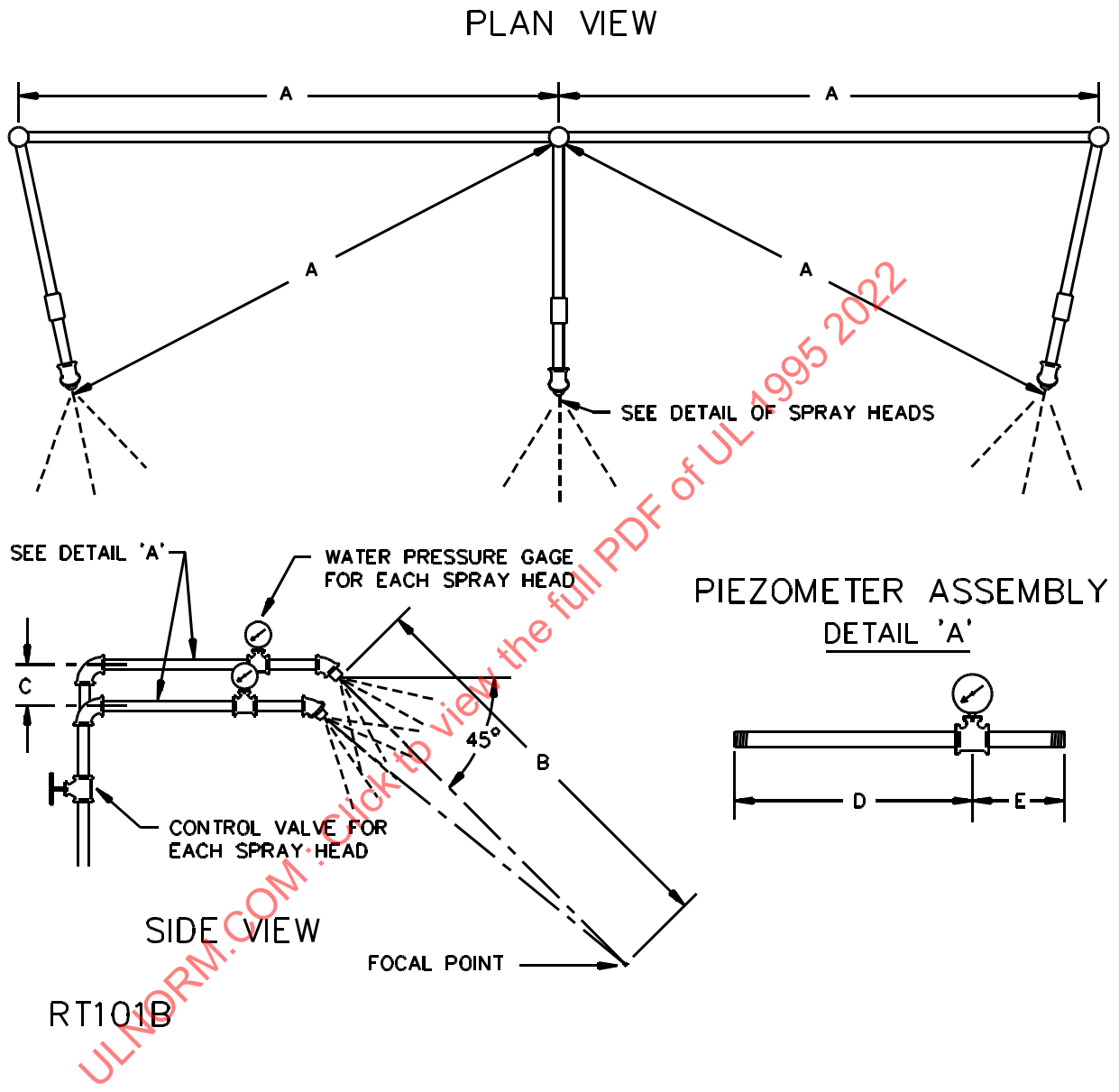
66.5 The transformer shall comply with the dielectric voltage-withstand test, Clause 61, following the above test.

67 Rain test

67.1 The rain test apparatus shall consist of three spray heads mounted in a water supply rack as shown in Figure 67.1. The spray heads shall be constructed in accordance with Figure 67.2. The product shall be brought into the focal area of the three spray heads in such position, and under such conditions, that the greatest quantity of water will enter the product.

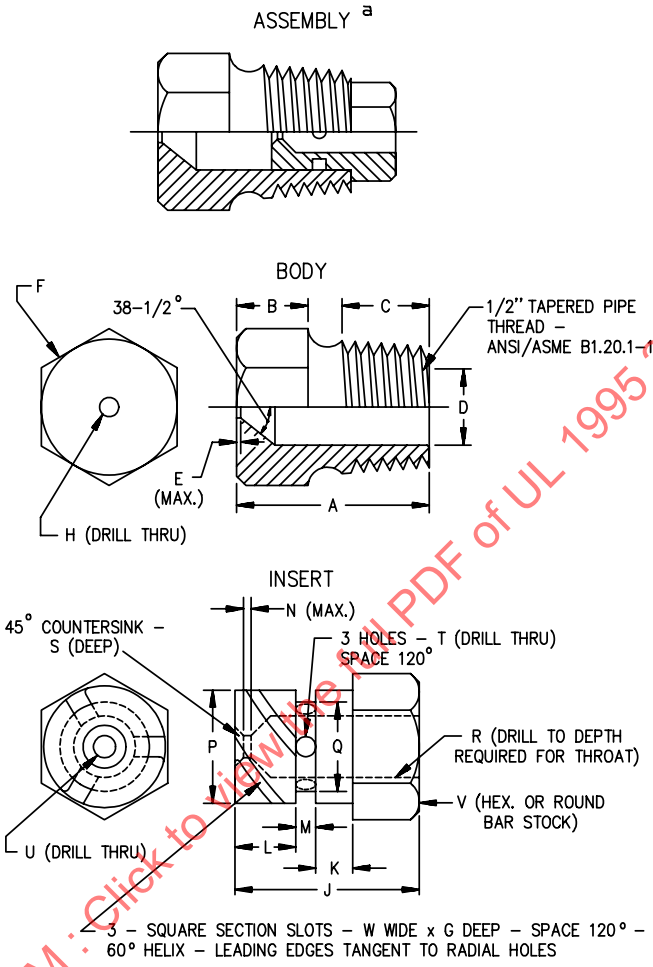
Figure 67.1

Rain test apparatus



Item	mm	inch
A	710	28
B	1400	55
C	55	2.25
D	230	9
E	75	3

Figure 67.2
Rain Test Spray Head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.53
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No. 9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-test spray heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional – To serve as a wrench grip.

67.2 The spray shall be directed, at an angle of 45° to the vertical, towards the louvres or other openings closest to live parts. Water pressure shall be maintained at 34.5 kPa (5 psig) at each spray head.

67.3 The equipment shall be operated so that electrical components are energized, and the product shall be tested under the intended conditions of use judged most likely to cause the entrance of water into or onto electrical components. If the unit is equipped with an outdoor service receptacle, the test shall be conducted with a plug inserted in the receptacle. It could be necessary to operate the unit under various modes of operation or to deenergize the product, if more adverse conditions could result. In any case, each exposure shall be for 1 h.

67.4 Openings intended for field conduit connection shall be provided with such connections, with the outer end sealed, but with pipe thread compound at the connection. Openings intended for the entry of conductors for Class 2 wiring shall not be sealed.

67.5 After the final exposure to the rain, the complete product shall be subjected to the Dielectric Voltage-Withstand Test, Clause 61.

67.6 When multiple exposures to rain are necessary, the dielectric-withstand test shall be repeated in the wet condition if drying could occur between exposures.

67.7 Water shall not enter enclosures above the lowest electrical component other than insulated wire. Uninsulated hazardous voltage parts and extra-low-voltage safety circuits shall not be wetted. There shall be no accumulation of water within the enclosures of electrical parts.

Exception No. 1: Water may enter an enclosure above the lowest electrical component, if the point of entrance is not in proximity to live parts, and if live parts except insulated wire are not wetted.

Exception No. 2: A motor winding may be wetted if the motor complies with the Dielectric Voltage-Withstand Test of Clause 61.

68 Accelerated aging tests

Gaskets

68.1 Rubber or neoprene compounds, except foamed materials, used for gaskets to seal electrical enclosures of outdoor equipment shall have physical properties as indicated in Table 68.1 before and after accelerated aging under the conditions indicated in Table 68.2.

68.2 If non-metallic sealing gaskets or protective barrier tape are employed to meet the requirements of Clause 89.2, and the application is such that UV exposure could affect the intended sealing or securing function, the material shall meet the requirements of Clause 89.1.

68.3 Foamed neoprene or rubber compounds forming gaskets to seal an electrical enclosure of outdoor equipment shall not harden or otherwise deteriorate to a degree that will affect their sealing properties after accelerated aging under the conditions indicated in Table 68.2.

68.4 Thermoplastic materials forming gaskets to seal an electrical enclosure of outdoor equipment shall not deform, melt, or otherwise deteriorate to a degree that will affect their sealing properties after accelerated aging under the conditions indicated in Table 68.2. Solid polyvinyl chloride gasket material shall have physical properties as indicated in Table 68.1 before and after the accelerated aging.

68.5 Gaskets of materials other than those mentioned in Clauses 68.1 to 68.3 shall be nonabsorptive, and shall provide equivalent resistance to aging and temperatures.

The temperatures indicated in Table 68.2 correspond to the maximum temperatures measured on the gasket during the temperature and pressure tests.

Table 68.1
Physical properties for gaskets

	Neoprene or rubber compound		Polyvinyl chloride materials	
	Before test	After test	Before test	After test
Recovery–Maximum set when 25.4 mm (1 in) gauge marks are stretched to 63.5 mm (2-1/2 in), held for 2 min and measured 2 min after release	6.4 mm (1/4 in)	–	Not specified	
Elongation–Minimum increase in distance between 25.4 mm (1 in) gauge marks at break	250% 25.4 – 88.9 mm (1 – 3-1/2 in)	65% of original	250% 25.4 – 88.9 mm (1 – 3-1/2 in)	75% of original
Tensile strength–Minimum force at breaking point	5.86 MPa (850 psi)	75% of original	8.27 MPa (1200 psi)	90% of original

Table 68.2
Accelerated aging conditions for gaskets

Measured temperature °C (°F)		Material	Test program
60	(140)	Rubber or neoprene	70 hours in an air-circulating oven at 100°C ± 2°C (212°F ±3.6°F)
60	(140)	Thermoplastic	7 days in air-circulating oven 87°C (189°F)
75	(167)	Rubber or neoprene	168 hours in an air-circulating oven at 100°C ± 2°C (212°F ±3.6°F)
75	(167)	Thermoplastic	10 days in an air-circulating oven at 100°C (212°F)
80	(176)	Rubber, neoprene, or thermoplastic	7 days in an air-circulating oven at 113°C (235.4°F)
90	(194)	Rubber or neoprene	10 days in an air-circulating oven at 121°C (249.8°F)
90	(194)	Thermoplastic	7 days at 121°C (249.8°F) or 60 days at 97°C (206.6°F) in an air-circulating oven
105	(221)	Rubber, neoprene, or thermoplastic	7 days in an air-circulating oven at 136°C (276.8°F)

Polymeric Materials

68.6 Specimens of polymeric material used for cabinets and structural parts shall be conditioned as indicated in Table 68.3. A sufficient number of samples should be conditioned for the tests of Clauses 68.6 and 68.7.

Table 68.3
Accelerated aging conditions for polymeric materials

Intended use[a]	Normal operating temperature[b] °C (°F)	Oven aging Condition	
		Temperature °C (°F)	Time, h
Cabinet (Indoor only)	65 (149)	90 (194)	168
Cabinet	75 (167)	90 (194)	1440
Cabinet	85 (185)	95 (203)	1440
Cabinet	95 (203)	105 (221)	1440
Cabinet	100 (212)	121 (250)	1440
Structural Parts	50 (122)	75 (167)	1440
Structural Parts	75 (167)	100 (212)	1440
Structural Parts	100 (212)	121 (250)	1440

[a] If the same polymeric material is used for both a cabinet and a structural part, it shall be subjected to the oven aging condition shown for a cabinet. The oven aging condition shall be the higher of the values shown for either the cabinet or structural part but not less than that for a normal operating temperature of 75°C (167°F).

[b] Normal operating temperature shall be determined by Table 46.1 and Table 46.2 as applicable. If this temperature is between two values, the higher of these two values shall be used in determining the oven aging condition.

68.7 Conditioned specimens shall comply with the flame/burning tests specified for the material (see Clause 5.10.1) in accordance with CAN/CSA-C22.2 No. 0.17 and UL 94.

68.8 Conditioned specimens shall be subjected to the following tests in accordance with CAN/CSA-C22.2 No. 0.17 and UL 746A as applicable:

a) Tensile strength,

b) Flexural strength,

c) Izod impact,

d) Tensile impact.

68.9 After the applicable test of Clause 68.7, the specimens shall not have more than a 50-percent reduction of the unconditioned property values for items (a) – (d).

Exception: Polymeric material specimens that already have a thermal index rating equal to or greater than that indicated in Table 68.3 under the normal operating temperature column in accordance with UL 746B and CAN/CSA-C22.2 No. 0.17 are considered to be in compliance with the requirements in Clause 68.5 – 68.7 and need not be retested.

69 Impact test

69.1 Cabinets, structural parts, and enclosures shall comply with the requirements of this standard following the impact tests.

69.2 These tests shall be applicable to polymeric materials used as a cabinet, structural part, or an enclosure. These polymeric materials shall be tested for strength in locations judged most likely to fail under impact on samples in the as received condition.

69.3 A cabinet, structural part or an outer enclosure shall withstand an impact of 6.8 J (5 ft-lb).

Exception: Cabinets of indoor units intended to guard against moving parts shall withstand an impact of 2 J (1.5 ft-lb).

69.4 An internal structural part or an internal enclosure shall withstand an impact of 2 J (1.5 ft-lb).

69.5 With reference to Clauses 69.3 and 69.4, the application of an impact from a steel ball 51 mm (2 in) in diameter and weighing 0.53 kg (1.2 lb) shall be applied. This steel ball shall be suspended by a cord and allowed to swing as a pendulum or allowed to fall freely from a height of 1290 mm (50.8 in) for a 6.8 J (5 ft-lb) impact and a height of 380 mm (15 in) for a 2 J (1.5 ft-lb) impact.

69.6 The steel ball shall not impact the surface more than once in the same location.

69.7 Equipment intended for outdoor use shall comply with the resistance to impact test at minus 35 ± 2°C (minus 31°F ± 3.6°F) in CAN/CSA-C22.2 No. 0.17 and UL 746C.

70 Strength tests

70.1 These tests shall be applicable to those refrigerant-containing parts and hot water and steam coils that are required to comply with the strength requirements specified in Clause 34.

Exception: Pressure-actuated refrigeration controllers and crankshaft seals are not required to meet the requirements of Clause 68.

70.2 Two samples of each refrigerant-containing part shall be tested, except that only one sample of the following need be tested on liquid chillers employing centrifugal motor compressors, motor-compressor enclosure, volutes, cross-over pipe, condenser and evaporator, and the equivalent.

70.3 The test samples shall be filled with any inert liquid, such as water, to exclude air, and shall be connected in a hydraulic pump system. The pressure shall be raised gradually until the required pressure is reached, and shall be maintained for 1 min.

70.4 The test pressure required shall be computed in accordance with Clauses 34.4 and 34.8.

70.5 Parts shall be considered to comply with the requirement if they do not burst or leak, except that leakage at gaskets shall not be considered a failure if the leakage occurs at a pressure greater than 40 per cent of the required test pressure.

70.6 With reference to Clauses 70.1 to 70.5, sections of the refrigerant system constructed of continuous tubing, or of lengths of tubing connected by hard soldered brazed or welded joints, shall be considered as meeting the requirements, provided the tubing employed in the assembly meets the minimum thickness requirements of Table 34.1.

71 Fatigue test analysis

General

71.1 These tests shall be applicable to those parts or the complete system that contains refrigerant and that are required to comply with the strength requirements specified in Exception No. 3 of Clause 34.3.

Test Specification

71.2 When tested in accordance with Clause 71, a part or a complete system shall have sufficient strength to withstand the pressure strength test requirements specified in the Strength tests, Clause 70. The test pressure utilized for Clause 70 shall be the higher of:

a) Two times the maximum normal working pressure, see Clause 34.8,

b) Two times the maximum abnormal pressure developed (or setting of the pressure limiting device), see Clause 34.9,

c) Three times the minimum design pressure specified in Table 85.1, or

d) Two times the start-to-discharge value of the pressure-relief valve for equipment intended to utilize carbon dioxide (R744) in a secondary loop or a cascade system, or equipment not in the high-side of a transcritical system.

Material Specifications

71.3 Materials used in the pressure containment system and subjected to this test shall be identified by reference to an industry standard material specification, such as ASTM, SAE, AISI, and the like, as specified by the manufacturer. Joining methods shall be specified by materials, the manufacturer's process specifications, or the equivalent.

General Test Specifications

71.4 Three samples of each refrigerant-containing part shall be tested at the cyclic pressure values specified in Clauses 71.10 and 71.13 for the number of cycles specified in Clause 71.9, as described in the test method, Clauses 71.6 and 71.7. At the manufacturer's option, three samples of the complete system shall be used for the test.

71.5 The samples shall be considered to comply if they comply with Clause 71.8 at the completion of the test and if they do not rupture, burst, or leak.

Test Method

71.6 The test samples shall be filled with inert fluid, and shall be connected to a pressure driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer. The full specified pressure excursion shall occur during each cycle. The shape of the pressure cycle shall be such that the upper and lower pressure values shall be maintained for at least 0.1s.

NOTE: For safety purposes, it is suggested that the inert fluid described in Clause 71.6 should be a hydraulic fluid. The fluid should completely fill the part, displacing all of the air.

71.7 Material such as steel, copper, and aluminum have fatigue properties that are practically independent of temperature at the continuous operating temperatures normally encountered under the operating temperature conditions and internal system temperatures of the unit. If the continuous operating temperature is less than or equal to 121°C (250°F) for copper or aluminum or 204°C (400°F) for steel, the test temperature of the component part or assembly shall be at least 20°C (68°F). If the continuous operating temperature of the component exceeds 121°C (250°F) for copper or aluminum or 204°C (400°F) for steel, the test temperature of the parts or assemblies that are at these temperatures, and subjected to the pressure, shall be at least 149°C (300°F) for copper or aluminum and 260°C (500°F) for steel. For other materials or higher temperatures, the effects of temperature on the material fatigue characteristics shall be evaluated.

71.8 Following the specified number of test cycles, the test pressure shall be increased to the highest amount specified in (a) or (b) below. After the pressure is raised, the test value shall be maintained for 1 min without rupture, burst, or leak.

a) Two times the minimum upper pressure values specified in Clause 71.13; or

b) One and one-half times the marked or accepted pressure rating required in Clause 44.3(k).

Test parameters

71.9 The number of cycles shall be 500,000. The test pressure of the first cycle of the test shall be determined by Clause 71.10. The test pressure for the remainder of the test shall be determined by Clause 71.13.

71.10 Except as specified in Clause 71.11, the test pressure for the first cycle shall be the pressure identified in Clause 71.2 prior to multiplying by three.

71.11 If the high-side maximum design pressure for the equipment equals or exceeds the critical pressure of the refrigerant, then the upper pressure of the high-side parts during the first cycle shall be the higher of either the equipment maximum abnormal pressure or maximum design pressure.

71.12 In reference to Clause 71.11, the critical pressure of R-744 is 7,295 kPa (1,058 psig).

Cycle test pressure specification

71.13 Except as specified in Clause 71.14, the pressure for the remainder of the test cycles shall be as follows:

a) Except as indicated in Items (c) and (d), for components subject to high-side pressures, the upper pressure value shall not be less than the saturated vapor pressure of the refrigerant at 49°C (120°F), and the lower pressure value shall not be greater than the saturated vapor pressure of the refrigerant at 4.4°C (40°F).

b) Except as indicated in Items (c) and (d), for components subjected to only low side pressures, the upper pressure value shall be not less than the saturated vapor pressure of the refrigerant at 26.7°C (80°F), and the lower pressure value shall be between 0 psig and the greater of 5 psig or the saturated vapor pressure of the refrigerant at minus 12.2°C (10°F).

c) For components used in equipment intended to utilize carbon dioxide (R744) in a secondary loop or cascade system, or in the low-side of a transcritical system, the upper pressure value shall not be less than the start-to-discharge value of the pressure-regulating relief valve. The lower pressure shall be not more than 690 kPa (100 psig).

d) For components used in equipment intended to utilize carbon dioxide (R-744) in portions of a transcritical system designed for operation at pressures between the low-side and high-side of the system, the upper pressure value shall not be less than start-to-discharge value of the pressure relief valve. The lower pressure shall be not more than saturated vapor pressure of the refrigerant at 10°F (minus 12°C). For R-744, this value is 2.4 MPa (345 psig).

Note 1: The objective is to avoid a test value that is a negative pressure but to require a lower pressure value of the saturated vapor pressure at -12.2°C (10°F) or 5 psig, whichever is greater.

Note 2: For zeotropic mixtures, the average of the dew point pressure value and the bubble point pressure value at the specified temperature is used as the saturated vapor pressure value.

71.14 If the high-side design pressure of the equipment equals or exceeds the critical pressure of the refrigerant, then the upper pressure for the remaining cycles shall be not less than 95 percent of the higher of either the maximum abnormal pressure or the maximum design pressure of the equipment.

71.15 In reference to Clauses 71.11 and 71.14, the lower pressure for all cycles shall not be greater than the saturated vapor pressure of the refrigerant at 40°F (4.4°C). For R-744, this value is 4.0 MPa (580 psig).

72 Rupture member tests

72.1 This test shall be applicable to devices, the marking of which has not been verified by a recognized testing agency.

72.2 The rupture member shall burst at a pressure within 5 percent of its set bursting pressure.

72.3 The set pressure is considered to be the minimum marked bursting pressure plus one-half the difference between the minimum and maximum marked bursting pressures.

72.4 Three samples of each size shall be tested as follows: each sample shall be connected to a convenient source of fluid pressure, and the pressure increased until rupture occurs. After the pressure reaches 90 per cent of the minimum marked bursting pressure, the rate of pressure increase shall be not faster than 5 percent of the minimum marked bursting pressure per minute.

73 Fusible plug test

73.1 This test shall be applicable to devices not covered by a separate component standard.

73.2 A fusible plug shall function within 5.6°C (10°F) of its marked temperature rating, when tested in accordance with Clause 73.3.

73.3 Three samples shall be tested as follows:

a) the samples shall be attached to a length of coiled copper tubing not less than 3.1 m (10 ft) within which air pressure not less than 276 kPa (40 psig) is maintained;

b) the coil and test sample shall be immersed in a fluid, the temperature of which is raised slowly; and

c) the relief temperature shall be considered to be that temperature at which complete blowout of the fusible element occurs.

74 Regulating relief valve endurance test

74.1 This test applies to pressure-regulating relief valves which can be used on equipment using carbon dioxide (R744) in a secondary loop, cascade, or transcritical system.

74.2 Three samples of the valve shall be tested. Each sample shall be connected to a gas source, such as air, carbon dioxide, or nitrogen, but oxygen or any flammable gas shall not be used. The sample shall be immersed in water, and the pressure shall be gradually increased until the valve starts to discharge, as evidenced by the occurrence of bubbles in the water.

74.3 The average of the initial three start-to-discharge pressure values shall be used as a reference, and this average value shall not exceed the marked setting of the regulating relief valve. Also, each individual

sample shall have a start-to-discharge pressure within ±7% of the marked setting of the regulating relief valve.

74.4 The same three test samples shall then be cycled 300 times between the start-to-discharge pressure and any lower pressure such that no air is discharged through the test samples.

74.5 At the conclusion of the test, the start-to-discharge pressure obtained on the final cycle for each of the three test samples shall be averaged and compared to the initial referenced value. The final averaged value shall be within ±7% of the initial averaged reference value, and each individual sample valve shall have a start-to-discharge pressure within ±10% of the marked setting of the regulating relief valve.

75 Leakage current test – cord-connected products

75.1 The leakage current of a cord-connected unit shall be no more than 0.75 milliamperes when tested in accordance with Clauses 75.8 – 75.10.

75.2 Cord-connected equipment that complies with both of the Items (a) and (b) below may be permitted to have a leakage current from simultaneously accessible parts to the grounded supply conductor higher than specified in Clause 75.1, but in no case shall the leakage current be greater than 3.5 milliamperes.

a) The product requires EMI suppression filtering for compliance with FCC regulations.

b) The product is equipped with a grounding-type supply cord and plug.

75.3 Components are considered to be in compliance with Clause 75 if they have already been evaluated to and comply with other UL or CSA standards that contain a leakage current test.

75.4 Leakage current refers to all currents, including capacitively-coupled currents, which can be conveyed between exposed conductive surfaces of a unit and ground or other exposed conductive surfaces.

75.5 All exposed conductive surfaces shall be tested for leakage currents. The leakage currents from these surfaces shall be measured to the grounded supply conductor individually as well as collectively and from one surface to another where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure providing protection in accordance with Clause 5. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages which are considered to be low-voltage.

75.6 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current shall be measured using metal foil with an area of 3.9 by 7.8 inches (100 by 200 mm) in contact with the surface. Where the surface is less than 3.9 by 7.8 inches, the metal foil shall be the same size as the surface. The metal foil shall not remain in place long enough to affect the temperature of the unit.

75.7 The measurement circuit for leakage current shall be as shown in Figure 75.1. The measurement instrument is defined in (a) – (c) and, unless it is being used to measure leakage from one part of the unit to another, the meter shall be connected between the accessible parts and the grounded supply conductor. The meter which is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

a) The meter shall have an input impedance of 1500 Ω resistive shunted by a capacitance of 0.15 μF.