UL 998

STANDARD FOR SAFETY

Humidifiers

UL Standard for Safety for Safety for Humidifiers, UL 998

Sixth Edition, Dated April 9, 2020

Summary of Topics

This new edition of UL 998 dated April 9, 2020 includes a revising the Scope in Supplement SA and other editorial updates.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 9, 2019.

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Fifth Edition

Underwriters Laboratories Inc.
UL 998
Sixth Edition

Humidifiers

April 9, 2020

Approved American National Standard

ANSI/UL 998-2020

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 anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

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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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This ANSI/UL Standard for Safety consists of the Sixth Edition.

The most recent designation of ANSI/UL 998 as an American National Standard (ANSI) occurred on April 9, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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PREFACE

This is the harmonized CSA Group and UL Standard for Humidifiers. It is the fifth edition of CSA C22.2 No. 104, and the sixth edition of UL 998. This edition of CSA C22.2 No. 104 supersedes the previous edition(s) published on April 25, 2011. This edition of UL 998 supersedes the previous edition(s) published on April 25, 2011.

This harmonized Standard was prepared by CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of 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 Humidifiers, under the jurisdiction of the CSA Technical Committee on Consumer and Commercial Products and the Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

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 identical standard for CSA Group and UL.

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

Interpretations

The interpretation by the 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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HUMIDIFIERS

INTRODUCTION

1 Scope

1.1 These requirements cover humidifiers rated 600 V or less, and intended to be used in accordance with the National Electrical Code (NEC), ANSI/NFPA 70, and the rules of CSA C22.1, Canadian Electrical Code (CEC), Part I.

1.2 These requirements cover humidifiers intended for residential and commercial use. This includes humidifiers of the centrifugal atomizing type, evaporative-media type, water-injection type, steam type, and the like. The humidifiers are intended for installation in a room, mounted on a wall or a ceiling, or for duct or plenum mounting.

1.3 These requirements apply to equipment that includes an electric heating element to heat air or water, or both.

1.4 These requirements do not apply to evaporative coolers that are also intended to be used for cooling.

1.5 These requirements do not apply to portable, electrode-type products, such as vaporizers, which are covered by UL 499 and CAN/CSA-C22.2 No. 64.

2 Definitions

2.1 The following definitions apply in this Standard.

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

2.3 CIRCUIT, HAZARDOUS VOLTAGE – A circuit having characteristics in excess of those of an extra-low-voltage circuit.

2.4 COMBINATION TEMPERATURE-REGULATING AND TEMPERATURE-LIMITING THERMOSTAT – A thermostat whose function is to regulate the temperature under normal conditions of use, and that also serves to prevent a hazard that might result from conditions of abnormal operation of the heater.

2.5 ENCLOSURE – The enclosure that houses the electrical components, live parts, and/or moving parts. It may be an integral part of the component, a separate item, part of the ultimate enclosure, or the ultimate enclosure (e.g., the outer cabinet).

2.6 HEATER ELEMENT – A complete or partial assembly of a heating element, an electrical insulation (e. g., refractory, mica), a metal sheath, a glass or quartz envelope or panel, thermal insulation, and a frame or adaptor for holding the assembly together and fastening it in the heater; and leads or terminal connections, or both, which may or may not include bolts and nuts.

2.7 HEATING ELEMENT – The actual electrical conducting medium that is intended to be heated by an electric current.

2.8 HUMIDIFIER – Equipment that is designed to increase the relative humidity of air.

2.9 JUNCTION BLOCK – A wiring device that encloses splices between wires and that may provide a receptacle for connecting a component of the equipment.

2.10 PORTABLE EQUIPMENT – Equipment designed to not be used in a fixed position and that receives current through a flexible cord or cable and an attachment plug.

2.11 SAFETY-CIRCUIT– A circuit that 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 system, the failure of which to operate might result in an unsafe condition.

2.12 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.

2.13 TEMPERATURE-REGULATING THERMOSTAT – A thermostat that functions only to regulate the temperature under normal conditions of use. The failure of such a thermostat would not result in a hazard.

2.14 USER SERVICING – Any form of servicing that is likely to be performed by personnel other than those who are trained to maintain the product. Some examples include routine cleaning, filter replacement, and replacement of an accessible fuse or lamp.

3 General

3.1 Components

3.1.1 Except as indicated in Clause 3.1.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components used in the products covered by this Standard. A component shall comply with the CSA and UL Standards.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this Standard; or

b) Is superseded by a requirement in this Standard.

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

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

3.1.5 For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0.

3.1.6 Products covered by this Standard shall comply with the referenced installation codes and standards noted in Clause 3.2.

3.2 Reference publications

3.2.1 Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

CSA Group

B51-14
Boiler, Pressure, Vessel, and Pressure Piping Code

C22.1-18
Canadian Electrical Code, Part I

CAN/CSA-C22.2 No. 0-10 (R2015)
General Requirements – Canadian Electrical Code, Part II

C22.2 No. 0.3-09 (R2014)
Test Methods For Electrical Wires and Cables

C22.2 No. 0.15-15
Adhesive Labels

CAN/CSA-C22.2 No. 0.17-00 (R2018)
Evaluation of Properties of Polymeric Materials

C22.2 No. 64-10 (R2014)
Household Cooking and Liquid-Heating Appliances

C22.2 No. 72-10 (R2014)
Heater Elements

C22.2 No. 77-14
Motors with Inherent Overheating Protection

C22.2 No. 100-14
Motors and Generators

CAN/CSA-198.1-06 (R2015)
Extruded Insulating Tubing

CAN/CSA-198.3-05 (R2014)
Coated Electrical Sleeving

CAN/CSA-C22.2 No. 60950-1-07 (R2016)
Information Technology Equipment – Safety – Part 1: General Requirements

CAN/CSA-E60730-1-15
Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements

UL (Underwriters Laboratories Inc.)

UL 94
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 244A
Solid-State Controls for Appliances

UL 486A-486B
Wire Connectors

UL 499
Electric Heating Appliances

UL 723
Tests for Surface Burning Characteristics of Building Materials

UL 746C
Polymeric Materials – Use in Electrical Equipment Evaluations

UL 840
Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment

UL 900
Air Filter Units

UL 969
Marking and Labeling Systems

UL 1004-1
Rotating Electrical Machines – General Requirements

UL 1004-2
Impedance Protected Motors

UL 1004-3
Thermally Protected Motors

UL 1030
Sheathed Heating Elements

UL 1441
Coated Electrical Sleeving

UL 1581
Reference Standard for Electrical Wires, Cables, and Flexible Cords

UL 60730-1
Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements

UL 60950-1
Information Technology Equipment – Safety – Part 1: General Requirements

ASME (American Society of Mechanical Engineers)

ASME
Boiler and Pressure Vessel Code

ASTM (American Society for Testing and Materials)

ASTM D395
Standard Test Methods for Rubber Property – Compression Set

ASTM E162
Standard Test Method for Surface Flammability of Materials, Using a Radiant Heat Energy Source

IEC (International Electrotechnical Commission)

IEC 60417
Graphical Symbols for Use on Equipment

NFPA (National Fire Protection Association)

ANSI/NFPA No. 70
National Electrical Code

ULC (Underwriters Laboratories of Canada)

CAN/ULC-S102-10
Standard Methods of Test for Surface Burning Characteristics of Building Materials and Assemblies

3.3 Units of measurement

3.3.1 The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

3.4 Terminology

3.4.1 In this standard, a requirement that applies only to a particular type of humidifier is so identified by a specific reference in that requirement to the type or types of humidifiers involved. Absence of such specific reference or use of the term "product" indicates that the requirement applies to all types of humidifiers unless the context indicates otherwise.

CONSTRUCTION

4 General

4.1 A product shall be completely assembled when it is shipped from the factory. A product shipped partially, for example, to facilitate packaging or installation, shall be able to be properly assembled without a risk of fire, electric shock, or injury to persons, and each part shall be marked as required by Clause 76.3.

4.2 A product intended for mounting to the ceiling, floor, or wall shall have provisions for such mounting. All required fittings such as brackets, hangers, or the like, necessary for mounting shall be furnished with the product. Parts commonly available for the mounting of the product are not required to be provided if mounting instructions that refer to such parts are furnished in accordance with Clause 76.8.

4.3 A humidifier that is intended for mounting on the hot air plenum or duct of a furnace, and that requires the installation of an air deflecting means in the path of the moving air, shall include the necessary deflecting means as a part or accessory of the humidifier, and shall be accompanied by explicit instructions for the installation of the means so as to avoid impairment of the function of the furnace.

5 Enclosures

5.1 General

5.1.1 Products shall be constructed so that they have the strength and rigidity necessary to resist the abuse to which they might be subjected, without increasing the risk of fire, electric shock, or injury to persons, due to partial collapse with resultant reduction of spacings, loosening or displacement of parts, or other defects.

5.1.2 In determining compliance with Clause 5.1.1, all elements that contribute to the enclosing function, including enclosures of individual components and the exterior (decorative) cabinet, shall be considered.

5.1.3 Enclosures made in the form of grilles, etc., of wire or sheet metal, and intended to accommodate air flow required for the operation of the equipment, shall be considered to comply with Clause 5.1.1 if they provide resistance to deflection or impact that would be acceptable to the requirements specified in Clause 5.1.4 for enclosures of sheet metal.

5.1.4 Unless the surface under consideration is curved, ribbed, or otherwise reinforced, cast and sheet-metal sections of an enclosure shall not be thinner than as specified in Table 1.

5.1.5 A metal plate or metal plug used to cover an unused conduit opening or other hole that is required to be covered 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 product. Such plates or plugs shall be securely mounted.

5.2 Nonmetallic materials

5.2.1 Enclosures or parts of equipment manufactured of nonmetallic materials shall not cause a risk of fire, electric shock, or injury to persons, because of susceptibility to ignition or melting by electrical disturbances within, or because of deterioration from aging effects, or because of exposure to the operating environment.

5.2.2 Enclosures shall be considered to comply with Clause 5.2.1 if:

a) They comply with the flammability test specified in UL 746C and CAN/CSA-C22.2 No. 0.17;

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

c) The equipment is in compliance with Clauses 5.2.3, 5.2.4, and 5.2.5.

5.2.3 In addition to the requirements of Clause 5.2.1, an enclosure of polymeric material having in any unbroken section an exposed surface greater than 0.93 m^2 (10 ft^2), or a single dimension greater than 1.83 m (6 ft), shall have maximum flame spread rating of:

a) 200 for a portable product; and

b) 50 for a product intended to be permanently connected to the electrical supply.

5.2.4 The flame spread rating mentioned in Clause 5.2.3 shall be determined in accordance with the requirements in UL 723, or the radiant panel test requirement in accordance with ASTM E162 or CAN/ULC-S102.

5.2.5 Where bare live parts of electrical components, such as switch terminals, are individually enclosed with metal, or insulating tube or sleeving that complies with VW-1 flammability requirements in accordance with UL 224 and CSA C22.2 No. 198.1, or UL 1441 and CSA C22.2 No. 198.3, respectively; or polymeric material that complies with the requirements of the vertical burning test for classifying materials 5 VA in accordance with UL 94, and flammability rating of 5V (500 W), in CAN/CSA-C22.2 No. 0.17, the surrounding equipment enclosure shall be of material that is not more flammable than material classed as HB as specified in CAN/CSA-C22.2 No. 0.17, and HB as specified in UL 94, provided:

a) The equipment does not employ open-coil heaters;

b) Internal wiring within the surrounding equipment enclosure complies with flame test classification VW-1 as referenced in UL 1581 and FT1 of C22.2 No. 0.3;

c) Splices within the surrounding equipment enclosure are made with insulated wire connectors that are resistant to loosening due to vibration; and

d) The surrounding equipment enclosure, where relied upon to prevent a risk of electric shock, complies with the impact test requirements of Clause 59.

5.3 Enclosure integrity

5.3.1 The enclosure of a product shall reduce the likelihood that molten metal, burning insulation, flaming particles, or the like will fall on combustible materials, including the surface upon which the product is supported.

5.3.2 The requirement in Clause 5.3.1 necessitates the use of a barrier under wiring, unless it is neoprene- or thermoplastic-insulated, and under a motor unless:

a) The structural parts of the motor or the product provide the equivalent of such a barrier;

b) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the product when the motor is energized under each of the following fault conditions:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) Capacitor of permanent-split capacitor motor short-circuited – the short circuit shall be applied before the motor is energized, and the rotor shall be locked;

c) The motor is provided with a thermal motor protector, that is, a protective device that is sensitive to temperature and current that keeps the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor runs without causing the protector to cycle, and from exceeding 150°C (302°F) with the rotor of the motor locked; or

d) The motor complies with the requirements for impedance-protected motors in UL 1004-2, and C22.2 No. 77.

5.3.3 Aside from the terminals, Clause 5.3.1 also requires that a switch, a relay, a solenoid, or the like, be individually and completely enclosed. A component is not required to be completely enclosed if:

a) Malfunction of the component would not result in a risk of fire; or

b) There are no openings in the bottom of the product enclosure.

5.3.4 The barrier mentioned in Clause 5.3.2 shall be horizontal, shall be located as illustrated in Figure 1, and shall have an area not less than that described in the illustration. Openings for drainage, ventilation, and the like, that would not permit molten metal, burning insulation, or the like, to fall on combustible material, may be employed in a barrier.

5.3.5 If an opening for ventilation is provided in the enclosure of a product or an externally mounted component, and if the product is intended to be recessed into a wall or false ceiling, such an opening shall not allow venting into concealed space.

6 Doors and Covers

6.1 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; however, components having covers that comply with their respective standards do not require additional enclosures.

6.2 An interlocking mechanism complies with the requirements of Clause 6.1 if it:

a) Secures the cover in the closed position when engaged; and

b) Must be engaged before parts in a hazardous voltage circuit can be energized.

6.3 Accessibility shall be afforded to all parts that require normal servicing or adjustment (for example, controls, filters, oiling of bearings, adjustment of belts) when the equipment is installed as intended. Covers or access panels giving access to such parts that are required to be removed for routine maintenance shall not expose uninsulated live parts.

6.4 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.

6.5 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 any overcurrent protective device. If more than one door or cover has to be opened to provide access to the overcurrent protective device, only one of these shall comply with this requirement. A cover, panel, door, or other part of an enclosure that, due to its function or size, must be in place to complete the overall enclosure, is not required to be hinged, sliding type, or pivoted.

6.6 A cover as specified in Clause 6.5 is not required if fuses only of the following types are enclosed:

a) Fuses connected in extra-low-voltage circuits;

b) Extractor type fuses that have their own enclosures;

c) Control circuit fuses, provided that the control circuit loads (other than fixed loads, such as pilot lamps) are housed in the same enclosure as the fuses; or

d) Supplementary type fuses rated 2 A or less used in small, auxiliary resistance heater circuits having a maximum rating of 100 W.

6.7 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, provided that the resetting of the device does not result in exposure to uninsulated live hazardous voltage parts or moving parts.

7 Accessibility of Uninsulated Hazardous Voltage Live Parts and Film-Coated Wire

7.1 To reduce the risk of unintentional human contact with an uninsulated live part or film-coated wire, louvers or other openings in the enclosure of a product, and openings in a motor, shall be so designed, located, or baffled as to comply with the requirements specified in Table 2.

7.2 With respect to the requirement in Clause 7.1, insulated brush caps do not require additional enclosure.

7.3 In determining compliance with Clauses 7.1 and 7.2, any doors, covers, or components that are intended to be removed for routine maintenance purposes, or that might be removed, without using a tool, by the user to attach an accessory, to make an operating adjustment, or for other reasons, shall be removed.

7.4 In cord-connected humidifiers where the enclosure of a fan is completed by a drum supporting the evaporating medium, a marking in accordance with Clause 75.20 shall be acceptable.

7.5 The probes illustrated in Figure 2 – Figure 5 shall be applied to any depth that the opening enables and with a force not greater than 4.4 N (1 lbf), and shall be rotated or angled before, during, and after insertion through the opening to any position that is required to examine the product or motor. The probe illustrated in Figure 2 shall be applied in any possible configuration, and, when required, the configuration shall be changed after insertion through the opening.

7.6 With reference to the requirements in Table 2, an indirectly accessible motor is a motor:

a) That is accessible only by removing a part of the outer enclosure of a product, such as a guard or panel, that can be removed without using a tool; or

b) That is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

7.7 With reference to the requirements in Table 2 and Table 3, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening perpendicular to the plane of the opening with a force not greater than 22 N (5 lbf).

7.8 If Table 2 specifies a probe to be used to judge the accessibility of an uninsulated live part or film-coated wire, the probe shall not contact such a part or wire when inserted through an opening in the enclosure of a product or motor as described in Clause 7.5.

7.9 If Table 2 does not specify that a probe is to be used to judge the accessibility of an uninsulated live part or film-coated wire, such a part or wire shall not be:

a) Within "X" mm (inches) of the perimeter of an opening in the enclosure of a product or a motor; or

b) Within the volume generated by projecting the perimeter "X" mm (inches) normal to its plane. "X" equals five times the minor dimension of the opening, but not less than the values specified in Table 2. Please see Clause 7.7 and Figure 6.

7.10 Each lampholder shall be wired so that the screw shell will be connected to the conductor intended to be connected to the grounded conductor of the power-supply circuit.

8 Protection Against Risk of Injury to Persons – Mechanical Protection

8.1 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.

8.2 Openings in external enclosures or guards provided for compliance with the requirements specified in Clause 8.1 shall be acceptable if they prevent the probe, illustrated in Figure 7 from making contact with moving parts. The probe shall be inserted at any angle and with a force of 4.4 N (1 lbf). Openings of 25.4 mm (1 in) or larger shall be guarded such that the distance from an opening to the moving part is in accordance with Table 3.

8.3 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 8.1.

8.4 An enclosure or guard over a rotating member, such as a fan blade, shall retain a part that, because of breakage or other reason, might become loose or separate from a rotating part, and shall retain foreign objects that might be struck and propelled by the rotating member.

8.5 A guard or portion of an enclosure acting as a guard for a part presenting a risk of injury to persons shall be:

a) Mounted to the assembly so that the part cannot be operated with a guard removed;

b) Secured to the assembly using fasteners requiring a tool for removal; or

c) Provided with interlocks to protect against access. 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 1.

8.6 A fan blade of conventional construction shall be acceptably guarded if:

a) The relationship between the weight (W) of the fan blades and hub in kilograms, the radius (r) in millimeters, and the speed (N) in revolutions per minute is such that K in the formula

$$K = 6 \times 10^{-7}(Wr^2N^2)$$

is less than 29,032; and

b) The guarding is such that the probe illustrated in Figure 7 cannot touch the leading edge of the blade and hub when inserted with a force of 4.4 N (1 lbf) through any opening in the guard. For a reversible fan, both edges are leading edges.

9 Protection Against Risk of Injury to Persons – Materials

9.1 When breakage of materials used for the enclosure, frame, guard, or the like might result in a risk of injury, the materials shall have such properties that meet the demands of expected loading conditions. See Impact, Clause 59.

10 Protection Against Risk of Injury to Persons – Switches, Controls, and Interlocks

10.1 A device that automatically starts a product, such as a timer, an automatically reset overload-protective device, or the like, shall not be employed if such a device and its operations can cause or result in injury to persons.

10.2 The requirement in Clause 10.1 shall necessitate the use of an interlock if moving parts or the like would result in a risk of injury to persons upon the automatic starting or restarting of a motor. A product shall be constructed so as to reduce the likelihood of unintentional operation of any such part.

10.3 Each function of a multiple-function product shall be taken into consideration in determining compliance with Clause 10.2.

10.4 If unintentional operation of a switch can result in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely. The actuator of such a switch shall be guarded by recessing, use of ribs, barriers, or the like.

10.5 A risk of injury to persons shall not result when a product that is provided with a switch that can be locked in the "on" position is connected to the electrical source of supply when the product is in an at-rest position and the switch is in the "on" position.

10.6 The "off" position of a switch other than a momentary-contact type shall be such that the operator can determine by visual inspection that the product is off.

10.7 An interlock provided to reduce the risk of electric shock shall be constructed and installed so that it is reliable and complies with the requirements in Clause 10.8 or 10.9.

10.8 An interlock shall be such that it cannot be defeated readily:

a) Without damaging the product;

b) Without making a connection or alteration to the wiring;

c) Without a tool; or

d) With a material that is commonly available, such as adhesive tape, string, and a conventional extension cord set.

10.9 A product having an interlock to reduce the risk of electric shock that does not comply with the requirements in Clause 10.8 shall be marked as specified in Clause 75.26, and during intended operation and user servicing of the product:

a) The interlock shall not be likely to be defeated by improper disassembly, for example, removal of the wrong screws during removal of the cover;

b) The cover in which the interlock is mounted shall not rotate by its own weight during any stage of its removal or replacement, if such rotation gives access to a live part, or damages the interlock or the cover;

c) The act of removal or replacement of the interlocked cover shall not subject the user to unintentional contact with live parts; and

d) Misapplication of the interlocked cover shall not result in a risk of electric shock unless such misapplication is obvious during and after replacement of the cover.

11 Protection Against Risk of Injury to Persons – Surface Temperatures

11.1 During the Normal-Temperature Test, Clause 57, the temperature of a surface that could be contacted by the user shall not exceed the applicable value specified in Table 4. If the test is conducted at a room temperature other than 25°C (77°F), the results shall be corrected to that temperature.

12 Stability

12.1 A portable product shall not overturn when positioned in its most unstable condition, with or without water, and tipped through an angle of 10 degrees from the horizontal.

12.2 The product shall be levelled on a horizontal surface. The side of the product that will result in the most severe test shall be raised until the product is tipped through an angle of 10 degrees. For the test, casters, wheels, and other supporting means shall be positioned so as to result in the least stability. If adjustable feet are provided, they shall be adjusted to the same height. The product shall be blocked to prevent sliding during the test.

13 Strength of Handles

13.1 A handle used to support or carry a product shall withstand a force equal to four times the weight of the product when filled with water without breakage or damage to the handle, its securing means, or that portion of the enclosure to which it is attached, for a period of 1 minute. The load shall be uniformly applied over a 76 mm (3 in) width at the center of the handle, without clamping. The load shall be gradually applied so that the total test load will be reached in 5 – 10 seconds.

13.2 If more than one handle is furnished, the force shall be distributed evenly between the handles so that each handle will carry a load proportional to the load it would carry when the product is lifted by the handles. If the product has more than one handle, but can be carried by only one handle at a time, each handle shall support the entire test load.

14 Strength of Mounting

14.1 The mounting means of a product intended for wall or ceiling mounting shall withstand a force equal to four times the weight of the product without breakage of or damage to the mounting means, its securing means, and that portion of the product to which it is attached. Results shall be acceptable if the product and mounting systems remain in place with no evidence of damage or permanent distortion.

14.2 The product shall be mounted in accordance with the manufacturer's installation instructions, using the hardware and construction as described. The force – four times the weight of the product, or the product itself plus three times its own weight – shall be applied through a 76 mm (3 in) wide strap at the dimensional center of the product and shall be increased in a 5 – 10 second interval until a load equal to the weight of the product plus three times its weight, but not less than 4.5 kg (10 lbs), is applied to the mounting system. The load shall be sustained for 1 min.

14.3 With reference to Clause 14.2, if no wall constructions are specified, 3/8-inch trade size plaster board (dry wall, gypsum board) on nominal 2 by 4 inch wood studs spaced on 406 mm (16 in) centers shall be used as the support surface. The hardware shall be applied as specified in the instructions, and if not otherwise indicated, the securing screws shall be positioned between the studs and secured into the plasterboard. An adjustable product shall be adjusted to the position that will give the maximum projection from the wall.

15 Mechanical Assembly

15.1 A product shall be assembled in accordance with the requirements of this Clause so that it will not be adversely affected by the vibration of intended operation.

15.2 A switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be securely mounted and shall be prevented from shifting or turning.

15.3 With respect to 15.2, a switch is not required to be prevented from turning if all four of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to rotate the switch during intended operation of the switch;

b) Means for mounting the switch make it unlikely that operation of the switch will loosen it;

c) Spacings are not reduced below the minimum acceptable values if the switch rotates; and

d) Intended operation of the switch is by mechanical means rather than by direct contact by persons.

15.4 With respect to 15.2, a lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable jewel, is not required to be prevented from turning if rotation cannot reduce spacings below the minimum required values.

15.5 Means for preventing the rotation mentioned in Clauses 15.2 – 15.4 shall consist of more than friction between surfaces; for example, a lock washer may be used to prevent turning of a small stem-mounted switch or other device having a single-hole mounting means.

15.6 Uninsulated live parts and wiring shall be kept away from moving parts such as relays and contactors by clamping, routing, or equivalent means that will provide permanent separation.

15.7 An uninsulated live part, including a terminal, shall be secured to the supporting surface by a method other than friction between surfaces so that it will not be likely to turn or shift in position if such motion may result in the reduction of spacings below the minimum acceptable values. The security of contact assemblies shall be such that their continued alignment is maintained.

15.8 Friction between surfaces shall not be the sole means of reducing the likelihood of shifting or turning of live parts, but a lock washer shall be acceptable.

16 Liquid-Containing Parts

16.1 If the deterioration or breakage of any part that contains, conducts, or otherwise contacts a liquid can result in a risk of fire, electric shock, or injury to persons, the part shall be resistant to the liquid under all conditions of use. See Liquid-Container Test, Clause 68. Gaskets employed to:

a) Prevent water entry into an electrical compartment; or

b) Prevent hot water leakage external to the product,

are not required to comply with the test of Clause 68 when the gasket is normally dry during operation and complies with the requirements of Gasket Test, Clause 67.

16.2 In addition to complying with Clause 16.1, a polymeric material used to support electrodes in liquid-containing cylinders shall be subjected to the tests specified in (a) to (e):

a) A flammability test in accordance with the method for HB materials in UL 94, and HB materials in CAN/CSA-C22.2 No 0.17;

b) A mold stress relief test, as specified in Clause 73;

c) High-voltage-arc tracking, in accordance with the requirements in UL 746C, and CAN/CSA-C22.2 No. 0.17. This test is not required if a 12.7 mm (1/2 in) spacing is provided between live parts.

d) Comparative tracking index (CTI) under moist conditions, in accordance with the requirements in UL 746C, and CAN/CSA-C22.2 No. 0.17. The CTI value shall be a minimum of 100 V; and

e) Relative thermal index (RTI), in accordance with the requirements in UL 746C and CAN/CSA-C22.2 No. 0.17. The material shall not exceed the general use temperature for required properties.

17 Protection Against Corrosion

17.1 If corrosion of a part could result in a risk of fire, electric shock, or injury to persons, such a part shall be plated, painted, or the equivalent. Phosphate treatment with an oil or wax coating may be used for protecting magnets and armatures. Oil treatment may be used for steel springs. Stainless steel shall be acceptable without additional protection if it is polished or treated when necessary.

17.2 Metals shall be used in combinations that are galvanically compatible if galvanic action could adversely affect any cabinet, enclosure, or other parts.

17.3 Each hinge and other attachment shall be resistant to corrosion.

18 Cord-Connected Products

18.1 Equipment other than plenum- or duct-mounted humidifiers may be cord connected if:

a) The voltage rating does not exceed 250 V;

b) It will start and operate as intended from a circuit with a 30 A overcurrent protection (see Starting Test, Clause 55); or

c) The marked rating does not exceed 24 A.

18.2 Plenum- or duct-mounted humidifiers may be cord connected if:

a) The voltage rating does not exceed 150 V;

b) The current rating does not exceed 12 A;

c) A branch circuit overcurrent protection of not more than 15 A is required for satisfactory starting and operating; and

d) The design does not require that field-wiring connections operating at above 30 V shall be made at the time of installation to a furnace control or to a control for the humidifier.

19 Permanently Connected Products

19.1 A product intended for permanent connection to the power-supply circuit shall have provision for connection of one of the wiring systems acceptable for the product, in accordance with the National Electrical Code, ANSI/NFPA 70, and the Canadian Electrical Code, Part I, C22.1.

19.2 Equipment shall have provision for the connection of conduit or conduits of a size suitable for the supply circuit conductors needed to connect the unit in accordance with Table 2, Allowable Ampacities for Not More Than 3 Copper Conductors in Raceway or Cable, and Table 4, Allowable Ampacities for Not More Than 3 Aluminum Conductors in Raceway or Cable, in the Canadian Electrical Code, Part I, C22.1, and Table 310-16, Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts, 60° C through 90° C (140° F through 194° F) Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried) Based on Ambient Temperatures of 30° C (86° F), in the National Electric Code, ANSI/NFPA 70, basing the minimum conductor size on 125 percent of the rated current of the product. Please see Table 5 and Table 6 for further information. It is assumed that aluminum conductors are used, unless the product is marked in accordance with Clause 78.2.

19.3 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.

19.4 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 42, Spacings.

19.5 A single field-wiring opening may be provided for hazardous voltage and extra-low-voltage field supply circuits, and 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 29, Separation of Circuits.

19.6 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, and shall be marked in accordance with Clause 75.30.

19.7 An outlet or terminal box in which connections to the power supply circuit will be made shall be located so that, after the product has been installed as intended, such connections will be readily accessible for inspection.

19.8 No electrical components shall be mounted on a part such as the cover of a wiring terminal compartment that must be removed to make or inspect field-wiring connections.

19.9 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 as defined in Clause 19.10, including the accommodation of the necessary splices.

19.10 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 non-current-carrying parts likely to be grounded.

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

19.11 The wiring terminal compartment shall incorporate suitable means for the connection thereto of a grounding conductor.

19.12 A terminal compartment that is intended for the connection of a power-supply raceway and that is mounted integrally with the product shall be attached so as to be prevented from turning with respect to the product.

19.13 Wiring space or other compartments intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or the like that could damage the conductor insulation.

19.14 If field-wiring connections are made to a motor terminal compartment, the compartment shall comply with the requirements in UL 1004-1 and C22.2 No. 100.

20 Leads and Terminals

20.1 A terminal for field adjustment, such as a voltage-tap change terminal, is not considered to be a field-wiring terminal. A wire intended for connection to a field-adjustment terminal and its method of connection, such as a pressure-terminal connector, soldered loop, crimped eyelet, or the like, shall be factory assembled and provided as part of the product.

20.2 A field-wiring terminal shall be provided with a pressure-terminal connector, firmly bolted or held by a screw. A wire-binding screw at a terminal intended to accommodate a 5.3 mm^2 (10 AWG) or smaller conductors shall be permitted if upturned lugs or the equivalent are provided to hold the wire in position.

20.3 A wiring terminal shall accommodate connection of a supply conductor having an ampacity of at least 125 percent of the rated current of the product in accordance with the National Electrical Code, ANSI/NFPA 70, and the Canadian Electrical Code, Part I, C22.1.

20.4 Wiring terminals to which supply conductors will be attached in the field shall be prevented from turning. The use of lock washers shall not be considered an effective way to prevent turning of terminals.

20.5 A wire-binding screw shall thread into metal.

20.6 A wire-binding screw at a wiring terminal shall not be smaller than No. 10. A No. 8 screw employed at a terminal intended for the connection of a 2.1 mm^2 (14 AWG) or smaller conductor only, and a No. 6 screw employed at a terminal intended for connection of a 1.3 or 0.82 mm^2 (16 or 18 AWG) conductor only, shall be permitted.

20.7 2.1 mm^2 (14 AWG) is the smallest size of conductor that shall be used for branch-circuit wiring, and thus is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

20.8 The terminals of a control may be employed for the connection of supply-circuit conductors, provided that they comply with Clause 20.6.

20.9 A terminal plate tapped for a wire-binding screw shall be of metal at least 0.76 mm (0.030 in) thick. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

20.10 A wire connector may thread into a terminal plate if the threads are not stripped by applications of the torque specified in Table 7 to the wire connector.

20.11 Upturned lugs or a copper washer shall be capable of retaining a supply conductor under the head of the screw or washer when the supply conductor is sized for the ampacity indicated in Clause 20.3.

20.12 If leads are provided instead of terminals for connection to supply circuit conductors, they shall not be more than two AWG wire sizes smaller than the copper supply conductors to which they are to be connected, but not smaller than 0.82 mm^2 (18 AWG), nor less than 152 mm (6 in) in length. The leads are not required to be 152 mm long or greater if it is evident that the use of a longer lead could result in a risk of fire or electric shock.

20.13 A lead shall not be more than two AWG wire sizes smaller than a copper supply conductor to which it is to be connected.

20.14 It shall be assumed that wire having the specified temperature rating will be installed for the power-supply conductors to a product marked in accordance with Clause 78.1. Otherwise, it shall be assumed that 75°C (167°F) wire will be used.

20.15 Field-wiring terminals shall be acceptable for copper supply conductors or for either aluminum or copper supply conductors, in accordance with the marking required by Clause 78.2.

20.16 The distance between a pressure terminal connector intended for field wiring and the wall of an enclosure toward which the conductor is directed or through which the conductor might pass shall be as specified in Table 8. Table 8 shall not apply where a wall or other obstruction lies outside the area occupied by a conductor that is bent or deflected to a radius not less than the distance specified in Table 8.

20.17 A permanently connected product intended for connection to a grounded power-supply conductor and employing a lampholder of the screw-shell type, a single-pole switch, or a single-pole automatic control shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be connected to the screw shell of each lampholder and shall not be connected to any single-pole switch or single-pole overcurrent protective device other than automatic controls without a marked "off" position.

20.18 A terminal intended for the connection of a grounded power-supply conductor shall be made of, or plated with, a metal that is substantially white in color, or be identified by the word "white" or the letter "W" marked next to the terminal. The terminal shall be readily distinguishable from the other terminals, or proper identification of the terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

20.19 A lead intended to be connected to a grounded power-supply conductor shall be finished to show a white or gray color, and shall be readily distinguishable from the other leads.

21 Flexible Cords

21.1 A cord-connected product shall be provided with a flexible cord, 1.5 – 3.0 m (5 – 10 ft) long, and an attachment plug cap, for connection to the power-supply circuit.

21.2 The flexible cord shall have a voltage rating of not less than the rated voltage of the product, and it shall have an ampacity not less than the current rating of the product marked as specified in Clause 74.1.

21.3 The flexible cord may be attached to the product permanently, or it may be in the form of a separate cord set with means for connection to the product. If the latter construction is used, the product shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

21.4 The flexible cord shall be of a type as specified in Table 9, or of a type equally serviceable for the application.

21.5 An attachment plug shall have a current rating of not less than 125 percent of the rated current of the product and a voltage rating equal to the rated voltage of the product. If the product is adaptable for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided shall be acceptable for the voltage for which the product is connected when shipped from the factory.

21.6 If the equipment is intended to be grounded as specified in Grounding, General, Clause 31.1, the supply cord shall have an additional conductor for grounding purposes that is:

a) Colored green or green/yellow;

b) Terminated in a grounding pin or blade in the attachment-plug; and

c) Connected to the equipment so that it will comply with Clause 31.1.

21.7 A cord-connected product that employs an Edison-base lampholder or a manually operated single-pole switch shall be provided with a polarized or grounding type attachment plug.

21.8 If a switching device or a pilot device that controls a switch operates to interrupt the main supply circuit, it shall, when open, disconnect all ungrounded power-supply conductors.

21.9 The attachment plug of the power supply cord of an appliance provided with a 15- or 20-ampere general-use convenience receptacle shall be of the 3-wire grounding type. The attachment plug of the power supply cord of an appliance provided with either a manually operated, line-connected, single-pole switch for appliance on-off operation, or an Edison-base lampholder shall be of the polarized or grounding type.

21.10 When a 3-wire grounding-type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connections shall comply with Figure 8, and the polarity identification of the flexible cord shall comply with Table 10.

21.11 The conductor of the power supply cord that is intended to be grounded shall have the screw shell of an Edison-base lampholder and the terminal or lead receptacle intended to be grounded connected to it. Table 10 identifies the supply cord conductor intended to be grounded.

22 Strain Relief

22.1 Strain relief shall be provided so that a mechanical stress on a flexible cord will not be transmitted to terminals, splices, or internal wiring. See Strain-Relief Test, Clause 62.

22.2 A metal strain-relief clamp or band without auxiliary protection shall be acceptable with a Type SJ, SJO, SJT, SJTO, S, SO, ST, or STO cord. A metal strain-relief clamp or band shall be acceptable with Type SP-2 or lighter duty rubber-insulated cord, and Type SPT-2 cord, only if auxiliary nonconducting mechanical protection is provided over the cord.

22.3 Unless previously investigated and found to be acceptable, a clamp of any material is not acceptable for use on a Type SPT-2 or SVT flexible cord. For a heavier duty thermoplastic-insulated cord, a clamp may be used. In such cases auxiliary insulation is not required unless it is judged that the clamp may damage the cord insulation. A clamp may be used on a Type SPT-2 or SVT cord if protected by varnished cloth tubing, phenolic material, vulcanized fiber material, or the equivalent under the clamp, subject to the investigation described in the Cable-Clamp Test, Clause 64.

22.4 If a knot in a supply cord serves as strain relief, it shall not be made in the conductors from which a jacket has been stripped, and the surface against which the knot may bear or with which it could come into contact shall be free from burrs, projections, and sharp edges.

22.5 Means shall be provided to reduce the risk that the flexible cord could be pushed into the product through the cord-entry hole when such displacement:

a) Damages the cord;

b) Exposes the cord to a temperature higher than that for which it is rated; or

c) Reduces spacings, such as to a metal strain-relief clamp, below the minimum values in Clause 42.2.

See Power-Supply Cord Push-Back Relief Test, Clause 63.

23 Bushings

23.1 Where a flexible cord passes through an opening in a wall, barrier, or enclosure, there shall be a bushing or the equivalent that is reliably secured in place. This bushing shall be provided with a smooth, rounded surface against which the cord can bear. If the cord is Type SP-2 or SPT-2 or other type lighter than SVT, if the wall or barrier is of metal, and if the construction is such that the cord may be subjected to stress or motion, an insulating bushing shall be provided.

23.2 Ceramic materials and some molded compositions are generally acceptable for insulating bushings, but separate bushings of wood or hot-molded shellac-and-tar compositions shall not be acceptable.

23.3 A vulcanized fiber bushing no thinner than 1.2 mm (3/64 in), formed and secured in place so that it will not be adversely affected by conditions of moisture, may be employed.

23.4 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor, but not elsewhere in the product, provided the bushing is:

a) Not less than 1.2 mm (3/64 in) thick;

b) Mounted in a hole that is smooth and free from sharp edges; and

c) Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a harmful effect on the compound used (unless of an oil-resistant compound).

23.5 With respect to Clause 23.4, a bushing of any of the materials mentioned above may be employed at any point in a product if used in conjunction with a type of cord for which an insulating bushing is not required.

23.6 A bushing of the same material as the cord insulation and molded integrally with the cord shall be acceptable on a Type SP-2 or heavier cord if the built-up section is not less than 1.6 mm (1/16 in) thick at the point where the cord passes through the hole.

23.7 An insulated metal grommet shall be acceptable in place of an insulating bushing, provided the insulating material is not less than 0.8 mm (1/32 in) thick and completely fills the space between the metal of the grommet and the metal in which it is mounted.

24 Current-Carrying Parts

24.1 Metal employed as a current-carrying part shall be silver, copper, copper alloy, or other material acceptable for the application.

24.2 Iron or steel, if provided with a corrosion-resistant coating, may be used for current-carrying parts within a motor or associated governor, but not elsewhere in a product. Iron or steel may be used for current-carrying parts within a component, provided it complies with the requirements for such a component. See Clause 3.1.

25 Internal Wiring

25.1 The internal wiring of a product shall be acceptable for the application when considered with respect to the temperature and voltage to which it is likely to be subjected, and with respect to exposure to oil, grease, moisture, or other conditions of anticipated service.

25.2 Wiring that is routed in the equipment so as to be semi-exposed shall have an insulation thickness of not less than 0.79 mm (1/32 in) (nominal) of thermoplastic material.

25.3 Wiring that is routed in the equipment so as to be enclosed shall have an insulation thickness of not less than:

a) 0.40 mm (1/64 in) (nominal), if of thermoplastic material; and

b) 0.79 mm (1/32 in) (nominal), if of rubber or neoprene material.

25.4 Parallel-conductor appliance wiring shall not be separated into single conductors for a length greater than 75 mm (3 in) unless the insulation of the separated wiring has a thickness of 0.7 mm (0.028 in) (nominal) or greater.

25.5 Except as specified in Clauses 25.6 and 25.7, conductors shall have an ampacity acceptable for the particular application and in accordance with the following:

a) For cord-connected equipment, not less than one-third of the required ampacity of the power supply cord; or

b) For permanently connected equipment, not less than one-third of the required ampacity of the branch circuit conductors.

Note 1: This requirement does not apply to conductors that are 18 AWG or larger, not more than 1.2 m (4 ft) in length, and provided with overcurrent protection in the equipment at the point where the smaller conductor receives its supply.

Note 2: This requirement does not apply to conductors that are connected between two fixed impedances that reduce the risk of a high fault current within the conductors (e.g., a conductor extending between a motor-running capacitor and the start-winding of a permanent split capacitor motor).

Note 3: This requirement does not apply to conductors that are a jumper lead between controls and are not longer than 76 mm (3 in), unless the conductor is located in a control panel.

25.6 For wiring of extra-low voltage circuits, other than safety circuits such as temperature-limiting circuits, the conductor size is not specified.

25.7 Wiring with 20 AWG conductors shall be acceptable when employed as integral leads of components such as lampholders and solenoids that are rated 60 VA or less.

26 Protection of Wiring

26.1 The wiring and connections between parts of a product shall be protected or enclosed. If flexibility is essential, a flexible cord may be used for external interconnection.

26.2 With respect to the requirement in Clause 26.1, wiring shall be considered to be protected or enclosed if it is secured or located so that it is not likely to be grasped or hooked in such a manner that it or related electrical connections could be subjected to undue stress, even though it can be touched by the probe illustrated in Figure 7. A filter and other parts that are likely to be removed and replaced during user servicing shall be removed when the exposure of internal wiring is being judged.

26.3 Wiring space or other compartments intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or the like that can damage the conductor insulation. Wiring in a factory-wired enclosure, compartment, raceway, or the like shall be located or protected to reduce the likelihood of contact with any sharp edge, burr, fin, moving part, or the like that could damage the conductor insulation.

26.4 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of a product shall be provided with a smooth, rounded bushing or shall have a smooth, rounded surface upon which the wires may bear to reduce the likelihood of abrasion of the insulation. A flexible cord used for external interconnection as described in Clause 26.1 shall be provided with a bushing and strain relief.

26.5 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the product.

26.6 Where routine maintenance operations require the removal or displacement of a part of an assembly to which internal or interconnecting wiring is attached, the construction shall be such that the action of removal or displacement shall not result in damage to the conductors or insulation in the equipment.

27 Wiring Connections

27.1 If breaking or loosening of an electrical connection could result in a risk of fire or electric shock, it shall be soldered, welded, or otherwise securely connected. A soldered joint shall be mechanically secured before soldering.

27.2 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire cannot contact a non-current-carrying metal part or another live part not always of the same polarity as the wire. This may be accomplished by use of pressure wire connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or by other equivalent means.

27.3 An internal connection that must be made in the field on a cord-connected product that is shipped partially disassembled shall be by a plug-and-receptacle connector.

27.4 An internal connection that must be made in the field on a product intended for permanent connection to the power supply and shipped partially disassembled shall be made by a plug-and-receptacle connector, or in accordance with the relevant requirements of Permanently Connected Products, Clause 19.

28 Electrical Insulation

28.1 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-molded composition, or a material having equivalent electrical and physical properties.

28.2 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.

29 Separation of Circuits

29.1 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 circuits of different voltages. 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.

29.2 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.

29.3 Within a compartment that is not a control enclosure junction box or its equivalent, field-installed extra-low-voltage 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 conductors. The line shall allow for droop, and shall connect the opening provided for entrance of the extra-low-voltage conductors to the terminals or leads to which the conductors are attached.

29.4 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 could result in unsafe operation of the equipment; except at wiring terminals.

29.5 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 could result in unsafe operation of the unit.

29.6 The barrier may be removable or have openings for the passage of conductors, provided that instructions for the use of the barrier are a permanent part of the device. Please see Clause 78.4. 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.

29.7 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts that are connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors so that there is no likelihood of the intermingling of the conductors of parts of different circuits. If the number of openings in the enclosure:

a) Equals the minimum required for the proper wiring of the product, and if each such opening is located opposite a set of terminals, it shall be assumed that the conductors entering an opening will be connected to the terminals opposite that opening; or

b) Exceeds the minimum number of openings required for proper wiring, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting an insulated conductor or uninsulated live part of a different circuit shall be investigated.

29.8 To determine whether a product complies with the requirement in Clause 29.7, the product shall be wired as it would be in service, and in doing so, a reasonable amount of slack shall be left in each conductor within the enclosure, and no more than average care shall be used in stowing this slack in the wiring compartment.

29.9 A barrier used to comply with the requirements in Clauses 29.1, 29.2, 29.5, and 29.6 shall:

a) Be of metal not thinner than the enclosure metal, as specified in Table 1 or of an insulating material not less than 0.77 mm (0.03 in) thick. Insulating materials used as barriers shall be thicker if deformation that would defeat the purpose of the barrier could be readily accomplished;

b) Be securely held in place; and

c) If exposed or otherwise likely to be subjected to mechanical abuse, have the necessary mechanical strength.

29.10 Openings in a barrier for the passage of wires shall not be larger in diameter than 6.4 mm (1/4 in), and shall not exceed in number the total number of conductors that will pass through the barrier. A closure for an opening shall present a smooth surface wherever an insulated wire could come in contact with it, and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

29.11 The output of a transformer supplying a Class 2, extra-low-voltage circuit, and provided as part of a product, shall not be interconnected with the output of another such transformer device. The output of two or more transformer devices provided as a part of a product may be interconnected if the voltage and current measurements at the output terminals are within the limits for a single Class 2, 30 V rms or less transformer.

29.12 Class 2, extra-low-voltage circuits supplied by two or more transformers provided as part of a transformer shall be treated as separate circuits. If more than one such circuit is to be field-wired, the circuits involved shall be segregated or separated by barriers in accordance with Clauses 29.3 – 29.6, and the transformer output terminals or leads of each circuit of each terminals or leads of each circuit shall be marked to warn that the separation be maintained.

30 Secondary Circuits

Note: The term “grounding” as used in this clause relates to “bonding” in Canada.”

30.1 General

30.1.1 Each secondary circuit shall be judged by the requirements for hazardous-voltage circuits. A secondary circuit is not required to be investigated if:

a) It is not a circuit that is relied upon to reduce a risk of fire, electric shock, or injury to persons; and

b) It complies with the requirements for an extra-low-voltage secondary circuit, as described in Clauses 30.2.1 – 30.2.9.

30.1.2 A wiring compartment or the equivalent for field-wiring terminals for a secondary circuit shall be separated from a wiring compartment for other terminals. The use of a barrier or partition to separate the secondary circuit from the other terminals shall be acceptable.

30.1.3 A secondary circuit shall not be connected to the frame of the product at more than one point. A grounding bus of the necessary ampacity that is used as the return for a secondary circuit may be connected to the frame at more than one point.

30.1.4 The frame may be used as the return for an extra-low-voltage circuit.

30.2 Extra-low-voltage circuits

30.2.1 An extra-low-voltage circuit shall be supplied from:

a) A Class 2 transformer or

b) An isolating transformer having an open-circuit sinusoidal potential of 30 V rms (42.4 V peak) or less, and that includes at least one of the following means, which limit the power available to the levels specified for Class 2 transformer:

1) A fixed impedance;

2) A noninterchangeable fuse – the largest fuse that fits in the fuseholder provided – or a marking for fuse replacement adjacent to the fuseholder in accordance with Clause 75.28;

3) A nonadjustable manually reset circuit protector; or

4) A regulating network.

30.2.2 With reference to 30.2.1 (b)(1) and (b)(4), if the performance of a fixed impedance or regulating network could be adversely affected by the short circuit or open circuit of any single component in the network, the likelihood of such malfunction occurring shall be determined by investigation of that component.

30.2.3 The impedance, the fuse, the protector, or the regulating network and the wiring between those items and the isolating transformer mentioned in Clause 30.2.1 shall be judged as if it were part of a hazardous-voltage circuit.

30.2.4 A fuse or a circuit protector used to limit the power as specified in Clause 30.2.1 shall be rated or set at not more than 100/V Amps, where V is the open-circuit voltage, for a circuit operating between 20 and 30 V, and at not more than 5.0 A for a circuit operating at 20 V or less.

30.2.5 An impedance or a regulating network that is used to limit the current as specified in Clause 30.2.1 shall limit the current under short-circuit conditions to not more than 8.0 A measured after 2 minutes.

30.2.6 The performance of a regulating network used to limit the power in accordance with Clause 30.2.1 shall not be adversely affected by either short circuit or open circuit between any two terminals of any single rectifier, capacitor, transistor, or similar component in the network.

30.2.7 The wiring in an extra-low-voltage circuit shall be routed away from the wiring of other circuits or shall be provided with insulation that is rated for use at the highest of the voltages in the other circuits.

30.2.8 The wiring in an extra-low-voltage circuit shall be routed away from the uninsulated live components of other circuits.

30.2.9 Wires and cables that are part of an extra-low-voltage circuit shall be provided with strain relief if stress on the wire or cable would cause the internal wiring of the circuits to contact an uninsulated live part of another circuit.

31 Grounding

31.1 General

31.1.1 Each product shall be provided with a means for grounding. A portable product that is rated less than 150 V, or a product that contains extra-low-voltage circuits only, is not required to have provision for grounding.

31.1.2 For grounded products, each exposed non-current-carrying metal part that may become energized, and each non-current-carrying metal part within the enclosure that may be exposed to contact during user-servicing and that may become energized, shall be electrically connected to:

a) For a permanently connected product, the equipment-grounding terminal or lead; and

b) For a cord-connected product, the point of connection of the grounding conductor of the power-supply cord.

31.1.3 The equipment-grounding terminal or lead shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection. The grounding connection shall penetrate nonconductive coatings such as paint or vitreous enamel. The grounding point shall be located so that it is unlikely that the grounding means will be removed during normal servicing of the product.

31.2 Permanently connected products

31.2.1 A product intended for permanent electrical connection to the power supply shall have a field-wiring terminal or lead for the connection of an equipment-grounding conductor.

31.2.2 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal shaped, slotted, or both, with or without a secondary means of rotation. A pressure wire connector intended for connection of such a conductor shall be plainly identified by marking it "G", "GR", "GND", "Ground", "Grounding", the grounding symbol (from IEC 60417, Symbol 5019) as illustrated in Figure 9, or the like, or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be located so that it is not likely to be removed during normal servicing of the product.

31.2.3 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor (as noted in Table 250-122, Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment, of the National Electrical Code, ANSI/NFPA 70) or equipment bonding conductor (as noted in Table 16, Minimum Size Conductors for Bonding Raceways and Equipment, of the Canadian Electrical Code, Part I, C22.1) shall be green, with or without one or more yellow stripes, and no other lead shall be so identified.

31.2.4 A terminal for connection of a product grounding conductor shall be capable of securing a conductor of the size specified in Clause 31.2.6.

31.2.5 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector shall not be used for the grounding terminal.

31.2.6 The size of each grounding conductor shall comply with the applicable requirements for connection of an equipment grounding conductor as specified in Table 16, Minimum Size Conductors for Bonding Raceways and Equipment, of the Canadian Electrical Code, Part I, C22.1, and Table 250-122, Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment, of the National Electrical Code, ANSI/NFPA 70, except that such a conductor need be no larger than one of the power-supply conductors.

31.3 Cord-connected products

31.3.1 A power-supply cord of a product which is required to be grounded, in accordance with Clause 31.1.1, shall include an equipment-grounding conductor that is green in color, with or without one or more yellow stripes.

31.3.2 The equipment-grounding conductor of a flexible cord shall be connected to the fixed grounding member of an attachment plug, and shall be connected at its other end, by a screw or other means not likely to be removed during normal servicing, to the metal parts required to be grounded. Solder alone shall not be used for securing the grounding conductor to the product.

31.3.3 The screw mentioned in Clause 31.3.2 shall be of a corrosion-resistant metal, or shall be protected against corrosion. A lock washer shall be used to reduce the likelihood of the screw becoming loosened by vibration.

31.4 Bonding of internal parts

31.4.1 On a product required to be grounded, an exposed non-current-carrying part that is likely to become energized through electrical fault shall be bonded to the point of connection of the field equipment-grounding means. The following are not required to comply with the requirement for grounding:

a) Small internal assembly screws or other small fasteners such as rivets;

b) Handles for pull-out disconnect switches;

c) Relay and contactor magnets and armatures;

d) Metal parts such as adhesive-attached foil markings, screws, handles, and the like, that are located on the outside of the enclosure or cabinet and are isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized, or are separated from wiring and spaced from uninsulated live parts as if they were grounded parts;

e) A panel or cover that is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant material not less than 0.8 mm (1/32 in) thick and secured in place, or that does not enclose uninsulated live

parts, and wiring that is positively separated from the panel or cover so that it is not likely to become energized; and

f) An isolated metal panel or cover that is separated from live parts and wiring by grounded or bonded interposing metal, such that the interposing metal would be subject to the electrical fault before the isolated metal part in question.

31.4.2 Guards, baffles, and covers that do not require tools for removal shall be removed when determining the exposure to contact of a part. A part that can be contacted by a hemispherical-ended 9.5 mm (3/8 in) diameter rod inserted through an opening in a permanently attached guard or baffle for a distance of 102 mm (4 in) shall be considered exposed for the purposes of the grounding requirement.

31.4.3 Uninsulated metal parts of a cabinet, electrical enclosure, cover, motor frame, mounting bracket, controller mounting frame and bracket, capacitor, and other electrical components, interconnecting tubing and piping, valve, plumbing accessory, and the like shall be electrically bonded together if they could be contacted by the user or service personnel.

31.4.4 Operations or adjustments that are considered as subjecting parts to contact by users shall include those made at the time of installation or during intended use – including seasonal adjustments – and operations such as cleaning or replacing a filter, relamping, replacing a fuse, resetting overload devices, or oiling motors. These procedures and those specified in Protection of Service Personnel, Clause 48, shall also be considered as subjecting parts to contact by service personnel.

31.4.5 A part on the back side of a component mounting panel or a part located so as to require major disassembly by using tools shall not be considered to be exposed to contact by the user, and such a part shall not be considered exposed to service personnel unless it is likely that servicing will be done with the product energized after such disassembly has been accomplished.

32 Bonding Means

32.1 A hazardous-voltage component, such as a control, that may be separated from its intended grounding means after installation in the end-use product for purposes of testing or adjustment while the equipment is energized shall be provided with a bonding terminal or with a bonding conductor that does not require removal from the component for such testing or adjustment.

32.2 Bonding shall be accomplished by a positive means, such as by metal-to-metal contact of the parts, or by a separate bonding conductor in accordance with Clauses 32.3 – 32.13. 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.

32.3 A bolted or screwed connection that incorporates a star washer or serrations under the screw head shall be acceptable for penetrating nonconductive coatings as required by Clause 32.2. The use of two or more screws, or two full threads engagement of a single screw in metal, shall comply with Clause 32.2 if the bonding means depends upon screw threads.

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

32.5 A separate component-bonding conductor shall be copper, a copper alloy, or other material that could be used as an electrical conductor. A ferrous metal part in the grounding path shall be protected against corrosion by enamelling, galvanizing, plating, or other equivalent means.

32.6 A separate bonding conductor or strap shall be protected from damage or shall be located within the confines of the outer enclosure or frame, and shall not be secured by a removable fastener used for

any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener. The ends of the conductor shall be in metal-to-metal contact with the parts to be bonded.

32.7 The size of an individual conductor or strap employed to bond an electrical enclosure or motor frame shall be determined by the rating of the overcurrent protective device of the branch circuit to which the product will be connected in accordance with Table 250-122, Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment, of the National Electrical Code, ANSI/NFPA 70, and Table 16, Minimum Size Conductors for Bonding Raceways and Equipment, of the Canadian Electrical Code, Part I, C22.1, except that such a conductor is not required to be larger than one of the power-supply conductors.

32.8 With respect to Clause 32.7, a bonding conductor smaller than specified may be used if the conductor does not open when tested as described in the Bonding-Conductor Test, Clause 71.

32.9 With respect to 32.7, for a cord-connected product, the grounding wire in the cord may be the same size as the current-carrying conductors.

32.10 A bonding conductor to a motor or other electrical component is not required to be larger than the motor circuit conductors or the conductor supplying the component.

32.11 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.

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

32.13 If more than one size of 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 product, a bonding conductor for that motor shall be sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

33 Capacitors

33.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for elimination of radio-frequency interference or power-factor correction, shall be housed within an enclosure or container that will reduce the likelihood of mechanical damage of the plates and that will reduce the likelihood of emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.51 mm (0.020 in). The individual container of a capacitor may be of sheet metal thinner than 0.51 mm (0.020 in) or may be of other material if the capacitor is mounted in an enclosure that houses other parts of the product and is acceptable for the enclosure of a live part.

33.2 A capacitor employing a liquid dielectric medium shall not expel the medium when tested in accordance with the applicable performance requirements in this Standard, including faulted overcurrent conditions based on the branch circuit in which it is used.

34 Coil Windings

34.1 Each coil winding of a motor, relay, transformer, and the like shall be treated to resist the absorption of moisture by impregnating, dipping, or brushing with varnish or by other means.

34.2 Film-coated wire shall not be required to be additionally treated to resist the absorption of moisture, but fiber liners, cloth coil wrap, and similar materials shall be provided with impregnation or otherwise treated to resist moisture absorption.

35 Heating Elements

35.1 A heating element shall be supported in an acceptable and reliable manner. It shall be protected against mechanical damage and contact with outside objects.

35.2 The supporting means for a heating element shall be evaluated with respect to sagging, loosening, and other adverse conditions resulting from continuous heating of the element.

35.3 An open-wire element, that is, one consisting of uninsulated resistance wire, may be used in a product provided it is enclosed or protected by barriers or covers that require tools for removal, and provided it complies with all live part accessibility requirements. See Accessibility of Uninsulated Hazardous Voltage Live Parts and Film-Coated Wire, Clause 7.

35.4 Coiled-wire heating elements may be supported on porcelain, hook-type insulators, depending upon the stiffness of the coil, the spacing between hooks, the shape of the hook, or the like. Porcelain insulators of all types shall be retained in place by means other than the heating element.

35.5 A heating element intended for operation only in an air stream shall be wired or controlled so that the element can be operated only while under the cooling effect of an air stream. A product in which the cooling effect of the motion of a part is necessary to prevent excessive temperatures shall be wired or controlled so that the element cannot be operated without such motion.

35.6 A sheathed heating element shall be suitable for the applications, and shall comply with the requirements in UL 1030 and C22.2 No. 72.

36 Motors

36.1 General

36.1.1 A motor shall comply with the requirements in UL 1004-1 and C22.2 No. 100, and shall be capable of driving the maximum normal load of the product without a risk of fire or electric shock.

36.1.2 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary to reduce the likelihood of an accessible non-current-carrying metal part becoming energized, and a live part becoming accessible.

36.1.3 Each brush cap shall be secured or located so as to be protected from mechanical damage that could otherwise occur during intended use.

36.2 Motor overload protection

36.2.1 All motors shall be protected by thermal or by overcurrent protective devices, or a combination of these, except as specified in Clause 36.2.12.

36.2.2 If thermal protection is incorporated it shall comply with the applicable requirements in UL 1004-3 and C22.2 No. 77.

Note 1: For a product that includes a control as mentioned in Clause 36.2.4, the duration of the temperature test and the endurance test, both under locked-rotor conditions, may be less than that specified but shall not be less than the period of operation permitted by the product.

Note 2: If the time required to operate a manually reset protective device through 10 cycles of operation is longer than the time that the product is likely to be operated during each use, the number of operations of the device for the temperature test under locked-rotor conditions may be less than 10 cycles, but shall not be less than 4 cycles.

36.2.3 A motor intended to move air only, by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft, shall not be required to have running overload protection.

36.2.4 The control mentioned in Note 1 to Clause 36.2.2 shall positively and reliably limit the length of time the product can be operated, as, for example, a timer.

36.2.5 For a multispeed motor that uses a separate overload-protective device to provide running protection, the protection shall be effective at all intended motor speeds.

36.2.6 The overload protection of a single-speed, continuous duty fan motor having a marked rating over 746 W output (1 HP) is not required to be provided as part of the product if all of the following conditions exist:

a) The motor is located where it is not affected by an external source of heat;

b) The motor is to be field-wired to a separate circuit that does not supply any other loads within the product;

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

d) Energization of electric heating elements does not occur without motor operation or evidence of air flow.

36.2.7 Compliance with the requirements of Clause 36.2.1 shall be considered to be achieved if the protection is provided by a separate device that is responsive to motor current, and is rated or set to trip at not more than the percentage of the motor nameplate full-load current rating as specified in Table 11. If the percentage protection specified in Column A of Table 11 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 11.

36.2.8 A three-phase motor shall be provided with overload protection as follows:

a) Three overcurrent units; or

b) 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.

36.2.9 Where the overheating protection of three-phase motors is provided by devices that are current responsive only, such devices shall consist of three current responsive elements which may be:

a) Connected directly in the motor circuit conductor; or

b) Fed by two or three current transformers, and so connected that all three phases will be protected.

36.2.10 Overload devices shall consist of one of the following:

a) A separate overload device that is responsive to motor current, rated or set at values not greater than the percentages of the marked full-load current specified in Clause 36.2.7, and that combines the functions of overload and overcurrent protection if it is capable of fully protecting the circuit and motor both under overload and short circuit conditions;

b) A protective device, integral with the motor, responsive to motor current, or to both motor current and temperature, providing such device will protect the circuit conductors and control equipment, as well as the motor;

c) Notwithstanding (a), where the marked service factor of a motor is less than 1.15, or where 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 percent of the full load current of the motor; or

d) An overload protector included as part of the assembly.

36.2.11 Fuses shall not be used as motor overload protective devices unless the motor is adequately protected by the fuse of the highest current rating that can be inserted in the fuseholder.

36.2.12 Impedance protection shall be acceptable, provided the motor:

a) Complies with the applicable requirements in UL 1004-2 and C22.2 No. 77;

b) Does not overheat when subjected to the performance tests of this Standard; and

c) Is not installed in a compartment that handles air for circulation to the conditioned space through a duct system, unless no smoke is generated under any required test condition while the rotor of the motor is locked.

36.3 Short circuit protection

36.3.1 Motor overcurrent protective devices and thermal protective devices shall comply with the applicable short circuit requirements for the class of protective device.

36.3.2 Except as indicated in Clause 36.3.3, 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, without creating a risk of fire or electric shock.

36.3.3 The short circuit tests specified in Clauses 36.3.1 and 36.3.2 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.

37 Overcurrent Protection

37.1 A protective device shall not be accessible from outside the product without opening a door or cover. See Clause 6.5. The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and a similar part may project outside the enclosure.

37.2 No uninsulated live part of a fuseholder other than the screw shell or clips shall be exposed to contact by a person removing or replacing a fuse. This requirement shall not apply if the presence of the protective device would ordinarily be unknown to the user of the product because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like for the product.

37.3 Plug fuses shall not be used in circuits exceeding 150 V to ground. The screw shell of a plug type fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

37.4 If a product includes an attachment-plug receptacle intended for general use, and if the overcurrent protection of the branch circuit to which the product will properly be connected exceeds that acceptable for the receptacle, each receptacle circuit shall have overcurrent protection at not more than the rating of the receptacle provided as a part of the product.

37.5 The overcurrent protection specified in Clauses 37.4 and 37.8 – 37.10 shall be located in each ungrounded conductor and shall comply with the requirements for branch-circuit protection.

37.6 If a fuse is used for the overcurrent protection referred to in Clause 37.5, it shall be a Class CC, G, H, J, K, L, RK, or T cartridge fuse, a Type S fuse, or the equivalent.

37.7 The rating of the branch-circuit overcurrent protective device shall not exceed the overcurrent protective device rating marked on the product or, if there is no marking, 20 A for a product rating not exceeding 13.3 A and 150 percent of the product rating for a product rating greater than 13.3 A. Standard ratings for overcurrent protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, and 200 A. If 150 percent of the rating of the product does not equal one of the aforementioned, it shall be assumed that the next higher rating or setting of overcurrent protective device will be employed.

37.8 A product provided with auxiliary-circuit terminals shall incorporate an overcurrent protective device in accordance with Clause 37.5 in each ungrounded conductor connected to the terminals. An overcurrent protective device is not required as part of the product if it is determined that equivalent or better protection will be obtained from the branch-circuit overcurrent protective device through which the product will be supplied.

37.9 Each lampholder circuit in a permanently connected product having a lampholder independent of any heating-element circuit shall have overcurrent protection rated not more than 20 A in the product, if the overcurrent protection of a branch circuit to which the product may be properly connected in accordance with Clause 37.7 would exceed 20 A.

37.10 A product rated more than 48 A shall have the heating-element circuits subdivided. Each subdivided circuit shall not exceed a rating of 48 A, and each shall be provided with overcurrent protection rated not more than 60 A. A product complying with the following conditions may be subdivided into circuits not exceeding 120 A each if:

a) The load consists of resistance-type immersion heating elements that are contained within a water or steam tank, provided that the tank bears ASME marking letter H, M, or S in a clover leaf;

b) Each subdivided circuit is protected at not more than 150 A; and

c) The overcurrent protection in (b) is provided as an integral part of the product or is provided by the manufacturer as a separate assembly for independent mounting and use with the product.

38 Protection Against Overheating

38.1 The setting, construction, and location of protection devices used to prevent the attainment of unsafe operating temperatures as the result of either normal or abnormal operation shall be investigated with respect to all features bearing on the life and fire hazards involved in actual service.

38.2 Fusible links provided in heaters to prevent the attainment of unsafe temperatures due to abnormal operation of heaters shall be so constructed or enclosed as to prevent tampering and shall operate without the short circuiting or grounding of live parts. Please see Thermal Cutoff Test, Clause 66, for additional information.

38.3 The reset lever or button of a manual reset protective device that is not trip-free shall be recessed or guarded.

38.4 Where a humidifier employs a single magnetically operated relay device or contactor that performs the temperature regulating and limiting function for an electric heating element, the device shall be rated for at least 250 000 endurance cycles.

38.5 Except as specified in Clause 38.9, a humidifier employing electric heating elements shall be provided with one or more manually resettable or replaceable backup protective devices of the type specified in Clause 38.6 that will, with the contacts of the control described in Clause 38.4, permanently closed, comply with the abnormal operation test, Clause 65, and the thermal cutoff test, Clause 66.

38.6 The manually resettable or replaceable protective devices specified in Clause 38.5 shall be functionally independent of the automatically resetting limit control. The following types of controls comply with this requirement:

a) One or more thermal cut-offs, non-resettable 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; and

b) A combination consisting of one or more normally open switching device and thermal cut-offs, non-resettable temperature-limiting controls, or manually resettable limit controls. The thermal cut-off or limit control shall be connected in the coil circuit of the switching device.
The combination shall be:

1) Integral with the product;

2) Able to open a sufficient number of ungrounded supply conductors to permit the product to comply with the specified temperature limits; and

3) Independent of control by an automatic cycling device with the unit.

38.7 Replacement of a thermal cut-off or non-resettable limit control shall not necessitate any of the following:

a) Removal of the unit or heater assembly from its installation, except removable heating elements or an element assembly may be withdrawn, or a heater may be partially withdrawn, to replace a thermal cut-off or non-resettable limit control, if withdrawal will not result in non-compliance with the requirements of Clause 38.7 (b), (c), and (d);

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.

38.8 With respect to Clause 38.7, a thermal cut-off or non-resettable limit control that is not required in order to comply with any of the requirements in this Standard is not required to comply with 38.7 (a) and (b).

38.9 The requirement specified in Clause 38.5 does not apply if no part of the automatically resetting temperature-limiting control circuit cycles under intended operating conditions. For example, an automatically resetting temperature-limiting control that directly controls a heating element is not required to be provided with the backup protection specified in Clause 38.5. The backup protection specified in Clause 38.5 is required for a humidifier employing an electric heating element that incorporates a switching device whose coil circuit is controlled by both the temperature-limiting control and temperature-regulating control for the heater.

39 Receptacles

39.1 A 15- or 20-A attachment-plug receptacle intended for general use in a product provided with means for grounding shall be of the grounding type. The grounding contact of the receptacle shall be electrically connected to metal parts in the grounding/bonding circuit.

39.2 The face of a receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface; or

b) Project at least 0.38 mm (0.015 in) beyond a conductive surrounding surface.

39.3 Receptacles shall not be provided on products intended to be duct- or plenum-mounted.

40 Switches and Controllers

40.1 A switch or other control device shall be acceptable for the application, and shall have a current and voltage rating not less than that of the load it controls.

40.2 The current rating of a switch that controls an inductive load, such as a transformer of a fluorescent-lamp ballast, shall not be less than twice the rated full-load current of the transformer or ballast, unless the switch has been investigated and found to be acceptable for the application.

40.3 A switch in a circuit including one or more motors and some other load and that may break the circuit under locked rotor conditions shall have a current interrupting capacity not less than the total of the locked rotor motor current of the largest motor and the other load.

40.4 A switch shall be of the indicating type.

40.5 The indicating means referred to in Clause 40.4 may be incorporated on the switch or knob, on an attached plate, or on the panel on which the switch is mounted.

40.6 A switching device or a pilot that controls a switch may be marked with the symbols "I" and "O" to represent the "ON" and "OFF" positions, respectively, of the device.

40.7 If a switching device or a pilot device that controls a switch with a marked or indicated "OFF" position operates to interrupt the main supply circuit, it shall, when open, disconnect all ungrounded power-supply conductors.

40.8 If a switch or a control that can be turned manually to an "OFF" position is used to control one or more functions, its "OFF" position, at least, shall be indicated on or adjacent to the switch. Alternatively, keys or legends may be used for showing the operating positions of switches; they shall indicate at least the "OFF" position and shall appear in a conspicuous, permanent location. No additional marking need appear if the handle is of such shape or design that the "OFF" position of the switch is thereby clearly indicated.

40.9 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be investigated and found to be acceptable for use with tungsten-filament lamps.

40.10 A product provided with a power-supply cord and an attachment plug and employing a motor rated more than 250 W output (1/3 HP) shall be provided with a control for starting and stopping the motor.

40.11 A speed-control switch shall be provided with a product that employs a multispeed motor.

40.12 Switches shall be so located or protected that in normal use they will not be exposed to mechanical damage.

41 Electrically Operated Valves and Solenoids

41.1 An electrically operated valve or solenoid shall be so located, guarded, or enclosed that it will not be subject to mechanical damage during the normal operation or servicing of the equipment.

41.2 An electrically operated valve or solenoid shall not create a risk of fire if it fails to operate properly.

41.3 If a valve must be cleaned periodically, the construction shall be such that this operation can be performed without damage to the electrical parts of the valve or wiring.

42 Spacings

42.1 The spacings between wiring terminals of opposite polarity, between a wiring terminal and an uninsulated non-current-carrying metal part, or between a wiring terminal and uninsulated live part of opposite polarity shall not be less than as specified in Table 12.

42.2 Other than at wiring terminals, and as noted in Clause 42.7, the spacing between uninsulated live parts of opposite polarity, and between an uninsulated live part and a non-current-carrying metal part, shall not be less than as specified in Table 13. If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or if a moveable non-current-carrying metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing will be maintained.

42.3 The spacings at installer wiring terminals shall apply with the required size of supply conductors in place, including the use of aluminum supply conductors.

42.4 The spacings in Table 12 at installer wiring terminals shall not apply to bars or straps connected to such terminals.

42.5 The spacings through air and over the surface from terminals and other bare live parts to removable enclosures of metal shall be not less than 9.5 mm (3/8 in) for voltages not exceeding 375 V, and not less than 12.5 mm (1/2 in) for voltages from 376 to 600 V.

42.6 The inherent spacings of a component supplied as part of a product, such as a snap switch, lampholder, or motor, shall be judged under the requirements for that component. The spacings from a component to another component and to the enclosure, and the spacings at wiring terminals, shall be as specified in Table 12 and Table 13.

42.7 At terminal screws and studs to which connections can be made in the field by means of wire connectors, eyelets, and the like, the spacings shall not be less than those specified in Table 13 when such connectors, eyelets, and the like are in such a position that minimum spacings to parts of opposite polarity and to non-current-carrying metal exist.

42.8 An insulating liner or barrier of vulcanized fiber or similar material employed in lieu of spacings shall not be less than 0.8 mm (1/32 in) thick, and shall be so located or of such material that it will not be adversely affected by arcing. Fiber not less than 0.4 mm (1/64 in) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

42.9 Where higher-than-rated voltage is developed in a motor circuit through the use of capacitors, the rated voltage of the system shall be employed in applying the spacings indicated in this Standard, unless the developed steady-state voltage measured in the Normal-Temperature Test, Clause 57, exceeds 500 V, in which case the developed voltage shall be used in determining the spacings for the parts affected.

42.10 Bare live parts connected to circuits of different voltage shall be spaced from one another as though they were parts of opposite polarity, in accordance with Table 12 and Table 13 for the highest voltage involved.

42.11 For an extra-low-voltage safety circuit, if operation of the product with a short circuit or grounded circuit could result in unsafe operation of the controlled device, spacings shall be not less than as specified in Table 13.

42.12 For extra-low-voltage nonsafety circuits, spacings are not specified.

43 Thermal Insulation

43.1 Thermal insulation shall be of such a nature and located and mounted or supported so that it will not be adversely affected by any intended operation of the product.

43.2 Combustible or electrically conductive thermal insulation shall not contact uninsulated live parts of a product. Some types of mineral-wool thermal insulation contain conductive impurities in the form of slag, and shall not be used with uninsulated live parts.

43.3 Thermal insulation that is not rigid shall be mounted or supported so that it will not sag.

43.4 Adhesive employed for mounting thermal insulation shall be investigated and found to be acceptable for use at the temperature to which it may be subjected.

43.5 Determination of the acceptability of an adhesive shall not be necessary if the thermal insulation is mechanically supported by at least one rivet or the equivalent per 929 cm^2 (1 ft^2) of material.

44 Wetting Live Parts

44.1 There shall be no wetting of electrical parts as a result of any likely condition of normal or abnormal use, such as overfilling, improper replacement of parts that are moved or removed during user servicing, malfunction of water-handling systems, moving or portable products, and the like.

44.2 No electrical part in a product having a reservoir arranged for hand filling by the user shall be wetted during any likely filling operation.

44.3 A product having a reservoir intended for filling by an automatic valve shall not allow electrical parts to be wetted when the valve is held in its open position.

45 Internal Plumbing

45.1 A product connected to a potable water-supply system shall be provided with an air-gap fitting as described in Clause 45.2.

45.2 For the air-gap fitting mentioned in Clause 45.1, the minimum unobstructed vertical distance through free air between the lowest opening in the water-inlet device supplying water to the product and the flood-level rim of the reservoir that receives the water shall be at least 25.4 mm (1 in) or twice the inside diameter of the inlet pipe, whichever is greater; or the product shall comply with the Backflow Test, Clause 70.

45.3 The flood-level rim mentioned in Clause 45.2 shall be the highest point in the reservoir from which water overflows.

45.4 Each part of the potable water-supply assembly of a product that is in contact with the water, through the discharge terminal point of the air-gap fitting, shall be constructed of nontoxic and corrosion-resistant materials.

46 Filters

46.1 A filter provided with a humidifier intended for connection to ducts or plenums shall comply with the requirements in UL 900.

47 Pressure Vessels and Parts Subjected to Pressure

47.1 If the equipment includes pressure vessels having an inside diameter over 152 mm (6 in) and an internal volume over 0.0425 m^3 (1.5 ft^3), and operating at more than 103 kPa (15 psig), they shall comply with CSA B51, and shall be designed, tested, and stamped in accordance with the ASME Boiler and Pressure Vessel Code for a design pressure no less than the pressure determined in accordance with Clause 47.2. A pressure vessel that is not required to comply with ASME Code and that complies with the requirements in Clause 47.2 is not required to be tested and stamped as specified.

47.2 A part or assembly that is subject to air or vapor pressure (including the pressure in a vessel containing only a superheated fluid) during normal or abnormal operation shall withstand, as described in Tests on Parts Subject to Pressure, Clause 72, a pressure equal to the highest of the following that is applicable to the particular vessel:

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the product, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief valve or other device provided as a part of the product;

b) Five times the marked maximum supply pressure from an external source, but not more than the limits specified in (a);

c) Five times the pressure setting of a required pressure-relief device;

d) Five times the maximum pressure that can be developed by an air compressor that is part of the product, unless the pressure is limited by a pressure-relief device as described in (a);

e) Five times the working pressure marked on the part; or

f) Five times the maximum pressure that can be developed in a nonenclosed system or vessel. (A nonenclosed system or vessel is a system or vessel using an overflow open to the atmosphere.)

47.3 A section of a pressure system constructed of continuous tubing or lengths of tubing connected by hard soldered, brazed, or welded joints shall be considered to comply with the requirements in Clause 47.2 if the thickness of tubing is not less than the applicable value specified in Table 14.

47.4 A pressure vessel bearing the CRN or ASME Code inspection symbol shall be considered to comply with the requirements in Clause 47.2 if it is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal conditions.

47.5 A means for relieving pressure shall be provided for all parts in which pressure may be generated by an external fire.

47.6 A pressure-relief device, such as a fusible plug, soldered joint, nonmetallic tubing, or other equivalent pressure-relief means, may be employed to comply with the requirement in Clause 47.5.

47.7 There shall be no shutoff valve between a pressure-relief means and the part it is intended to protect.

47.8 A vessel having an inside diameter of more than 76.2 mm (3 in) and subject to air or steam pressure generated or stored within the product shall be protected by a pressure-relief device.

47.9 The start-to-discharge pressure setting of the relief device shall not be higher than the working pressure marked on the vessel. The discharge rate of the device shall be sufficient to relieve the pressure.

47.10 Each pressure-relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the product it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair and cannot readily be rendered inoperative so that it will not perform its intended function; and

c) Have its discharge opening located and directed so that:

1) Operation of the device will not deposit moisture on a live part or on insulation or a component that could be adversely affected by such moisture and

2) It is not likely to scald persons.

47.11 A pressure-relief device having an adjustable setting is judged on the basis of its maximum setting unless the adjusting means is sealed at a lower setting.

47.12 A pressure-relief device is considered to be a pressure-actuated valve or rupture member intended to automatically relieve excessive pressures.

47.13 If a system is open to the atmosphere and the opening to the atmosphere is used as a pressure-relief means, the opening shall be capable of relieving the pressure at the maximum generating capacity and shall discharge in a manner so that the steam is directed in an area that is not likely to cause a risk of electric shock or injury to persons.

48 Protection of Service Personnel

48.1 General

48.1.1 The intent of Clause 48 is to reduce the risk of electric shock or injury to service personnel performing service functions of a mechanical nature on an energized product. Such functions do not in themselves require exposure of live parts or moving parts capable of causing injury, but it is often necessary to perform these functions with the product energized.

48.1.2 The following are not considered to be uninsulated live parts for the purposes of Clause 48:

a) Coils and windings of a controller, a relay, and a solenoid, and a transformer, if these coils and windings are provided with insulating overwrap;

b) Enclosed motor windings;

c) Terminals; and

d) Splices with insulation and insulated wire.

48.2 Construction

48.2.1 An uninsulated live part or a moving part that can cause a risk of injury to persons within the enclosure shall be located, guarded, or enclosed so as to reduce the risk of unintentional contact by service personnel performing mechanical service functions that can be performed with the product energized.

48.2.2 Examples of mechanical service functions that can be performed with the product energized are:

a) Adjusting a water control valve;

b) Adjusting the setting of a temperature, humidity, or a water or pressure control with or without a marked dial setting;

c) Resetting a control trip mechanism; and

d) Adjusting an airflow damper.

48.2.3 An adjustable or resettable electrical control or manual switching device shall be located or oriented with respect to an uninsulated live part or a moving part that presents a risk of injury to persons so that manipulation of the mechanism for adjustment, resetting, or other service operations can be done in the intended direction of access if an unguarded, uninsulated live part or a moving part that presents a risk of injury to persons is not located in front, in the direction of access of the mechanism, and not located within 152 mm (6 in) on any side or behind the mechanism.

48.2.4 With reference to Clause 48.2.3, only uninsulated live parts in a hazardous-voltage circuit shall be considered.

48.2.5 An electrical control component that could require examination, adjustment, servicing, or maintenance while energized – excluding voltage measurements other than at jacks or terminals specifically intended for that purpose – shall be located and mounted with respect to other components, and with respect to grounded metal parts, so that it is accessible for electrical service functions without subjecting service personnel to a risk of electric shock from an adjacent uninsulated live part or injury to persons from an adjacent moving part.

48.2.6 Accessibility and protection from a risk of electric shock and injury to persons shall be obtained by mounting the control components in an assembly so the unimpeded access is provided to each component through an access cover or panel in the outer cabinet, and the cover of the control assembly shall be in accordance with the following items and Figure 10:

a) No component in the control assembly shall be located more than 356 mm (14 in) from the plane of the access opening in the outer cabinet.

b) An uninsulated live part outside the control assembly projected clear space – other than a live part within a control panel – or an unguarded moving part shall be located no closer than 152 mm (6 in) from any side of the access area. The projected clear space shall be considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or control enclosure when provided. The access area shall be considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or control enclosure.

c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet, within the access area, shall be completely free of obstructions, including wiring.

d) Access to the components in the control assembly shall not be impeded in the direction of access by other components or by wiring in the assembly.

e) An extractor-type fuseholder and a snap switch mounted through the control assembly enclosure shall be located so that there is unimpeded access to these components through the access opening in the outer cabinet and so that they are not immediately adjacent to an uninsulated live part outside the control assembly enclosure, unless the live part is guarded.

48.2.7 A component or control may be rotated or otherwise displaced for service if the electrical control components are accessible for service as required.

48.2.8 Other arrangements of component location or guarding that provide the required access to electrical control components shall also be acceptable.

48.2.9 The electrical components referred to in Clauses 48.2.3 – 48.2.8 include the following:

a) Fuses;

b) Adjustable or resettable overload relays;

c) Manual or magnetic motor controllers;

d) Magnetically operated relays;

e) Adjustable or resettable pressure or temperature controllers;

f) Manual switching devices;

g) Clock timers;

h) Incremental voltage taps; and

i) Motor-speed tap terminals for variable-speed motors.

Such components in an extra-low-voltage circuit shall comply with the requirements in Clause 48.2.1 in their relation to uninsulated live parts in a hazardous-voltage circuit and to moving parts capable of causing injury to persons.

48.2.10 Under certain conditions, some of the components referred to in Clause 48.2.9 are not required to be accessible for service. The following are examples of such components:

a) A nonadjustable magnetic motor controller or a magnetically operated relay that is inaccessible for service while energized because it is located behind a subbase or equivalent, and is not visible when the access panel is removed;

b) Enclosed potential or current-type single phase motor-starting relay;

c) An incremental voltage tap or motor-speed-control tap for a variable-speed motor; and

d) A contact with bare live parts of the voltage or speed tap to affect the speed or voltage change, such as an uninsulated screw or quick-connect terminal.

49 Duct- and Plenum-Mounted Products

49.1 The requirements in Clause 50 apply to duct- and plenum-mounted products intended for commercial or residential use. A duct- or plenum-mounted product shall also comply with all of the applicable requirements in Clauses 1 – 48 of this Standard.

50 Construction of Duct- and Plenum-Mounted Products

50.1 Installation

50.1.1 A product intended to be duct-mounted by the user shall be constructed so that it can be installed mechanically by means of ordinary tools (such as a screwdriver, a drill, and the like) and electrically by means of plug-in connections available on the furnace or as part of the building wiring.

50.1.2 The construction of a duct- or plenum-mounted product intended to be installed by qualified service personnel shall be such that:

a) The mechanical installation can be accomplished by means of tools normally available at the installation site or by means of tools provided by the manufacturer as part of the installation kit; and

b) The electrical connections can be readily accomplished by making use of existing terminals and connections in the furnace or as part of the building wiring.

50.1.3 If a product is intended to obtain its power supply from a furnace, the method of wiring shall be such that the internal wiring and internal components of a furnace are not altered.

50.2 Polymeric material

50.2.1 A polymeric material that is used in a product intended to be duct- or plenum-mounted, where the polymeric material of the product is exposed to duct air, shall have a flame-spread rating of 25 or less, and a smoke developed rating of 50 or less in accordance with UL 723 and CAN/ULC-S102. A small part, such as the wheel on which the water-absorbing medium is mounted, the float or float valve, a knob, or a slinger, shall not be required to have the specified ratings or be included in the surface-area calculation as specified in Clause 50.2.2(b).

50.2.2 A polymeric material employed in a residential duct- or plenum-mounted product where the product is exposed to the duct or plenum air complies with the requirements in Clause 50.2.1 when:

a) The material has no single dimension greater than 1.83 m (6 ft);

b) The sum of the surface areas exposed to the air stream on all such materials in the product is not more than 0.93 m^2 (10 ft^2); and

c) One of the following conditions exists:

1) The material has a flammability classification of 5VA in accordance with UL 94 and 5VA in accordance with CAN/CSA-C22.2 No. 0.17; or

2) Results that comply with the intent of the requirement are obtained when the material is subjected to an enclosure flammability 127-mm (5-inch) flame test as described in UL 746C and 5VA in CAN/CSA-C22.2 No. 0.17.

50.3 Evaporation pad

50.3.1 An evaporative pad for use in a duct-mounted product shall be Class 1 or 2, and shall not be treated with a chemical that is water soluble.

50.4 Supply cord

50.4.1 A product intended for mounting in or on an exhaust duct or plenum may be provided with a power-supply cord if:

a) The cord is

1) A 3-conductor, Type SJT or heavier duty type rated for at least 105°C (221°F);

2) Terminated in a properly rated grounding attachment plug; and

3) No longer than 1.83 mm (6 ft); and

b) Installation instructions, as described in Clause 78.8, are included with the product.

PERFORMANCE

51 General Test Parameters

51.1 General

51.1.1 Except as otherwise required, one representative sample of the equipment shall be subjected to the applicable tests of this Standard.

51.1.2 The order of the tests, as far as applicable, shall correspond to the Leakage-Current Test, Clause 52 to the Mold Stress-Relief Test, Clause 73, but not so as to require unnecessary samples.

51.2 Voltage

51.2.1 Except as otherwise specified, humidifiers shall be tested at a frequency of 60 Hz, and at the voltages, maintained at the unit supply connections, as specified in Table 15. Units rated at other than 60 Hz frequencies shall be tested at their rated voltages and frequencies.

51.3 Ambient temperatures

51.3.1 Except as otherwise provided in this Standard, equipment may be tested in any convenient ambient temperature between 20 and 40°C (68 and 104°F).

52 Leakage-Current Test

52.1 When tested in accordance with Clauses 52.2 – 52.7, the leakage current of a cord-connected product rated 240 V or less shall not be more than:

a) 0.5 mA for a portable product; and

b) 0.75 mA for all other products.

52.2 All exposed conductive surfaces shall be tested for the presence of leakage currents. The leakage currents from these surfaces shall be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Parts shall be considered to be exposed surfaces unless guarded by an enclosure considered acceptable to reduce the risk of electric shock as described in the Accessibility of Uninsulated Hazardous Voltage Live Parts and Film-Coated Wire, Clause 7. Surfaces shall be considered simultaneously accessible if they can be readily contacted. Leakage current is not required to be measured at terminals of an extra-low-voltage circuit.

52.3 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 100 x 200 mm (4 x 8 in) in contact with the surface. If the surface is less than 100 x 200 mm, the metal foil shall be the same size as the surface. The foil shall not remain in place long enough to affect the temperature of the products.

52.4 The measurement circuit for leakage current shall be as illustrated in Figure 11. The measurement instrument is defined in (a) – (c) below. The meter that is actually used for a measurement need only indicate the same numerical value for a measurement as would the defined instrument. The meter used is not required to have all the attributes of the defined instrument.

a) The meter shall have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

b) The meter shall indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry shall have a frequency response ratio of indicated to actual value of current – equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 mA, the measurement shall have an error of not more than 5 percent at 60 Hz.

52.5 Unless the meter is being used to measure leakage from one part of a product to another, the meter shall be connected between the accessible parts and the grounded supply connector.

52.6 A sample of the product shall be tested for leakage current starting with the as-received condition, as-received being without prior energization except as might occur as part of the production-line testing, and with its grounding conductor open at the attachment plug. The supply voltage shall be adjusted to the voltage specified in Figure 11. The test sequence with reference to the measuring circuit – Figure 11 – shall be as follows:

a) With switch S1 open, the product shall be connected to the measuring circuit. Leakage current shall be measured using both positions of switch S2, and with the product switching devices in all of their intended operating positions.

b) Switch S1 shall then be closed, energizing the product, and within 5 seconds the leakage current shall be measured using both positions of switch S2 and with the product switching devices in all of their intended operating positions.

c) The leakage current shall then be monitored until thermal stabilization. Both positions of switch S2 shall be used in determining this measurement. Thermal stabilization shall be obtained by operation as in the Normal-Temperature Test, Clause 57.

d) After thermal stabilization, switch S1 shall be opened to de-energize the product. Monitoring of leakage current shall continue until the leakage current stabilizes or decreases after de-energizing the product, using both positions of switch S2.

52.7 Products with speed, temperature, or humidity controls shall be tested at low, medium, and high settings of the controls.

53 Humidity-Conditioning Test

53.1 A product shall be conditioned for 48 hours in air having a relative humidity of 88 ± 2 percent at a temperature of 32 ±2°C (90 ±4°F). After conditioning:

a) A cord-connected product rated for a nominal 240 V supply or less shall comply with the requirements in Clause 52.1 in a repeated leakage current test; and

b) A product other than as mentioned in (a) shall have an insulation resistance of 50,000 ohms or more between live parts and interconnected non-current-carrying metal parts.

53.2 A sample of the product shall be heated to a temperature just above 34° C (93° F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample shall be placed in the humidity chamber and conditioned as specified in Clause 53.1.

53.3 Following conditioning:

a) A cord-connected product rated for a nominal 240 V supply or less shall be tested as described in Clause 52.6. The test shall be discontinued when the leakage current stabilizes or decreases; and

b) The insulation resistance of a product other than as described in (a) shall be measured as described in Clause 53.4.

53.4 Ordinarily, insulation resistance shall be determined by using a high-resistance voltmeter and a 250 V, direct-current circuit.

54 Operation Test

54.1 A product shall be operated for 24 hours in cycles of 15 minutes on and 45 minutes off, with water circulating through it in the intended manner. Immediately upon conclusion of the final on cycle of the 24-hour period, the leakage current or insulation resistance shall be measured as described in Clause 53.2. The leakage current or insulation resistance, as applicable, shall comply with the requirement in (a) or (b) of Clause 53.1. This requirement does not apply to a steam-type product.

54.2 A steam-type product shall be tested as described in Clause 54.3. The leakage current shall not exceed 0.5 mA, and there shall be no evidence of deterioration of the physical properties of the enclosure.

54.3 One sample of a steam-type product shall be supplied with water and operated continuously for 30 days at rated voltage and rated frequency. At the end of the 30 days, the sample shall be subjected to the Leakage-Current Test, Clause 52.

55 Starting Test

55.1 A product shall start and operate as intended on a circuit protected by a fuse as specified in Clause 55.2. During this test, the fuse shall not open. Also, any overload protector provided as part of the product shall not trip.

55.2 The fuses required by Clause 55.1 shall:

a) For cord-connected equipment, be the same rating as the attachment plug of the supply cord. The fuses shall be the time delay type, if equipment marking so specifies; and

b) For equipment intended for permanent connection to the supply, be either of the same rating as marked on the equipment or, if not marked, be of the same rating as the maximum permitted for motor-branch circuits in the National Electrical Code, ANSI/NFPA 70, and the Canadian Electrical Code, Part I, C22.1. The fuses shall be the time delay type, if equipment marking so specifies.

55.3 To determine compliance with Clause 55.1, the equipment, when connected to a supply circuit at the required test voltages and rated frequency, shall be capable of starting, from standstill to normal operating speed(s), three consecutive times without blowing the fuse, with the equipment initially at room temperature.

55.4 The equipment shall start and run under all normal speed control settings.

56 Input Test

56.1 When tested as described in Clauses 56.2 and 56.3, the input in amperes or watts or kilowatts to a product shall not be more than 110 percent of the rated value of the product, except that for single-phase motors with marked rating of 3 A or less, the input may be not more than 120 percent of the rated value.

56.2 The input measurement shall be made with the equipment dry, and also with water present so that the product is functioning in the intended manner.

56.3 If the humidifier includes heater(s), the input shall also be measured with the heater(s) in operation.

57 Normal-Temperature Test

57.1 All products

57.1.1 When a product is tested as described in Clauses 57.1.2 – 57.2.4, the temperature at any point shall not be high enough to:

a) Cause a risk of fire;

b) Damage any material used; or

c) Exceed the maximum acceptable temperatures specified in Table 16.

57.1.2 Temperatures shall be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). When thermocouples are used in determining temperatures of an electrical product, it is common practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument, and such equipment shall be used whenever referee temperature measurements by thermocouple are necessary.

57.1.3 A thermocouple junction and adjacent lead wire shall be securely held in thermal contact with the surface of the material to be measured, such as by securely taping or cementing the thermocouple in place. If a metal surface is involved, brazing or soldering the thermocouple to the metal might be necessary. For a thermocouple-measured temperature of a coil of an alternating-current motor having a frame diameter of 178 mm (7 in) or less, the thermocouple shall be mounted on the integrally applied insulation on the conductor.

57.1.4 A temperature shall be considered to be constant when three successive readings taken at 10 minute intervals indicate that stabilized temperatures have been established (no more than 1 percent net increase between the last two readings). If the temperatures measured are within 5 percent of the values specified in Table 16, the test shall be continued until two successive 10-minute readings indicate constant temperatures.

57.1.5 Ordinarily, coil or winding temperatures shall be measured by thermocouples. However, if the coil is inaccessible for mounting thermocouples, such as one immersed in sealing compound, or if the coil wrap includes thermal insulation or more than two layers of cotton not more than 0.8 mm (1/32 in) thick, the resistance method shall be used.

57.1.6 When the change-of-resistance method is used, determination of the temperature rise of a winding shall be calculated by the following formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise of the winding in °C;
R is the resistance of the coil at the end of the test in ohms;

r is the resistance of the coil at the beginning of the test in ohms;

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant (k) for other conductors shall be determined;

t_1 is the ambient temperature at the beginning of the test in °C; and

t_2 is the ambient temperature at the end of the test in °C.

57.1.7 When required, the value of R at shutdown shall be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after shutdown. A curve of the resistance values and the time shall be plotted and extrapolated to give the value of R at shutdown.

57.1.8 All values for temperature rises in Table 16 are based on an assumed ambient temperature of 25°C (77°F). However, tests that are conducted at any ambient temperature within a range of 10 – 40°C (50 – 104°F) shall comply with the intent of this requirement.

57.1.9 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60° C (140° F), such as at terminals, shall be acceptable if supplementary heat-resistant insulation of acceptable dielectric strength and temperature rating is employed on the individual conductors of the cord to reduce the likelihood of deterioration of the conductor insulation.

57.1.10 If a test is conducted at an ambient temperature other than 25° C (77° F), an observed temperature other than as mentioned in Clause 57.1.11 shall be corrected as described in Clause 57.1.12. Neither a corrected temperature, as specified in Clause 57.1.12, nor an observed temperature as specified in Clause 57.1.11, shall exceed the values specified in Table 16.

57.1.11 An observed temperature limited by an automatic temperature control or by a process such as the boiling of water or the introduction of a liquid at a fixed temperature shall not be corrected.

57.1.12 An observed temperature shall be corrected by addition [if the ambient temperature is lower than 25°C (77°F)] or subtraction (if the ambient temperature is higher than 25°C) of the difference between 25° C and the ambient temperature.

57.1.13 If a corrected temperature exceeds the value specified in Table 16, at the request of the manufacturer the test may be repeated at an ambient temperature closer to 25°C (77°F).

57.1.14 The product shall be operated under each condition of normal service. For a multispeed product, this includes operation at each speed, and for a reversible product, it includes operation in both directions. If a reversible product continues to operate in the same direction, but at a slower speed when the reversing switch is thrown, the requirement applies at the lower speed as well as at the normal speed. Operation shall be continued until temperatures have become constant. Please see Clause 57.1.4.

57.1.15 The temperature test shall be conducted with the product dry as well as with water as intended. The requirement in Clause 57.1.1 shall apply for both conditions. A product that is permanently connected to a water supply is not required to be operated without water.

57.1.16 A product having a regulating means that operates in response to the relative humidity of the air so as to cause intermittent operation shall have the regulator bypassed or defeated during the normal temperature test.

57.1.17 A product that has an adjustable humidifying output shall be operated at the maximum output for the normal temperature test.

57.1.18 Controls that are actuated by either room temperature or humidity shall be shunted out of the circuit to obtain maximum normal condition.

57.1.19 A stationary or fixed product where one of the following applies, shall be tested in an alcove:

a) It is obvious the product is not intended for duct or plenum mounting; or

b) The product is marked in accordance with Clause 76.2, or lends itself to such installation.

57.1.20 The walls of the alcove shall consist of nominal 9.5 mm (3/8 in) plywood, the inside surfaces of which shall be painted dull black. The alcove shall consist of two sides, a back, and a top, and shall be of such dimensions as to extend 0.61 m (2 ft) beyond the back and one side of the product. The product shall be located as close to the sides of the alcove as its construction will permit, and it shall be located so that maximum heating of the walls will occur. A product marked in accordance with Clause 76.2 shall be spaced away from the sides of the alcove as specified in the marking.

57.1.21 For the temperature test, a separate controller – a controller that is not a physical part of the product – that is intended for installation in a wall shall be mounted as follows. The controller shall be secured inside its own enclosure, if provided; otherwise it shall be installed inside the smallest standard flush-type outlet box that will accommodate it, and the box shall be mounted in a simulated wall section as illustrated in Figure 12.

57.2 Duct- or plenum-mounted products

57.2.1 The temperature test of a product (whether intended for residential or commercial applications) that could be mounted in or on a furnace duct or plenum shall be conducted with the product mounted in or on a duct or plenum with the intended water supply connected. The temperature of the outlet air from the furnace during the test shall be maintained at 93°C (199°F) for a residential-type product, and at 121°C (250°F) for any other products. A product marked in accordance with Clause 78.5 shall not be tested in or on a duct or plenum.

57.2.2 A product intended for residential applications, and for duct or plenum mounting, shall be tested as described in Clause 57.2.3, and there shall be no emission of flame, smoke, or molten metal, nor shall the fuse in the grounding connection open.

57.2.3 The product shall be mounted in the intended manner and non-current-carrying metal parts shall be connected to ground through a 3 A fuse. The product shall be operated without water in the mode of operation most likely to result in the highest temperatures. This test shall be continued until ultimate results are obtained.

57.2.4 A grid consisting of nine thermocouples of identical length, wired in parallel, shall be installed in the furnace outlet duct to measure the temperature of the furnace outlet air. The arrangement shall be such that one thermocouple will be located centrally in each of nine equal rectangular duct areas in a plane perpendicular to the axis of the duct. The grid shall be located not more than 152 mm (6 in) downstream from the location nearest the furnace at which no thermocouple will be directly affected by radiation from a heating element, and the humidifier air-inlet shall be located 152 mm downstream from the grid.

58 Disassembly and Reassembly Test

58.1 If the instructions involve disassembly of any parts for cleaning, it shall be determined that the product is unlikely to be reassembled in a manner that will result in a risk of fire, electric shock, or injury to persons.

59 Impact

59.1 A part as described in Clause 9.1 shall be subjected to an impact of 2 J (1.5 ft-lbs) on any surface that is exposed to a blow during intended use, and:

a) The performance of the product shall not be adversely affected so that a risk of fire or electric shock is introduced; and

b) A moving part presenting a risk of injury to persons shall not be exposed to contact as determined by use of the probe illustrated in Figure 7 and Table 3.

A component such as a pilot lamp, a lens, a control knob, or the like is not required to be subjected to the impact test.

59.2 A smooth steel sphere, 51 mm (2 in) in diameter and weighing approximately 0.5 kg (1.18 lbs) shall be allowed to fall vertically from rest through a distance of 381 mm (15 in) to strike the part being tested.

For a part that cannot be struck from above by the freely falling sphere, the sphere shall be suspended by a cord and allowed to fall as a pendulum through a vertical distance of 381 mm. Only one impact shall be applied at a given point.

60 Rotating Members

60.1 A rotating part, the breakage or loosening of which may create a risk of injury to persons, shall be constructed of such material and in such a manner as to reduce the likelihood of its breakage or loosening.

60.2 A product having a series motor shall be tested as described in Clause 60.3, and no part that could cause an injury shall become loosened. A test is not required to be conducted if a review of the manufacturer's specifications indicates that the part or parts are adequately strong.

60.3 For the test discussed in Clause 60.2, a product having a series motor shall be operated for 1 minute at the no-load speed resulting from application of 130 percent of rated voltage.

61 Dielectric Voltage-Withstand Test

61.1 A product shall withstand, without breakdown, a 40 – 70 Hz potential applied for 1 minute between hazardous-voltage live parts and dead metal parts and between live parts of hazardous-voltage and extra-low voltage circuits. The test potential shall be 1000 V plus twice the rated voltage. The test potential for units rated at not more than 373 W output (1/2 HP) shall be 1000 V.

61.2 Equipment using an extra-low-voltage circuit shall withstand, without breakdown, a 40 – 70 Hz potential of 500 V applied for 1 minute between the extra-low-voltage circuit and dead metal parts. When components such as a temperature limiting device, motor overload protective device or other protective device where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons are used in the extra-low-voltage circuit, the dielectric voltage-withstand test shall also be conducted between live parts of opposite polarity.

61.3 With reference to Clause 61.2, the test between extra-low-voltage parts of opposite polarity shall be conducted on magnet coil windings after breaking the inner coil lead where it enters the layer. This opposite polarity test is not required to be conducted on the complete assembly as long as the components have been separately subjected to this test.

61.4 A 500 V-A or larger transformer, the output voltage of which is essentially sinusoidal and is capable of being varied, shall be used to determine compliance with the requirements in Clauses 61.1 – 61.3. The applied potential shall be increased gradually from zero until the required test value is reached and shall be held at that volume for 1 minute. The requirement of a 500 V-A or larger transformer is not required when the high potential testing equipment maintains the specified high potential voltage at the equipment during the duration of the test.

61.5 When the charging current through a capacitor or capacitor-type filter connected across-the-line, or from line-to-earth ground, is large enough to make it impossible to maintain the required alternating-current test potential, the capacitors and capacitor-type filters shall be tested as described in Clause 61.6.

61.6 The capacitors and capacitor-type filters specified in Clause 61.5 shall be subjected to a direct-current test potential of 1414 V for equipment rated 250 V or less or 1414 V plus 2.828 times the rated circuit voltage for equipment rated at more than 250 V. The direct-current test potential shall be maintained for 1 minute without breakdown.

61.7 Components providing a direct current path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices, may be disconnected during the test.

62 Strain-Relief Test

62.1 General

62.1.1 The strain-relief means provided on the flexible cord of a product shall be tested as described in Clause 62.1.2. During this test, there shall be no such movement of the cord as to indicate that stress would have been transmitted to the connections.

62.1.2 The connections of the cord within the product shall be disconnected. A 15.9 kg (35 lb) weight shall be suspended on the cord and supported by the product so that the strain-relief means will be stressed from any angle that the construction of the product permits. The stress shall be applied for 1 minute.

62.2 Through-cord switch

62.2.1 The connections between the terminals of a through-cord switch and the flexible cord shall withstand a 133 N (30 lbf) pull, applied for 1 minute between the cord and the switch, without detachment of a conductor from a terminal and without exposing the uninsulated conductor of the cord.

63 Power-Supply Cord Push-Back Relief Test

63.1 To determine compliance with Clause 22.5, a product shall be tested in accordance with Clause 63.2 without occurrence of any of the conditions specified in Clause 22.5 (a) – (c).

63.2 The power-supply cord shall be held 25 mm (1 inch) from the point where the cord emerges from the product. It shall then be pushed back with casual force until either:

a) The cord buckles; or

b) The force required to push the cord into the product exceeds 25 N (5.6 lbf).

64 Cable-Clamp Test

64.1 If a clamp is used with Type SPT-2 or SVT cords as mentioned in Clause 22.3, six samples of the clamp that have been secured to the cord in the intended manner shall be investigated to determine if they are acceptable for the application. Three samples shall be subjected to the dielectric voltage-withstand and strain-relief tests in the as-received condition. The other three samples shall be placed in an air oven for 168 hours. The oven temperature shall be 10° C (18° F) higher than the temperature rating of the insulation of the cord, but not less than 100° C (212° F). The samples shall comply with the dielectric voltage-withstand test requirements in Clause 61.1, the value of applied potential being based on the rating of the product. The potential shall be applied between the clamp and all conductors spliced together. After cooling to room temperature, the conditioned samples shall comply with the Strain-Relief Test, Clause 62.

65 Abnormal Operation Test

65.1 General

65.1.1 If the conditions of normal operation are not representative also of abnormal conditions likely to be encountered in actual service, the product shall not cause a risk of fire, electric shock, or injury to persons when operated under such abnormal conditions.

65.1.2 The conditions resulting from abnormal operation of a product shall be confined by the enclosure when the product is subjected to tests such as blocked armature in a relay, transformer burnout, stalled rotor, operation without liquids, or other conditions that could be encountered in service.

65.1.3 An electrode-type product shall be operated as described in Clause 65.1.4 until ultimate results are obtained. The results shall not be acceptable if a nonintegral branch-circuit protector trips during the test. After the test, the product shall comply with the Starting Test, Clause 55 and the Input Test, Clause 56. A product is not required to be subjected to this test if the water-level-limiting device operates for 100,000 cycles with no mechanical or electrical malfunction or significant pitting or burning of the contacts.

65.1.4 The product shall be mounted as intended and connected to a source of rated voltage. The drain valve shall be blocked closed, the water-inlet valve blocked open, each water-level-limiting device shall be bypassed, and the electrodes shall be electrically connected. In addition, the product shall be mechanically and electrically isolated from any ground means. If the hardness of the water could be a factor, the test shall be performed with a solution of 0.5 g (0.018 oz) of calcium sulfate ($CaSO_4$) per litre of distilled water. The product shall be operated until ultimate results are obtained.

65.1.5 A product that is permanently connected to a water supply shall be operated without water.

66 Thermal Cutoff Test

66.1 A thermal cutoff shall open the circuit in the intended manner without causing the short circuiting of live parts and without causing live parts to become grounded to the enclosure when the product is tested as described in Clause 66.2. Opening of the fuse in the grounding circuit is also not acceptable.

66.2 The enclosure of the product shall be connected through a 3 A fuse to ground and any other thermally-operated control devices in the product shall be short circuited. The supply voltage shall be as described in Clause 51.2. The product shall be operated with separate thermal cutoffs five times. Each thermal cutoff shall perform as intended.

67 Gasket Test

67.1 A material covered in Table 17 that is used for gaskets to:

a) Prevent water entry into an electrical compartment; or

b) Prevent hot water leakage external to the product

shall have physical properties as specified in Table 17 before and after accelerated aging under the conditions specified in Table 18. Gaskets shall not be required to have physical properties as specified in Table 17 when the gasket is normally wet during operation and complies with the test of Clause 68.

67.2 A gasket of material other than those covered in Table 17 shall be nonabsorptive and shall provide equivalent resistance to aging and temperature.

68 Liquid-Container Test

68.1 If the deterioration or breakage of a liquid container, seal, or similar component could increase the risk of electric shock, the component shall be resistant, as determined by investigation, to deterioration from the liquid intended to be used in contact with that component.

68.2 The test procedure for determining whether a component complies with the requirements in Clause 68.1 depends upon the material of which it is composed, its size, shape, mode of application in the product, and the like. The test procedure shall include visual inspection for determination of cracks,

deformation, and the like, after accelerated aging, and a comparison of hardness, tensile strength, and elongation before and after accelerated aging.

68.3 With reference to Clause 68.2, a component of rubber, neoprene, or thermoplastic shall be tested to compare its tensile strength and elongation before and after conditioning as described in Clauses 68.4 and 68.5. The tensile strength and elongation after the conditioning described in Clause 68.4 shall not be less than 50 percent of the tensile strength and elongation measured before the conditioning, and not less than 60 percent after the conditioning described in Clause 68.5.

68.4 A component as mentioned in Clause 68.3 shall be immersed for 7 days in the liquid used with the material at a temperature not less than 10°C (18°F) higher than the maximum wet operating temperature of the material measured under intended operating conditions, but not less than 70°C (158°F).

68.5 A component as mentioned in Clause 68.3 shall be conditioned in an air-circulating oven at the temperature and for the number of days specified in Table 19. The maximum wet operating temperature of the material measured under intended operating conditions shall be used. When dry operating time is greater than 5 percent of total operating time, the maximum dry operating temperature shall be used.

68.6 As an alternative to air oven tests as specified in Table 19, the acceptability of a liquid container, seal, or diaphragm may be determined by means of an aging test of the complete product under service conditions. The duration of the test shall be representative of the expected service life of the product.

69 Flooding of Live Parts Test

69.1 To determine whether malfunction or breakdown of a timer switch, float- or pressure-operated switch, or the like will result in a risk of electric shock, the product shall be conditioned as described in Clauses 69.2 and 69.3. The results are not acceptable if:

a) During and after the conditioning:

1) There is obvious wetting, as described in Clause 69.5, of any electrical component; and

2) For a portable or stationary product when evaluated as described in Clause 69.4, the leakage current exceeds 5.0 mA; and

b) After the conditioning, the product:

1) Does not comply with the requirements of the Dielectric Voltage-Withstand Test, Clause 61; and

2) For a permanently connected product, the insulation resistance between current-carrying parts and exposed non-current-carrying metal parts is less than 50,000 ohms.

69.2 The product shall be connected to a water supply. The timer switch shall be defeated and the product started. If no automatic shutoff means is provided, the fill shall be continued for an additional 15 minutes following the first evidence of overflow of the reservoir. If a float- or pressure-operated switch is provided as an automatic shutoff means, actuation of the fill switch to terminate the fill will also terminate the test. If both a timer and fill switch are provided, a second test shall be conducted as described above with the timer operating as intended and with the fill switch defeated. Both during the after conditioning, the product shall be tested for compliance with (a) of Clause 69.1, and after conditioning, it shall be tested for compliance with (b) of Clause 69.1.

69.3 A rubber barrier or rim seal of a reservoir shall not be removed when a test is being conducted to simulate malfunction or breakdown of a timer switch or of a float- or pressure-operated switch.

69.4 A portable or stationary product shall be investigated using the method described in Clauses 52.2 – 52.6; however, with the concurrence of those concerned, the duration of the test may be shortened.

69.5 Obvious wetting signifies wetting by a stream, spray, or dripping of water on the component that obviously will be repeated during each flooding test, but does not signify wetting by random drops of water that may wet the component by chance.

70 Backflow Test

70.1 A product that is intended to be connected to a potable water supply shall be tested as described in Clauses 70.2 and 70.3. Backflow from the reservoir of the product into the water supply system shall not occur during the test.

70.2 With any valve-closing mechanisms on the product, including a check valve or backflow control, removed or bypassed, a vacuum tank with a minimum capacity of 379 L (100 US gal) and equipped with a vacuum pump, gauge, and shutoff valve, shall be connected to the water-supply hoses. The product shall be filled with water to the flood level rim and shall be operated as it would be during intended use. A check valve or backflow control is not required to be removed or bypassed if it complies with the requirements in Clause 70.4.

70.3 With the tank at 635 mm (25 in) of mercury vacuum, the shutoff valve shall be opened rapidly until there is 0 mm (0 in) of mercury vacuum. The vacuum pump shall then be operated until either 635 mm (25 in) of vacuum or its limit is reached. This operation shall be repeated twice, for a total of three operations. The results shall not be acceptable if there is evidence of liquid in the vacuum tank.

70.4 To determine whether a check valve or backflow control is not required to be removed or bypassed in accordance with Clause 70.2, it shall be tested as follows. A vacuum tank with a minimum capacity of 379 L (100 US gal) and equipped with a vacuum pump, gauge, and shutoff valve, shall be connected to the inlet of a backflow prevention device. A transparent tube shall be connected as closely as is possible to the outlet of the device. The free end of the transparent tube shall be submerged in water. A 0.813 mm (0.032 in) diameter wire shall be inserted through the backflow prevention device to interrupt its closing. Test results shall be acceptable if no water is drawn into the transparent tube when a constant vacuum of 635 mm (25 in) of mercury is applied for 30 seconds. The test shall be conducted three times.

71 Bonding-Conductor Test

71.1 A conductor or strap used to bond an electrical enclosure or motor frame and that has a smaller cross-sectional area than required by Clause 32.7 – 32.9 shall comply with the following requirements:

a) The conductor or strap shall not open its circuit when carrying for 2 minutes a current equal to twice the branch-circuit overcurrent device rating, but not less than 40 A; and

b) None of three samples of the conductor or strap selected at random shall open during a limited short circuit test while carrying the current as specified in Table 20, and while in series with a fuse as described in Clause 71.2.

71.2 The circuit for the test described in Clause 71.1(b) shall have a power factor of 0.9 to 1.0, and shall be limited to the current and voltage specified in Table 20. The open-circuit voltage of the test circuit shall be 100 – 105 percent of the specified voltage. The circuit shall be connected through a nonrenewable fuse, the characteristics of which are such that the fuse will not open in less than 12 seconds when carrying twice its rated current. The fuse shall have a current rating equal to that of the branch-circuit overcurrent device to which the product will be connected, but not less than 20 A. One test shall be performed on each of three samples of the bonding conductor.

71.3 The resistance between two parts connected by a bonding conductor shall not be more than 0.1 ohms.

71.4 Any acceptable resistance measuring instrument may be used to determine whether the product complies with the requirement in Clause 71.3. If unacceptable results are obtained, an alternating current of at least 20 A from a power supply of not more than 12 V shall be passed from the point of connection of the equipment-grounding means to the metal part in the grounding circuit, and the resulting drop in potential shall be measured between the two points. The resistance shall then be calculated by dividing the drop in potential in volts by the current in amperes passing between the two points. The grounding conductor of a power-supply cord shall not be included in this measurement.

72 Tests on Parts Subject to Pressure

72.1 To determine that a part or assembly complies with the requirement in Clause 47.2, two samples of the part shall be subjected to a hydrostatic-pressure test. During this test, the part shall not burst or leak. Leakage or rupture of nonmetallic fluid-transfer lines, their connections, or gaskets during the pressure test is acceptable if a repeat test conducted with the fluid they are intended to contain shows no evidence of presenting risk of electric shock or injury to persons. Consideration shall be given to the possibility of wetting of any live electrical part or insulation.

72.2 Each sample shall be filled with water so as to exclude air, and then connected to a hydraulic pump. The pressure shall be raised gradually to the specified test value and shall be held at that value for 1 minute.

72.3 A part supported or actuated hydraulically that could result in a risk of fire, electric shock, or injury to persons due to pressure loss shall comply with the requirements in Clause 72.2 when tested at a pressure equal to five times the maximum pressure capable of being developed in the system.

72.4 If a pressure-relief device is required to comply with the requirements for Pressure Vessels and Parts Subjected to Pressure, Clause 47, the control used to limit the pressure in the vessel shall operate under rated load for 100,000 cycles of operation and shall prevent the pressure from exceeding 90 percent of the relief-device setting under any condition of intended operation.

73 Mold Stress-Relief Test

73.1 Conditioning as described in Clause 73.2 for polymeric materials used as enclosures shall not cause softening of the material as determined by handling immediately after the conditioning, nor shall there be shrinkage, warpage, or other distortion of the enclosure, as judged after cooling to room temperature, that results in any of the conditions specified in (a) – (d):

a) Reduction of electrical spacings below those specified in Spacings, Clause 42;

b) Exposure of uninsulated parts as judged by the requirements in Protection Against Risk of Injury to Persons – Mechanical Protection, Clause 8;

c) Defeating the integrity of the enclosure; or

d) Causing interference with the intended operation of the equipment.

This test shall not be required for rigid thermosetting materials.

73.2 One sample of the complete enclosure or part or an appropriate section of the assembly shall be placed in a full-draft circulating-air oven maintained at a uniform temperature at least 10°C (18°F) higher than the maximum temperature rating of the material measured, but not less than 70°C (158°F) in any

case. The sample shall remain in the oven for 7 hours. After its removal from the oven and return to room temperature, the sample shall be examined for compliance with Clauses 68.1 and 68.2.

RATINGS

74 Electrical Ratings

74.1 A product shall be rated in volts, amperes, and frequency, expressed in one of the following terms: hertz, Hz, cycles-per-second, cps, cycles/second, or c/s. If the product is intended for operation on a polyphase circuit, the number of phases of the intended supply circuit shall also be included. See also Clause 75.13. A cord-connected product may be rated in watts or kilowatts instead of amperes if the overall full-load power factor is 0.80 or more or if the rating of the cord-connected product is 50 W or less.

MARKING AND INSTRUCTIONS

Advisory Note: *In Canada, there are two official languages; English and French. Annex B lists acceptable French translations of the markings specified in this Standard. All markings required by this Standard may have to be in other languages to conform with the language requirements where the product is to be used.*

75 Identification and Ratings

75.1 Markings shall be as follows. All wording shall be equivalent to that in the following Clauses.

75.2 A product shall be legibly and permanently marked where readily visible, without the use of tools, with the following:

a) The manufacturer's name, trade name, or trademark;

b) Date or other dating period of manufacture not exceeding any three consecutive months;

c) A distinctive catalog or model number of the equivalent; and

d) The electrical rating.

The manufacturer's identification may be in a traceable code if the product is identified by the brand or trademark of a private labeler. The date of manufacture may be abbreviated, in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

75.3 A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped, or etched metal that is permanently secured, or indelibly stamped on pressure-sensitive labels secured by adhesives that comply with the applicable portions of the requirements in UL 969 and CSA C22.2 No. 0.15.

75.4 With reference to Clause 75.2, the repetition time cycle of a date code shall not be less than 15 years. The date code shall not require reference to the manufacturer's records to determine when the product was manufactured.

75.5 If a manufacturer produces or assembles a product at more than one factory, each finished product shall have a distinctive marking by which it can be identified as the product of a particular factory.

75.6 If the product employs a single motor as its only electric energy-consuming component, and the motor nameplate is readily visible with all parts of the product, including the motor, in place, the electrical rating given on the motor nameplate is not required to be duplicated elsewhere on the product.

75.7 Unless the proper wiring connections are plainly evident, wiring terminals shall be marked or the equipment shall be provided with a suitable wiring diagram to indicate the connections.

75.8 If a product employs a dual-voltage motor, and if the motor nameplate is used to give the electrical ratings of the product as described in Clause 75.6, a marking or other means shall be provided to indicate the voltage for which it is connected when shipped from the factory. This marking is not required to be permanent. If the product employs an attachment plug, instructions or markings shall be provided to indicate the type of plug that should be used if the product is reconnected for an alternate voltage.

75.9 Each part of a product that is not completely assembled when shipped from the factory shall be marked to indicate the other parts with which it is intended to be used. For small parts shipped in an envelope or other package, the marking may be on the package.

75.10 With respect to Clause 75.9, a small part is not required to be marked if improper assembly or attachment of the part, or omission of the part from the product, would not result in a risk of fire, electric shock, or injury to persons.

75.11 The catalog number or equivalent designation marked on the individual part shall be acceptable for the marking required by Clauses 75.9 and 75.10.

75.12 If compliance of a product with any requirement in this Standard depends upon the functioning of a replaceable thermal cutoff:

a) The cutoff or link shall be marked with the name or trademark of the manufacturer of the device and with its catalog designation or equivalent; and

b) The product shall be marked with a statement that a replacement link should be of the same type and rating as the one provided in the product.

75.13 A product using steam under pressure shall be permanently marked with the maximum pressure rating.

75.14 Cord-connected equipment that requires a time-delay fuse for starting shall be clearly marked to indicate the type and rating of the fuse required.

75.15 Motor-operated equipment to be permanently connected to the power supply shall be marked:

a) For equipment having a single motor, with or without an electric heater, with the rated full load current of the motor, in amperes, and of the heater, with its input amperes or watts at marked voltage; and

b) For equipment having more than one motor, with or without an electric heater, with

1) The rated full load current in amperes of each motor;

2) The input amperes or watts of the heater, at marked voltage;

3) The minimum power supply circuit ampacity for each hazardous voltage circuit; and

4) The maximum overcurrent protective device size for each hazardous voltage circuit.

75.16 Cautionary markings and instructions shall be permanent and legible and shall be located on a part that cannot be removed without impairing the operation of the product.

75.17 Cautionary markings and instructions intended to instruct the operator shall be legible and clearly visible to the operator during use of the product. Other such markings for servicing instructions shall be legible and clearly visible when such servicing is being accomplished.

75.18 A marking that is required to be permanent shall meet the requirements of Clause 75.3. Usage, handling, storage, and the like of the product shall be considered in the determination of the permanence of the marking.

75.19 A residential duct- or plenum-mounted product shall be permanently marked to indicate that it is for residential use only.

75.20 A marking intended to reduce the risk of injury to a person shall be prefixed by the word "CAUTION", "WARNING", or "DANGER" in capital letters not less than 3.2 mm (1/8 in) high. This word shall be followed by a brief description of the risk, such as "risk of electric shock", and the measures that should be taken to reduce the risk. The words in such a marking shall be in letters not less than 1.6 mm (1/16 in) high.

75.21 The minimum circuit ampacity required by Clause 75.15(b)(3) shall be determined as follows. All concurrent load conditions shall be considered in the determinations. 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 multiplied by 125 percent, added to the rated currents of all of the other motors; and

b) for a combination load, a load consisting of one or more motors, electric heaters, and any other loads, the sum of the rated currents multiplied by 125 percent.

75.22 The maximum current rating of overcurrent protection for each hazardous voltage circuit, as required by Clause 75.15(b)(4), 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 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 75.15(b)(4).

75.23 If cleaning or similar servicing by the user, including replacement of a fusible link, requires disassembly by means of a tool and, if such disassembly involves the exposure of an enclosed or protected live part or a part that involves the risk of injury to persons where they might be inadvertently contacted by the user, the product shall be permanently marked with a warning that such servicing shall be done only with the product disconnected from the electrical supply.

75.24 Where bare live parts are exposed when a door or cover is removed, the door or cover shall be marked with the following or its equivalent:

"CAUTION: RISK OF ELECTRIC SHOCK. DISCONNECT THE APPLIANCE FROM THE ELECTRIC SUPPLY BEFORE REMOVING THIS COVER."

75.25 If a product has a moving part that can cause an injury to a person, a switch, other than a momentary contact switch that controls the motor that drives the part, shall have a plainly marked off position.

75.26 A product that incorporates an interlock device complying with Clause 10.8 shall be marked where it is readily visible during any approach to defeat the interlock to indicate the general location of the interlock. The marking shall include the word "WARNING" and the following or the equivalent: "This cover

is provided with an interlock to reduce the risk of electric shock. Do not defeat its purpose or attempt to service without removing cover completely".

75.27 A 2-wire, 220 – 240 V product intended for connection to a circuit operating at 150 V or less to ground shall be marked with the word "WARNING" and the following or the equivalent: "To reduce the risk of electric shock, do not connect to a circuit operating at more than 150 V to ground".

75.28 There shall be replacement marking adjacent to each fuse or fuseholder that is intended to reduce the risk of fire. The marking shall be readily visible during replacement of the fuse, and shall consist of the word "CAUTION" and the following or the equivalent: "To reduce the risk of fire, replace only with same size and type_____fuse". The rating of the fuse shall be marked in the blank space. For a fuse that is soldered in place and is perceptible during user servicing, the marking shall also include the following or the equivalent: "To be replaced only by qualified service personnel".

75.29 If available space does not permit locating a fuse replacement marking adjacent to a fuse or fuseholder, or if more than one fuse or fuseholder requiring marking is employed, the marking other than the rating may be at some other location readily visible during replacement of the fuse.

75.30 Equipment requiring multiple hazardous voltage power supply connections shall be marked, in letters not less than 3.2 mm (1/8 in) high: "CAUTION: THIS EQUIPMENT HAS MORE THAN ONE CONNECTION TO THE POWER SUPPLY (IES). DISCONNECT ALL REMOTE POWER SUPPLY CONNECTIONS BEFORE SERVICING", or the equivalent. This marking shall be located on all panels providing access to hazardous voltage uninsulated live parts.

75.31 If the value of the rating determined by applying Clause 75.22 does not equal a standard current rating of overcurrent protective device, the marked maximum rating shall be the next lower standard rating. 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 75.21, the marked rating of the device shall be increased to the largest standard overcurrent protective device rating appropriate for the marked minimum circuit ampacity.

75.32 The maximum current rating of the branch-circuit overcurrent protective device of a non-motor operated appliance shall not exceed 20 A for a product rating not exceeding 13.3 A and 150 percent of the product rating for a product rating greater than 13.3 A. Standard ratings for overcurrent protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, and 200 A. If 150 percent of the rating of the product does not equal one of the aforementioned, it shall be assumed that the next higher rating or setting of over-current-protective device will be employed.

76 Informational and Instructional Markings

76.1 If a product will not start and attain intended running speed when connected to a circuit protected by an ordinary – not a time-delay – fuse as described in Clause 55.1, the product shall be plainly and permanently marked "If connected to a circuit protected by a fuse, use a time-delay fuse with this product" or with an equivalent wording.

76.2 If a minimum spacing between a product as described in Clauses 57.1.19 and 57.1.20 and an adjacent surface is necessary to reduce the likelihood of the surface from reaching a temperature higher than 90°C (194°F) when the product is operated as intended, the product shall be marked "Do not install less than _____mm (_____in) from a (vertical, horizontal, or the like) surface". The value necessary to prevent the sides of the alcove from reaching a temperature higher than 90° C when the product is tested as described in Normal-Temperature Test, Clause 57, shall be marked in the allocated space. The statement shall be legible and shall be located so that it will be clearly visible during installation and examination of the power-supply connections.

76.3 Unless the proper method of assembly is obvious, a product shipped from the factory partially disassembled shall be provided with clear and detailed assembly instructions.

76.4 An instruction sheet, manual, or booklet shall bear the words "READ AND SAVE THESE INSTRUCTIONS" in all capital letters, and this wording shall appear above any other written materials.

76.5 Wiring instructions provided with a product shall not conflict with any other requirement in this Standard.

76.6 If servicing or replacement of any component of a product requires the removal or disconnection of any protective device, the instructions provided with the product shall state that such device shall be replaced in its proper position.

76.7 If user servicing or cleaning operations are contemplated, the instructions shall point out that the source of electrical supply shall be disconnected prior to beginning any such service or cleaning operation.

76.8 Complete, clear instructions shall be provided for the installation of a product intended to be mounted in a window frame or to a wall or ceiling. The instructions shall indicate the correct use of all hardware supplied with the product, and shall include a step-by-step outline of the mechanical and electrical operations that must be performed for proper installation and operation.

77 Operating Instructions

77.1 Operating instructions shall be provided with the product that include the following:

a) Information regarding the risks of fire, electric shock, or injury to persons that could exist due to use of the product. The instructions shall caution the user to place the product and connected cord so that the product is not likely to be upset.

b) Information regarding the potential risk of electric shock due to overfilling or cleaning the product and removal of the heating element portion of the product without disconnecting the power-supply cord.

c) Instructions regarding cleaning the product including any need for disassembly (and reassembly) and any need for the use of additives.

78 Field Wiring

78.1 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.

78.2 Other than as indicated in Clause 78.3, a field-wiring terminal shall be marked "Use copper conductor only," "For use with aluminum or copper conductors," or with an equivalent statement appropriate for the terminal. This marking shall be independent of all other marking on terminal connectors, and shall be visible during and after installation.

78.3 A terminal intended for the connection of an equipment-grounding conductor shall not be identified as acceptable for aluminum conductors.

78.4 If a removable barrier or one that has openings for the passage of conductors is used to comply with the requirement in Clause 29.4, instructions for use of the barrier shall be provided with the product.

78.5 A product shall be marked to indicate its intended use. A permanently connected product not intended for duct or plenum mounting shall be permanently marked "Do not connect to a duct or plenum" or with equivalent wording.

78.6 The terminals of the device shall be marked accordingly if an extra-low-voltage device or part thereof is intended to be wired in the field, and is intended to become part of either of the following:

a) A Class 1 circuit; or

b) A Class 2 circuit wired with Class 1 wiring,

An extra-low-voltage device, or part thereof, that is acceptable for either a Class 1 or a Class 2 circuit is not required to be so marked.

78.7 An extra-low-voltage switching or power-consuming device, or part thereof, that is intended to be wired in the field to become part of a Class 2 circuit, shall be marked accordingly. An extra-low-voltage power-supply device that includes a transformer is not required to be so marked.

78.8 Complete instructions shall be provided that clearly cover the installation of a product intended for duct- or plenum-mounting. Such instructions shall include the proper use of all hardware supplied with the product, and a step-by-step outline of the mechanical and electrical alterations that might be necessary for proper installation and operation.

78.9 If the manufacturer's wiring diagram indicates that a product may be field connected so as to utilize the blower motor of a furnace, the wiring diagram shall indicate specific terminals, such as "Fan Switch Terminals" and "Thermostat Terminals" for making connection to the electrical circuit of a furnace. The wiring arrangement shall not affect the intended operation of the furnace-control system in the heating cycle and shall not necessitate alteration of factory-installed wiring of the furnace.

78.10 Installation instructions provided with a product as specified in Clause 78.8 shall include

a) The method of installation and user maintenance;

b) A statement that the product is to be located so that connection can be made to the source of electrical supply without the use of an extension cord; and

c) If intended for electrical interconnection, a wiring diagram, and the intended location of the field-wiring compartment.

TABLES AND FIGURES

TABLES

Table 1
Minimum thicknesses of metal enclosures

(See Clauses 5.1.4, 8.5, 29.9, and 29.10)

Metal	At small, flat, unreinforced surfaces that are reinforced by curving, ribbing, and the like,		At surfaces to which system is to be connected in the field,		At relatively large unreinforced flat surfaces,	
	mm	(in)	mm	(in)	mm	(in)
Die-cast metal	1.26	(3/64)	–	–	2.0	(5/64)
Cast malleable iron	1.6	(1/16)	–	–	2.4	(3/32)
Other cast metal	2.4	(3/32)	–	–	3.2	(1/8)
Uncoated sheet metal	0.66	(0.026)	0.81	(0.032)	0.66	(0.026)
Galvanized sheet steel	0.74	(0.029)	0.86	(0.034)	0.74	(0.029)
Nonferrous sheet metal	0.91	(0.036)	1.14	(0.045)	0.91	(0.036)

Table 2
Clauses, figures, and tables for judging the accessibility of parts

(See Clauses 7.1, 7.6 – 7.9)

Parts	Enclosure other than that of a motor	Directly accessible motor	Indirectly accessible motor[a]
Uninsulated live part	MD[b] < 25.4 mm Clause 7.7 Figure 2 MD ≥ 25.4 mm Clause 7.8 Figure 6 X = 154 mm	MD < 25.4 mm Clause 7.7 Figure 5 MD ≥ 25.4 mm Clause 7.8 Figure 6 X = 154 mm	MD < 19.1 mm Clause 7.7 Figure 3 MD ≥ 19.1 mm Clause 7.8 Figure 6 X = 102 mm
Film-coated wire	MD < 25.4 mm Clause 7.7 Figure 2 MD ≥ 25.4 mm Clause 7.8 Figure 6 X = 154 mm	MD < 19.1 mm Clause 7.7 Figure 4 MD ≥ 19.1 mm Clause 7.8 Figure 6 X = 102 mm	MD < 19.1 mm Clause 7.7 Figure 4 MD ≥ 19.1 mm Clause 7.8 Figure 6 X = 102 mm

[a] See Clause 7.5

[b] MD = Minor dimension of opening. See Clause 7.6.

English units for values specified in Table 2

mm	(in)
19.1	(3/4)
25.4	(1)
102	(4)
154	(6-1/16)

Table 3
Clearance from openings

(See Clauses 7.7, 8.2, and 59.1)

Minor dimensions of opening,[a]		Minimum distance from opening to moving parts,[b]	
mm	(in)	mm	(in)
25.4	(1)	165	(6-1/2)
31.8	(1-1/4)	190	(7-1/2)
38.1	(1-1/2)	318	(12-1/2)
47.6	(1-7/8)	394	(15-1/2)
54.0	(2-1/8)	444	(17-1/2)
Over 54.0 but not more than 152	(Over 2-1/8 but not more than 6)	762	(30)

[a] See Clause 7.7.

[b] Between 25.4 mm (1 inch) and 54 mm (2-1/8 inches), interpolation shall be used to determine a value between values specified in the table.

Table 4
Maximum acceptable surface temperatures

(See Clause 11.1)

Location of surface	Composite of surface[a]			
	Metal		Other than metal	
	°C	(°F)	°C	(°F)
Handles or knobs that are grasped for lifting, carrying, or holding	50	(122)	60	(140)
Handles or knobs that are contacted, but do not involve lifting, carrying, or holding, and other surfaces subject to contact and user maintenance	60	(140)	85	(185)
Surfaces other than a heating function surface but known to be hot due to proximity to a heating function surface	70	(158)	95	(203)

[a] A handle, knob, or the like, made of a material other than metal, that is plated or clad with metal having a thickness of 0.013 mm (0.005 in) or less, shall be considered to be and shall be judged as a part of other than metal.

Table 5
Dimensions associated with openings for conduit

(See Clause 19.2)

Trade size of conduit,		Unthreaded openings				Threaded opening			
		Nominal knockout diameter,		Minimum diameter of flat surface at knockout,		Throat diameter			
						Minimum,		Maximum,	
mm OD	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
21.3	(1/2)	22.2	(7/8)	28.96	(1.140)	14.22	(0.560)	15.80	(0.622)
26.7	(3/4)	27.8	(1-3/32)	36.07	(1.420)	18.85	(0.742)	20.93	(0.824)
33.4	(1)	34.5	(1-23/64)	44.96	(1.770)	23.98	(0.944)	26.64	(1.049)
42.2	(1-1/4)	43.7	(1-23/32)	57.94	(2.281)	31.55	(1.242)	35.05	(1.380)
48.3	(1-1/2)	50.0	(1-31/32)	65.99	(2.598)	36.80	(1.449)	40.89	(1.610)
60.3	(2)	62.7	(2-15/32)	80.64	(3.175)	47.24	(1.860)	52.50	(2.067)
73.0	(2-1/2)	76.2	(3)	90.47	(3.562)	56.44	(2.222)	62.71	(2.469)

Table 6
Trade size of conduit[a]

(See Clause 19.2)

Wire size,		Number of wires				
mm^2	AWG	2	3	4	5	6
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

[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 can be used shall be 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 National Electrical Code or Type TW75, specified in the Canadian Electrical Code, Part I.

Table 7
Tightening torque for wire sizes

(See Clause 20.10)

Size of wire,		Tightening torque, N·M (pound-inches)			
		Screwdriver,		Wrench,	
mm^2	AWG or MCM	N·m	(lb - in)	N·m	(lb - in)
2.1 – 8.4	14 – 8	2.26	(20)	8.5	(75)
13.3 – 21.3	6 – 4	3.96	(35)	11.3	(100)
26.7 – 42.4	3 – 1	5.65	(50)	14.1	(125)
53.5 – 67.4	1/0 – 2/0	5.65	–	17.0	(150)
85.0- 107.2	3/0 – 4/0	–	–	22.6	(200)
127	250	–	–	28.2	(250)

Table 8
Wire bending space

(See Clause 20.16)

Size of wire,		Minimum bending space, terminal to wall			
		1 wire to pole		2 wires per pole,[a]	
mm^2	AWG or MCM	mm	(in)	mm	(in)
2.1 – 5.3	14 – 10	Not specified		–	–
8.4 – 13.3	8 – 6	38.1	(1-1/2)	–	–
21.3 – 26.7	4 – 3	50.8	(2)	–	–
33.6	2	63.5	(2-1/2)	–	–
42.4	1	76.2	(3)	–	–
53.5 – 67.4	1/0 – 2/0	88.9	(3-1/2)	127	(5)
85.0 – 107.2	3/0 – 4/0	102	(4)	152	(6)
127	250	114	(4-1/2)	152	(6)

[a] Applies to two conductors that can approach a terminal only from the same direction.

Table 9
Flexible cord types for products

(See Clause 21.4)

Type of product	Acceptable types of cord
Portable	
For household use	SPT-2, SVT, SP-2
All others	S, SJ, SJO, SJT, SJTO, SO, ST, STO

Table 10
Polarity identification of flexible cords

(See Clauses 21.10, 21.11 and Figure 8)

Method of identification	Combinations		
	Wire intended to be grounded[a]		All other wires[a]
Color of braids on individual conductors	A	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	B	Color other than white or gray, with tracer in bold	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	C[b]	Solid white or gray	Solid color other than white or gray
	C1[c]	Light blue	Solid color other than light blue, white or gray
Color of separators	D[d]	White or gray	Color other than white or gray
Other means	E[e]	Tin or other white metal on all strands of the conductor	No tin or other white metal on the strands of the conductor
	F[e]	A stripe, ridge, or groove on the exterior surface of the cord	

[a] A wire finished to show a green color with or without one or more yellow stripes or tracers shall be used only as an equipment grounding conductor. See Clause 21.10 and Figure 8.

[b] Only for cords – other than Type SP-1 and SPT-1 – having no braid on any individual conductor.

[c] For jacketed cord.

[d] Only for Types SP-1, SP-2, and SPT-2 cords.

[e] Only for Types SPT-1 and SPT-2 cords.

Table 11
Protective device activation level

(See Clause 36.2.7)

	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

Table 12
Spacings at wiring terminals

(See Clauses 42.1, 42.4, 42.6, and 42.10)

Potential involved, V	Minimum spacing					
	Between wiring terminals through air or over surface,		Between terminals and other uninsulated metal parts not always of the same polarity[a]			
			Over surface,		Through air,	
	mm	(in)	mm	(in)	mm	(in)
0 – 250	6.4	(1/4)	6.4	(1/4)	6.4	(1/4)
251 – 600	12.7[b]	(1/2)	12.7[b]	(1/2)	9.5	(3/8)

[a] Applies to the sum of the spacings involved where an isolated dead part is interposed.

[b] A spacing of not less than 9.5 mm (3/8 in) through air and over surface shall be acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

Table 13
Spacings at other than wiring terminals

(See Clauses 42.2, 42.6, 42.7, 42.10, and 42.11)

Potential involved, V	Minimum spacing							
	Product employing a motor having a diameter 178 mm (7 in) or less[a]				Product employing a motor having a diameter more than 178 mm (7 in) through 279 mm (11 in)[a]			
	Over surface,		Through air,		Over surface		Through air	
	mm	(in)	mm	(in)	mm	(in)	mm	(in)
0 – 125	2.4[b]	(3/32)	2.4[b]	(3/32)	6.4[c,d]	(1/4)	3.2[c,d]	(1/8)
126 – 250	2.4	(3/32)	2.4	(3/32)	6.4[c,d]	(1/4)	6.4[c,d]	(1/4)
251 – 600	12.7[c]	(1/2)	9.5[c]	(3/8)	12.7[c]	(1/2)	9.5[c]	(3/8)

[a] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes, and the like, used solely for the motor mounting, assembly, or connection.

[b] For a product having a motor rated 250 W output (1/3 HP) or less, these spacings shall be not less than 1.6 mm (1/16 in).

[c] Spacings of not less 2.4 mm (3/32 in) shall be acceptable throughout a product with a universal motor only.

[d] Film-coated wire shall be considered to be an uninsulated live part. However, a spacing of not less than 2.4 mm (3/32 in) over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a non-current-carrying metal part shall be acceptable in a product rated more than 250 V or employing a motor having a diameter of more than 178 mm (7 in). See note a.

Table 14
Tubing wall thickness

(See Clause 47.3)

Outside diameter,		Minimum wall thickness[a]					
		Copper				Steel,	
		Protected		Unprotected			
mm	(in)	mm	(in)	mm	(in)	mm	(in)
6.35	(1/4)	0.62	(0.0245)	0.67	(0.0265)	0.064	(0.025)
7.94	(5/16)	0.62	(0.0245)	0.72	(0.0285)	0.064	(0.025)
9.53	(3/8)	0.62	(0.0245)	0.72	(0.0285)	0.064	(0.025)
12.70	(1/2)	0.62	(0.0245)	0.72	(0.0285)	0.064	(0.025)
15.88	(5/8)	0.80	(0.0315)	0.80	(0.0315)	0.081	(0.025)
19.05	(3/4)	0.80	(0.0315)	0.98	(0.0385)	0.081	(0.025)
22.23	(7/8)	1.04	(0.0410)	1.04	(0.0410)	1.17	(0.032)
25.40	(1)	1.17	(0.0460)	1.17	(0.0460)	1.17	(0.032)
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)	1.58	(0.046)
38.10	(1-1/2)	1.41	(0.0555)	1.41	(0.0555)	1.58	(0.062)
41.3	(1-5/8)	1.41	(0.0555)	1.41	(0.0555)	1.58	(0.062)
54.0	(2-1/8)	1.626	(0.0640)	1.626	(0.0640)	–	–
66.7	(2-5/8)	1.88	(0.0740)	1.88	(0.0740)	–	–

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 shall be considered shielded. Tubing not so shielded shall be considered unprotected with respect to this table.

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

Table 15
Test voltages

(See Clause 51.2.1)

Nameplate voltage rating	Test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600

Table 16
Maximum temperatures

(See Clauses 57.1.1, 57.1.4, 57.1.8, 57.1.10, and 57.1.13)

Materials and components	°C	(°F)
A. MOTORS		
1. Class A insulation systems on coil windings of alternating-current motors[a,b] having a frame diameter of 178 mm (7 inches) or less, not including universal motors:		
(a) In open motors –		
Thermocouple or resistance method	100	(212)
(b) In totally enclosed motors –		
Thermocouple or resistance method	105	(221)
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 178 mm (7 inches) of direct-current motors, and of universal motors:		
(a) In open motors –		
Thermocouple	90	(194)
Resistance method	100	(212)
(b) In totally enclosed motors –		
Thermocouple method	95	(203)
Resistance method	105	(221)
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 178 mm (7 inches) or less, not including universal motors:		
(a) In open motors –		
Thermocouple or resistance method	120	(248)
(b) In totally enclosed motors –		
Thermocouple or resistance method	125	(257)
4. Class B insulation systems on coil windings of alternating-current motors[a,b] having a frame diameter of more than 178 mm (7 inches) and of direct-current and universal motors:		
(a) In open motors –		
Thermocouple method	110	(230)
Resistance method	120	(248)
(b) In totally enclosed motors –		
Thermocouple method	115	(239)
Resistance method	125	(257)
5. Class F insulation on coil windings of motors[a,b] having a frame diameter of 178 mm (7 in) or less not including universal motors:		
(a) In open motors –		
Thermocouple or resistance method	145	(293)
(b) In totally enclosed motors –		
Thermocouple or resistance method	150	(302)
6. Class F insulation on coil windings of motors[a,b] having a frame diameter of more than 178 mm (7 in), not including universal motors:		
(a) In open motors –		
Thermocouple method	135	(275)
Resistance method	145	(293)

Table 16 Continued on Next Page

Table 16 Continued

Materials and components	°C	(°F)
(b) In totally enclosed motors –		
Thermocouple method	140	(284)
Resistance method	150	(302)
7. Class H insulation on coil windings of motors[a,b] having a frame diameter of 178 mm (7 in) or less, not including universal motors:		
(a) In open motors –		
Thermocouple or resistance method	160	(320)
(b) In totally enclosed motors –		
Thermocouple or resistance method	165	(329)
8. Class H insulation on coil windings of motors[a,b] having a frame diameter of more than 178 mm (7 in), including universal motors:		
(a) In open motors –		
Thermocouple method	150	(302)
Resistance method	160	(320)
(b) In totally enclosed motors –		
Thermocouple method	155	(311)
Resistance method	165	(329)
B. COMPONENTS		
1. Capacitors:		
Electrolytic types[c]	65	(149)
Other types[d]	90	(194)
2. Field wiring	75	(167)
3. Relay, solenoid, and other coils with[b]:		
(a) Class A insulated winding –		
Thermocouple method	92	(194)
Resistance method	110	(230)
(b) Class B insulated winding –		
Thermocouple method	110	(230)
Resistance method	130	(266)
(c) Class F insulated winding –		
Thermocouple method	135	(275)
Resistance method	145	(293)
(d) Class H insulated winding –		
Thermocouple method	150	(302)
Resistance method	160	(320)
4. Solid contacts	90	(194)
5. Transformer enclosures –		
(a) Class 2 transformers	85	(185)
(b) Power and ignition transformers	90	(194)
6. Fuse bodies[e]	90	(194)
C. INSULATED CONDUCTORS[f]		

Table 16 Continued on Next Page

Table 16 Continued

Materials and components	°C	(°F)
1. Flexible cords and wires with rubber, thermoplastic, or neoprene insulation	60	(140)
D. ELECTRICAL INSULATION – GENERAL[f]		
1. Fibre used as electrical insulation on cord bushings	90	(194)
2. Phenolic composition used as insulation or as parts where failure results in a risk of fire, electric shock, or other hazardous condition	150	(302)
3. Thermoplastic material	temperature rating of material	
E. GENERAL		
1. A surface upon which a stationary product is capable of being placed or mounted in service, and a surface that is adjacent to the product when it is so placed or mounted	90	(194)
2. Any point on or within a terminal box or a stationary product	90	(194)
3. Wood or other combustible material		

[a] The motor diameter shall be measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, and similar parts, used solely for motor cooling, mounting, assembly, or connection.

[b] When the coil is inaccessible for mounting thermocouples (for example, a coil immersed in sealing compound) or when the coil wrap includes thermal insulation or more than two layers, 0.8 mm (1/32 in) maximum, of cotton, paper, rayon, or similar materials, the resistance method shall be used. For a thermocouple measured temperature of a coil of an alternating-current motor, 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 accepted by an external source of heat, the temperature measured by a thermocouple is not prohibited from being:

(1) 5°C (9°F) for Item A1(a) of this Table;

(2) 10°C (18°F) for Item A3(a) of this Table;

(3) 15°C (27°F) for Item A2(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, as long as the temperature rise of the coil, as measured by the resistance method, is not more than that specified in this Table.

[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature on insulating material integral with the capacitor enclosure shall be no more than 90°C (194°F).

[d] A capacitor that operates at a temperature higher than 90°C (194°F) complies with the intent of this requirement. However, a capacitor shall be prohibited from operating at a temperature higher than its marked temperature rating.

[e] Includes both casing and ferrule. However, a temperature not more than 20°C (36°F) higher than the values indicated in this Table may be used on the casing (not ferrule) of a Class G, J, T, or L fuse.

[f] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been successfully investigated for higher temperatures than those specified in this Table.

Table 17
Physical properties of gasket materials

(See Clauses 67.1 and 67.2)

Materials	Physical properties	Acceptable limits	
		Before conditioning	After conditioning
Elastomers (neoprene, rubber, ethylene, propylene, and the like)	Minimum acceptable elongation[a]	250 percent	65 percent of original
	Minimum acceptable tensile strength	100 psi (10.3 MPa)[d]	75 percent of original
	Maximum acceptable set[b]	1/4 in (6.4 mm)	–

Table 17 Continued on Next Page

Table 17 Continued

Materials	Physical properties	Acceptable limits	
		Before conditioning	After conditioning
Non-elastomers (solid polyvinyl chloride, and the like, excluding cork, fibre, and similar materials)	Maximum acceptable compression set[c]	15 percent	–
	Minimum acceptable elongation[a]	200 percent	65 percent of original
	Minimum acceptable tensile strength	1500 psi (10.3 MPa)	75 percent of original
Foamed neoprene or rubber compound		The compound shall not burden or otherwise deteriorate to a degree that will affect its sealing properties.	
Thermoplastic		The compound shall not deform or melt, or otherwise deteriorate to a degree that will affect its sealing properties.	

[a] Percent increase in distance between gauge marks at break compared to initial distance of 25.4 mm (1 in). For example, a distance at break of 88.9 mm (3.5 in) is 250 percent elongation.

[b] Difference between 63.5 mm (2.5 in) and final distance when specimen is stretched so that gauge marks initially 25.4 mm apart are 63.5 mm apart, held for 2 minutes, and measured 2 minutes after release.

[c] Percent set measured after Type 1 button specimens are compressed to one-third of original thickness and heat conditioned for 24 hours at 70°C (158°F) or 10°C (18°F) higher than normal operating temperature, whichever is higher, following the procedure in Standard Test Methods for Rubber Property – Compression Set, ASTM D395, Method B.

[d] 500 psi (3.4 MPa) for a silicone rubber gasket (having the characteristic constituent of polyorganosiloxane) that is not subjected to mechanical abuse after assembly in the product.

Table 18
Accelerated aging conditions

(See Clause 67.1)

Measured temperature rise,[a]		Test Program	
C°	(F°)	Rubber or neoprene	Thermoplastic
35	(63)	Air oven aging for 70 hours at 100°C (212°F)	7 days in an air-circulating oven at 87.0 ±1.0°C (188.6 ±1.8°F)
50	(90)	Air oven aging for 168 hours at 100°C (212°F)	10 days in an air-circulating oven at 100 ±1.0°C (212.0 ±1.8°F)
55	(99)	7 days in an air-circulating oven at 113.0 ±1.0°C (235.4 ±1.8°F)	
65	(117)	7 days in an air-conditioning oven at 121.0 ±1.0° C (249.8 ±1.8°F)	
80	(144)	7 days in an air-circulating oven at 136.0 ±1.0°C (276.8 ±1.8°F)	

[a] These temperatures correspond to the maximum temperature rise measured on the gasket during the Normal-Temperature Test, Clause 57.

Table 19
Oven conditioning temperatures

(See Clauses 68.5 and 68.6)

Temperature on material during normal temperature test,		Number of days in oven	Oven temperature,	
°C	(°F)		°C	(°F)
60	(140)	7	87	(189)
75	(167)	7	100	(212)
80	(176)	7	113	(234)
90	(194)	7	121	(250)
105	(221)	7	136	(277)
145	(293)	10	150	(302)
150	(302)	10	160	(320)
160	(320)	30	170	(338)
170	(338)	30	180	(356)
180	(356)	30	190	(374)
190	(374)	30	200	(392)
200	(392)	30	210	(410)

Table 20
Short circuit test on bonding conductors

(See Clauses 71.1 and 71.2)

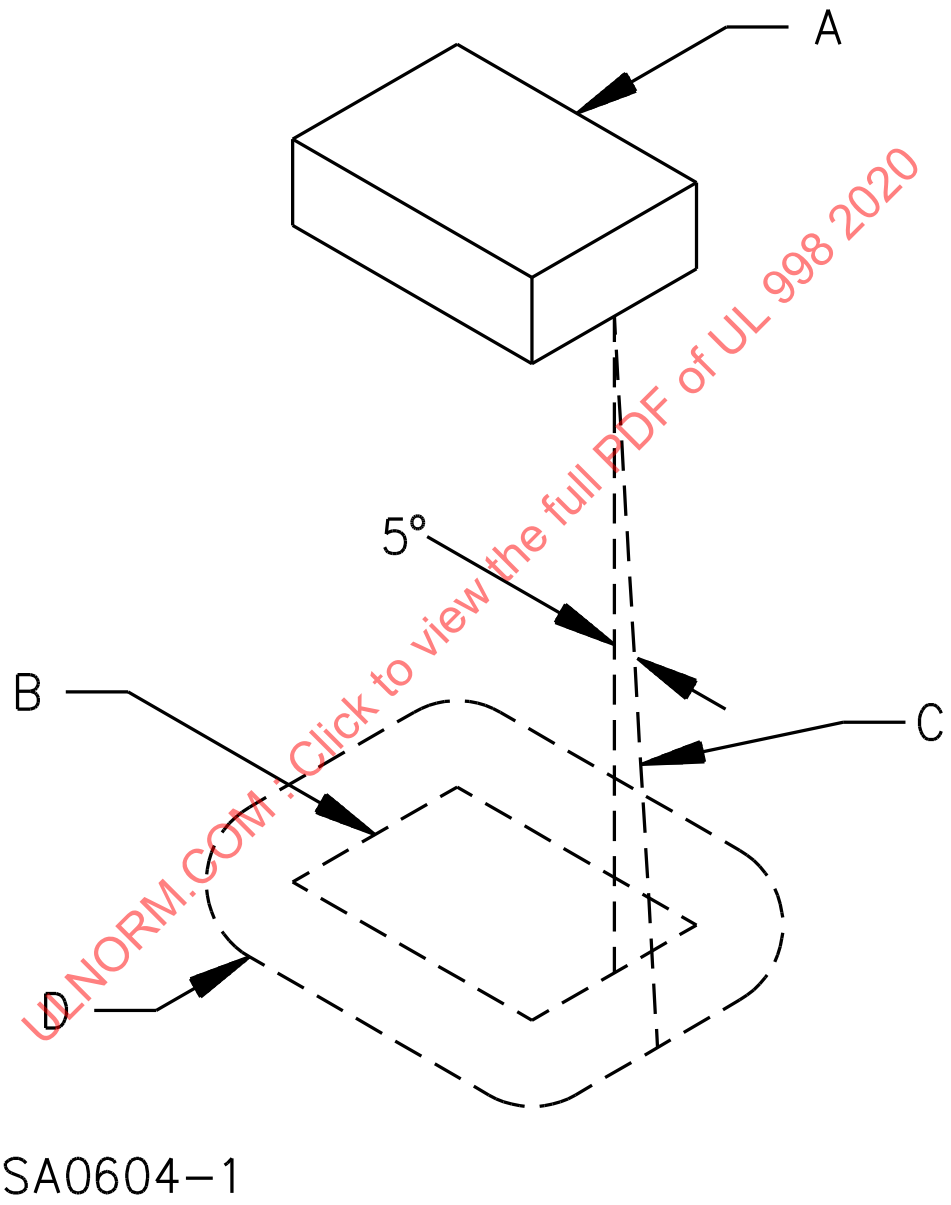
Combined rating of overcurrent device				Circuit capacity, A	
V-A			W output (HP)		
Single-phase	Three-phase	DC		0 – 250 V	251 – 600 V
0 – 1176	0 – 832	0 – 624	373 (1/2 maximum)	200	1000
1177 – 1920	833 – 1496	625 – 1128	373 to 746 (Over 1/2 to 1 maximum)	1000	1000

FIGURES

Figure 1

Location and extent of barrier

(See Clause 5.3.4)



Notes:

(A) The region to be shielded by barrier consists of the entire component if it is not otherwise shielded. If a component is partially shielded by the component enclosure or equivalent, the region consists of the unshielded portion of the component.

(B) Projection of outline of component on horizontal plane.

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

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

Figure 2

Articulated probe with web stop

(See Clause 7.5 and Table 2)