



UL 1017

Underwriters Laboratories Inc. Standard for Safety

Vacuum Cleaners, Blower
Cleaners, and Household Floor
Finishing Machines



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UL Standard for Safety for Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines,
UL 1017

Eighth Edition, Dated September 10, 2010

Summary of Topics

The new edition dated September 10, 2010 was issued to incorporate the following new and revised requirements and to reflect the September 10, 2010 ANSI recognition of the standard:

- Addition of requirements for portable rechargeable battery-powered appliances.
- Clarification for polymeric fluid-handling component requirements.
- Clarification of the meter circuit in Figure 6 – Leakage Current Measurement Circuits.
- Addition of installation instruction for a permanently connected appliance.
- Addition of requirements for detachable power supply cords.
- Addition of requirement for coatings applied to the exterior surfaces of polymeric materials and other external polymeric parts.
- Addition of an exception to Clause 4.13.5 for spacings within a motor.
- Revisions to address accessibility of moving parts through openings 1.375 inches or greater.
- Addition of blower cleaner impeller requirements.
- Leakage current testing in lieu of volume resistivity requirements.
- Revision of proprietary fluid requirements for self contained carpet cleaning machines.
- Revision of central vacuum outlet assembly grounding requirements.
- Requirements for a flexible switch actuator.
- Requirements for an electrical attachment with contacts on the underside of the attachment.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated January 9, 2009, July 10, 2009, September 11, 2009, and July 16, 2010.

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

Future Effective Date	References
August 1, 2013	Clauses 1.2, 2.3, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.16, 3.5.1, 4.14.1, 4.16.3.1, 4.16.3.3, 4.16.8, 5.12.8.1.1, 5.12.8.3, 5.27, 7, 8.2.6, 11.2.7, Table 9, Figures 25 and 26, and Annex C



Canadian Standards Association
CSA C22.2 No. 243-10
Fourth Edition



Underwriters Laboratories Inc.
UL 1017
Eighth Edition

Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines

September 10, 2010



ANSI/UL 1017-2010

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This ANSI/UL Standard for Safety consists of the Eighth Edition. The most recent designation of ANSI/UL 1017 as an American National Standard (ANSI) occurred on September 10, 2010. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. Any other portions of this ANSI/UL standard that were not processed in accordance with ANSI/UL requirements are noted at the beginning of the impacted sections.

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This ANNEX is provided for information only

ANNEX C

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Preface

This is the harmonized CSA and UL standard for Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines. It is the fourth edition of CSA-C22.2 No. 243, and the eighth edition of UL 1017. This edition of CSA-C22.2 No. 243 supersedes the previous edition(s) published in 2001. This edition of UL 1017 supersedes the previous edition(s) published in 2001.

This harmonized standard was prepared by the Canadian Standards Association (CSA) and Underwriters Laboratories Inc. (UL). The efforts and support of the Vacuum Cleaner industry of both the USA and Canada 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 Integrated Committee on Electrical Motor-Operated Cleaning Appliances for Industrial Use, under the jurisdiction of the CSA Technical Committee on Consumer and Commercial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Where reference is made to a specific number of samples to be tested, the specified number is 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 is published as an identical standard for CSA 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.

CSA effective date

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

UL effective date

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As of September 10, 2010 all products Listed by UL must comply with the requirements in this standard except for clauses, figures, tables, and annexes in the following list, which are effective August 1, 2013.

Clauses 1.2, 2.3, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.16, 3.5.1, 4.14.1, 4.16.3.1, 4.16.3.3, 4.16.8, 5.12.8.1.1, 5.12.8.3, 5.27, 7, 8.2.6, 11.2.7, Table 9, Figures 25 and 26, and Annex C

Between September 10, 2010 and August 1, 2013, new product submittals to UL may be evaluated under all requirements in this standard or, if requested in writing, evaluated under presently effective requirements only. The presently effective requirements are contained in the eighth edition of UL 1017.

A UL effective date is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Vacuum Cleaners, Blower Cleaners, And Household Floor Finishing Machines

1 Scope

1.1 This Standard applies to motor-operated vacuum cleaners and blower cleaners, and to household use floor finishing machines to be employed in accordance with the Canadian Electrical Code Part I (CEC), C22.1, and the National Electrical Code (NEC), ANSI/NFPA 70.

1.2 These requirements cover:

- a) household, commercial, and coin-operated vacuum cleaning machines and blower cleaners, intended for indoor or outdoor use or both;
- b) household, commercial, and coin-operated wet pick-up, dry pick-up, permanently mounted, portable, and central vacuum cleaners and blower cleaner systems;
- c) household electrically powered floor finishing machines, including floor polishers, floor scrubbers, floor sanders, rug shampooers, rug and floor washers, and similar machines;
- d) appliances covered by this Standard that are marked as being provided with double insulation and that employ double insulation in place of grounding in accordance with the Exception to Clause 4.14.1;
- e) portable rechargeable battery-powered appliances for indoor or outdoor use with rechargeable non-user and user replaceable batteries; see Clause 7;
- f) current-carrying hoses for use with vacuum cleaner/motorized nozzle combination appliances intended for household, dry pick-up, indoor use; see Clause 8;
- g) current-carrying hoses for use with motorized nozzles intended for use with central vacuum cleaning systems intended for household, dry pick-up, indoor use; see Clause 8;
- h) wet pick-up current-carrying hoses for use with household, indoor use carpet cleaning equipment; see Clause 8; and
- i) electrified wall valves for connection of current-carrying hose/motorized nozzle combinations for central vacuum cleaning systems intended for household use; see Clause 8.

1.3 These requirements do not cover appliances rated more than 250 V. An appliance that utilizes some other source of energy, such as gas or steam, in addition to electric energy is to be investigated under these requirements and under such additional requirements as are applicable to the appliance under consideration.

1.4 These requirements do not cover appliances for use in locations such as those areas of hospitals, laboratories, institutions, and the like where dispersion of pathological, chemical, physical, radioactive or other agents could produce a risk to health. Appliances intended for use in such locations are investigated under these requirements and under such additional requirements as are applicable to the appliance, with appropriate consideration being given to the specific intended use.

1.5 These requirements apply only to a specific type or types of appliances, such as a vacuum cleaner or floor finishing machine, if the requirement is so identified by specific reference to the type or types involved. Absence of such specific reference or use of the term "appliance" indicates that the requirement applies to all appliances covered by this standard.

2 Definitions

2.1 The following definitions apply in this Standard:

2.2 **Accessible part or surface** – A part or surface subject to contact by persons under any condition of operation or user function. In a determination of whether a live or noncurrent-carrying part or surface is accessible through an opening in the enclosure to such contact, the criteria specified in accessibility of live parts, Clause 4.1.4, applies.

2.3 **Appliance unit** – The functional part of the rechargeable battery-powered appliance that employs the motor assembly and battery assembly. The Class 2 power unit is not part of the appliance unit.

2.4 **Automatically controlled** – An appliance is considered to be automatically controlled if:

- a) the repeated starting of the appliance, beyond one complete predetermined cycle of operation to the point where some form of limit switch opens the circuit, is independent of any manual control;
- b) during any single predetermined cycle of operation, the motor is caused to stop and restart one or more times;
- c) upon energizing the appliance, the initial starting of the motor may be intentionally delayed beyond normal, conventional starting; or
- d) during any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

2.5 **Basic insulation** – The insulation in contact with live (current-carrying) parts to provide basic protection against the risk of electric shock.

2.6 **Battery assembly** – A single cell, or group of cells that are connected, that forms a part to provide power to the appliance unit.

2.7 **Battery assembly, Fully charged** – A battery assembly that is charged for a minimum of 16 h or in accordance with the manufacturer's instructions, whichever is greater.

2.8 **Battery assembly, Fully discharged** – A fully charged battery assembly that is discharged for one additional hour after the appliance unit has ceased operation.

2.9 **Battery, Integral** – A battery assembly that is contained within the appliance unit, and that is not removed from the appliance unit for charging purposes, but only removed for disposal or recycling purposes.

2.10 **Battery pack** – A battery assembly that is contained within its individual enclosure.

2.11 **Battery response** – An adverse reaction that may increase the risk of personal injury, such as a battery pack exploding, under certain conditions.

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2.12 Cell – A single (basic) functional electrochemical unit consisting of electrodes (positive and negative), electrolyte, container, terminals, and typically separators, that is a source of electrical energy by direct conversion of chemical energy.

2.13 Double insulation – An insulation system comprised of basic insulation and supplementary insulation, with the two insulations physically separated and so arranged that they are not simultaneously subjected to the same deteriorating influences (temperature, contaminants, and the like) to the same degree. See Figure 13.

2.14 Extra-low voltage circuit – A circuit involving a peak open-circuit potential of not more than 42.4 V (30 Vrms) for dry applications and 21.2 V (15 Vrms) for wet applications, supplied by a primary battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that, as a unit, complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current is not considered to be an extra-low voltage circuit.

2.15 Hard surface – Any surface that is not carpeted or upholstered.

2.16 Household extraction-type floor cleaning machine – Either a hard surface cleaning machine, a self-contained carpet cleaning machine, or a machine that can clean both hard surfaces and carpeted surfaces. These machines apply a cleaning solution to the surface to be cleaned and then extract the solution.

2.17 Line-voltage circuit – A circuit involving a potential of not more than 600 V and having circuit characteristics in excess of those of an extra-low voltage circuit.

2.18 Live (current-carrying) part – A part that is conductively connected to a line-voltage circuit. See Clause 2.17.

2.19 Measurement indication unit (MIU) – The unit used in measuring leakage current as defined in the Standard for Leakage Current for Appliances, UL 101.

2.20 Noncurrent-carrying metal part – A metal or other electrically conductive part, accessible or inaccessible, that is not conductively connected to a live part.

2.21 Proprietary fluid – An aqueous solution designated for use with a household extraction-type floor cleaning machine that is exclusively controlled by the same manufacturer as the appliance.

2.22 Reinforced insulation – An improved basic insulation system with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against a risk of electric shock as double insulation. It may consist of one or more layers of insulating materials.

2.23 Remotely controlled appliance – An appliance that is out of sight of the operator who is at the starting device.

2.24 Supplementary insulation – An independent insulation provided in addition to the basic insulation to protect against a risk of electric shock in case of mechanical rupture or electrical breakdown of the basic insulation. An enclosure of insulating material may form a part or all of the supplementary insulation.

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 generally used in the products covered by this standard. A component shall comply with the CSA and UL standards.

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

- a) involves a feature or characteristic not needed in the application of the component in the product covered by this standard; or
- b) is superseded by a requirement in this standard.

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

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

3.2 Attachments

3.2.1 A functional attachment that is recommended, made available, or packaged with an appliance by the manufacturer for use with an appliance shall be included in the investigation of the appliance.

Exception: A nonelectrical attachment, such as a crevice tool, an upholstery brush, or the like, that has no driven parts and is intended to facilitate a cleaning operation without the use of a liquid need not be investigated.

3.2.2 An electrical attachment provided with line-voltage electrical contacts on the underside of the attachment and in close proximity to the surface to be cleaned shall comply with the following:

- a) Based on the anticipated build up of dust or dirt on the bottom of the attachment and the possibility of a conductive path being established between the electrical contacts, there shall not be an increase in the risk of fire due to the shorting of the electrical contacts. The attachment shall be tested as described in the abnormal operation – shorted electrical contact test, Clause 5.10.3.
- b) During the anticipated cleaning of the attachment, there shall not be an increase in the risk of electric shock to the user. The attachment, while connected to the appliance, shall be tested as described in the cleaning test, Clause 5.12.9.
- c) If the electrical attachment is intended to be inserted into mating electrical contacts (such as the contacts of a motorized brush), the mating of which can energize a load (such as the brush motor or relay coil), the mating electrical contacts on the attachment shall have suitable voltage and current ratings, and be suitably rated to make and break the particular load in accordance with the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977 and the Standard for Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type, CSA C22.2 No. 182.1.

d) The applicable severe conditions (see Clause 5.21.5) and abnormal operation (see Clause 5.21.7) tests shall be conducted with and without the electrical attachment connected to the appliance as intended.

3.3 Fluids – proprietary

3.3.1 For a household extraction-type floor cleaning machine that is intended to be used with a proprietary fluid in accordance with Exception No. 2 to Clause 5.12.8.1.1, the manufacturer shall package the proprietary fluid with the appliance. If the appliance is intended for use with more than one proprietary fluid, the manufacturer shall package at least one of the proprietary fluids with the appliance.

3.4 Instructions provided with the appliance

3.4.1 A copy of the operating, user-maintenance, and other instructions intended to accompany an appliance as produced shall be used as a guide in the examination and test of the appliance. For this purpose, a draft copy is sufficient and a final printed copy is not required.

3.4.2 The instructions provided with an appliance shall include such directions and information as deemed by the organization responsible for the appliance to be necessary to cover the operation, use and maintenance of the appliance, and shall comply with the requirements for instruction manuals specified in Clause 11.

3.5 Reference publications

3.5.1 Products covered by this standard shall comply with the referenced installation codes and standards noted in Annex A. 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 Standards

C22.1

Canadian Electrical Code, Part I

C22.2 No. 0.17

Evaluation of Properties of Polymeric Materials

C22.2 No. 1

Audio, Video, and Similar Electronic Equipment

C22.2 No. 18.1

Metallic Outlet Boxes

C22.2 No. 18.2

Nonmetallic Outlet Boxes

C22.2 No. 24

Temperature-Indicating and Regulating Equipment

C22.2 No. 77

Motors With Inherent Overheating Protection

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C22.2 No. 100

Motors and Generators

C22.2 No. 182.1

Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type

C22.2 No. 223

Power Supplies with Extra-Low-Voltage Class 2 Output

UL Standards

UL 94

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

UL 101

Leakage Current for Appliances

UL 157

Gaskets and Seals

UL 514A

Metallic Outlet Boxes

UL 514C

Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

UL 746A

Polymeric Materials – Short Term Property Evaluations

UL 873

Temperature-Indicating and -Regulating Equipment

UL 1310

Class 2 Power Units

UL 1446

Systems of Insulating Materials – General

UL 1676

Conductive-Path and Discharge-Path Resistors for Use in Radio-, Video-, or Television-Type Appliances

UL 1977

Component Connectors for Use in Data, Signal, Control and Power Applications

UL 2111

Overheating Protection for Motors

American National Standards Institute (ANSI)

ANSI/ISA MC96.1

Temperature Measurement Thermocouples

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ANSI/NFPA 70
National Electrical Code

4 Construction

4.1 Enclosures

4.1.1 Mechanical strength

4.1.1.1 The frame and enclosure of an appliance shall have the necessary strength and rigidity to resist the abuses likely to be encountered during normal service. The degree of resistance inherent in the unit shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other defects that alone or in combination constitute a risk of fire, electric shock, or injury to persons.

4.1.1.2 For an unreinforced, flat surface:

- a) cast metal shall not be less than 1/8-in (3.2-mm) thick;
- b) malleable iron shall not be less than 3/32-in (2.4-mm) thick; and
- c) die-cast metal shall not be less than 5/64-in (2.0-mm) thick.

Exception No. 1: Metal of a lesser thickness but not less than 3/32, 1/16, and 3/64 in (2.4, 1.6, and 1.2 mm), respectively, may be acceptable provided the surface under consideration is:

- a) curved, ribbed, or otherwise reinforced to provide mechanical strength equivalent to that required; or*
- b) of size or shape that provides mechanical strength equivalent to that required.*

Exception No. 2: Metal of a lesser thickness may be employed if it complies with the physical abuse tests in Clause 5.19.

4.1.1.3 An enclosure of sheet metal shall be judged with respect to size, shape, thickness of metal, and acceptability for the application considering the intended use of the appliance. Sheet steel shall have a minimum thickness of 0.026 in (0.66 mm); aluminum shall have a minimum thickness of 0.036 in (0.91 mm); and copper or brass shall have a minimum thickness of 0.033 in (0.84 mm).

Exception: An area that is relatively small or a surface that is curved or otherwise reinforced need not comply with this requirement if it complies with the physical abuse tests in Clause 5.19.

4.1.1.4 Factors that shall be taken into consideration when judging the acceptability of magnesium and nonmetallic material other than a polymeric material are resistance to:

- a) mechanical damage;
- b) impact;
- c) moisture absorption;
- d) combustion; and

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

4.1.1.5 Polymeric parts employed to enclose uninsulated live parts or insulated live parts whose insulation is less than 0.028 in (0.7 mm), or equivalent, shall be subjected to the tests in Clause 5.21 and shall have a flammability rating as noted below in accordance with the Standard for Evaluation of Properties of Polymeric Materials, CSA C22.2 No. 0.17 and the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94:

a) 5 VA and 0.175 VA Test A for a stationary appliance or an appliance that is permanently installed;

b) HB and 0.17 HB minimum for a portable attended, intermittent duty, household appliance; and

c) V2 and 0.17 V2 minimum for an appliance other than as mentioned in (a) and (b).

4.1.1.6 Polymeric parts employed to enclose insulated live parts [insulation 0.028-in (0.7-mm) thick minimum or equivalent], internal wiring and moving parts shall have a minimum flammability rating of HB and 0.17 HB, and shall be subjected to the mold stress-relief distortion test, Clause 5.21.3, and the impact test, Clause 5.21.4.

4.1.1.7 Polymeric materials for use other than as described in Clauses 4.1.1.5 and 4.1.1.6 shall have a minimum flammability rating of HB and 0.17 HB.

Exception No. 1: A small part whose maximum volume does not exceed 0.12 in³ (2 cm³) is not required to comply with Clause 4.1.1.7.

Exception No. 2: An external polymeric part that is detachable without the use of tools is not required to comply with Clause 4.1.1.7.

4.1.1.8 The requirements of Clauses 4.1.1.5, 4.1.1.6, and 4.1.1.7 are not applicable for coatings, such as paint, applied to the exterior surfaces of polymeric enclosure materials or to other external polymeric parts provided that the coating does not offer a continuous path for an internal flame to propagate externally.

4.1.2 Openings in enclosures

4.1.2.1 The enclosure of a remotely or automatically controlled appliance shall prevent molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the appliance is supported. See Clause 2.1.

4.1.2.2 The requirement in Clause 4.1.2.1 will necessitate the use of a barrier of noncombustible material:

a) under a motor unless:

- 1) the structural parts of the motor or the appliance provide the equivalent of such a barrier;
- 2) the protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions:
 - i) open main winding;
 - ii) open starting winding;
 - iii) starting switch short-circuited; and
 - iv) 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; or
- 3) the motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will limit the temperature of the motor windings:
 - i) to 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle; and
 - ii) to 150°C (302°F) with the rotor of the motor locked; and

b) under wiring, unless there is no evidence of a risk of fire as a result of the tests in Clause 5.

4.1.2.3 A switch, a relay, a solenoid, or the like in an appliance as specified in Clause 4.1.2.1 shall be individually and completely enclosed.

Exception No. 1: The terminals of a switch, a relay, a solenoid, or the like need not be individually and completely enclosed.

Exception No. 2: If malfunction of the component would not result in a risk of fire then the component need not be individually and completely enclosed.

Exception No. 3: If there are no openings in the bottom of the appliance enclosure then a switch, a relay, a solenoid or the like need not be individually and completely enclosed.

4.1.2.4 The barrier mentioned in Clause 4.1.2.1 shall be located as illustrated in Figure 1, and shall have an area in accordance with that illustration. Openings for drainage, ventilation, or the like may be employed in the barrier, if such openings would not permit molten metal, burning insulation, or the like to fall on flammable material.

4.1.2.5 The construction of a vacuum cleaner intended to be exposed to rain shall comply with the water-spray test requirements specified in Clause 5.12.1.

4.1.2.6 The construction of a wet pick-up vacuum cleaner shall comply with the wet pick-up test requirements specified in Clause 5.12.2.

4.1.2.7 The door or cover of an enclosure shall be hinged or otherwise attached in an equivalent manner if it gives access to any overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device.

4.1.2.8 Means shall be provided for holding the door or cover over a fuseholder in a closed position, and the door or cover shall be tight-fitting.

4.1.2.9 A portable cord-connected appliance that is provided with keyhole slots, notches, hanger holes, or the like for hanging on a wall shall be constructed so that the hanging means attached to the wall is not accessible when the appliance is placed on the hanging means as intended.

4.1.2.10 To determine whether an appliance complies with the requirement in Clause 4.1.2.9, any part of the enclosure or barrier that can be removed without the use of tools to gain access to the hanging means shall be removed.

4.1.2.11 An opening in an appliance provided for hanging the appliance shall be located or guarded so that a nail, hook, or the like does not displace a part that would create a risk of fire or electric shock and does not contact one of the following:

- a) an uninsulated live part;
- b) magnet wire;
- c) internal wiring;
- d) moving parts; or
- e) any other part likely to create a risk of fire or electric shock.

4.1.3 Adhesives used to secure parts

4.1.3.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in Clause 5.23.

4.1.3.2 The requirement in Clause 4.1.3.1 also applies to an adhesive used to secure a part, including a nameplate, that can, if loosened or dislodged:

- a) make a live part accessible;
- b) reduce spacings below the minimum specified values; or
- c) expose a normally enclosed moving part.

4.1.4 Accessibility of live parts

4.1.4.1 To reduce the likelihood of unintentional contact that can involve a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either (a) or (b):

- a) for an opening that has a minor dimension (see Clause 4.1.4.5) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 2;
- b) for an opening that has a minor dimension of 1 in (25.4 mm) or more, such a part or wire shall be spaced from the opening as specified in Table 1.

Exception: A motor employed in an appliance intended for commercial use other than one used in either a hand-held appliance or a hand-supported portion of an appliance need not comply with these requirements if it complies with the requirements in Clause 4.1.4.2.

4.1.4.2 With respect to a part or wire as mentioned in Clause 4.1.4.1 in an integral enclosure of a motor as mentioned in the exception to Clause 4.1.4.1:

- a) an opening that has a minor dimension (see Clause 4.1.4.5) less than 3/4 in (19.1 mm) is acceptable if:
 - 1) film-coated wire cannot be contacted by the probe illustrated in Figure 3;
 - 2) an uninsulated live part cannot be contacted by the probe illustrated in Figure 4;
- b) an opening that has a minor dimension of 3/4 in (19.1 mm) or more is acceptable if a part or wire is spaced from the opening as specified in Table 1.

4.1.4.3 The probes illustrated in Figures 2 – 4 shall be applied to any depth that the opening will permit and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figures 2 – 4 shall be applied to any possible configuration and, if necessary, the configuration shall be changed after insertion through the opening.

4.1.4.4 The probes shall be used as measuring instruments to judge accessibility provided by an opening and not as instruments to judge the strength of a material.

4.1.4.5 With reference to the requirements in Clauses 4.1.4.1 and 4.1.4.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

4.1.4.6 During the investigation of an appliance to determine whether it complies with the requirements in Clause 4.1.4.1 or 4.1.4.2, a part of the enclosure that can be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

4.1.4.7 The connection of an accessible part to live parts, including a supply conductor, to facilitate the discharge of static electricity shall comply with (a) – (d). To determine compliance with the remaining requirements in this Standard, the resistors and associated circuitry shall be investigated as live parts. The lead of the resistor connected to the accessible parts shall be investigated as a dead metal part:

- a) a minimum of two resistors connected in series shall be employed;
- b) the resistors shall comply with the applicable requirements in the Standard for Conductive-Path and Discharge-Path Resistors for Use in Radio-, Video-, or Television-Type Appliances, UL 1676, and the Standard for Audio, Video, and Similar Electronic Equipment, CSA C22.2 No.1;
- c) for the tests described in Clauses 5.3, 5.4, 5.5, and 6.12, one resistor at a time shall be shorted; and
- d) for the test described in Clauses 5.11 and 6.13, as applicable, the lead of the resistor connected to the accessible part shall be disconnected.

4.2 Mechanical assembly

4.2.1 An appliance shall be so assembled that the vibration of normal operation will not result in a risk of electric shock, fire, or injury to persons.

4.2.2 Components such as switches, lampholders, receptacles and plug connectors provided as parts of equipment shall be fastened securely and rigidly, and shall be restricted from turning by means other than friction between surfaces. Lock washers, properly applied, may be used as a means to restrict the turning of stem-mounted controls, except those that operate with a rotary motion.

4.2.3 Uninsulated live parts shall be secured to the base or mounting surface so that they will be prevented from turning or shifting in position, if such motion can result in a reduction of spacings below the minimum specified values. Friction between surfaces to restrict shifting or turning of live parts shall not be used, but a lock washer, properly applied, may be used.

4.2.4 Fluid-handling tubing shall be mechanically secured at connections if there is a risk of fire or electric shock should the tubing become disconnected (see Clause 5.12.8.1.1 (a) and (b)). Tubing subject to a pressure greater than 10 psi (0.7 kg/cm²) shall also comply with the tubing pressure test described in Clause 5.12.8.4.

Exception: Fluid-handling tubing subject to a pressure of 10 psi or less is not required to be mechanically secured if the tubing complies with the tubing pressure test (see Clause 5.12.8.4).

4.3 Corrosion protection

4.3.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means if the corrosion of such unprotected parts would be likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: In certain instances in which the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet steel and cast-iron parts within an enclosure will in some cases not be required to be protected against corrosion.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, or the like need not be protected against corrosion.

4.3.2 If deterioration or breakage of a liquid container provided as a part of an appliance would result in a risk of fire, electric shock, or injury to persons, the container shall be of a material that is resistant to corrosion by the liquid intended to be contained.

4.4 Supply connections

4.4.1 Cord-connected equipment

4.4.1.1 An appliance intended to be connected to the power-supply circuit by means of a flexible cord shall be provided with a length of flexible cord and an attachment plug for connection to the supply circuit.

4.4.1.2 A stationary appliance may be provided with not more than 8 ft (2.44 m) of cord and an attachment plug for supply connection. The investigation of such a feature shall include consideration of the utility of the appliance and the necessity of having it readily detachable from its source of supply by means of the plug.

4.4.1.3 Supply cords and cord sets shall:

- a) have a voltage rating not less than the rated voltage of the appliance;
- b) have an ampacity not less than the current rating of the appliance; and
- c) employ flexible cords as specified in Table 2 or a type at least as serviceable.

4.4.1.4 The voltage rating of the attachment plug shall correspond to the voltage rating of the product and the ampere rating of the attachment plug shall not be less than 125% of the ampere rating of the product. When the product has provision to be field adapted for use with two or more different supply voltages, the attachment plug on the power supply cord provided with the product shall be rated for the supply voltage selected at the factory. See Clause 10.3.2.

Exception No. 1: A stationary product marked in accordance with Clause 10.3.6 shall employ an attachment plug cap rated no less than the current rating of the appliance or the input current under normal load conditions as specified in Clause 5.2, whichever is greater.

Exception No. 2: A commercial vacuum cleaner marked in accordance with Clause 10.3.7, rated 120 V, 60 Hz, 12 – 15 A, and employing a motor driven cleaning brush 22-in (55.9-cm) wide, or wider, shall employ an attachment plug cap rated not less than the current rating of the appliance.

4.4.1.5 The attachment plug on an appliance intended to be connected to a nominal 120-V circuit, and employing devices required to be connected to a specific supply conductor as specified in Clauses 4.9.7, 4.11.3, and 4.12.8 shall be a polarized type. The connections to the attachment plug shall be in accordance with Figure 5 and Table 3. See also polarization instructions, Clause 11.4.

4.4.1.6 An appliance that is required to employ a polarized attachment plug as specified in Clause 4.4.1.5, and that is provided with a detachable cord set shall also employ an appliance connector of the polarized type.

4.4.1.7 The power-supply cord of a portable appliance shall exit from the body of the attachment plug in a direction parallel to the major dimension of the blades and at a point opposite a point on the face of the plug geometrically centered between the blades. An angled attachment plug shall not be provided with a portable appliance.

4.4.1.8 The flexible cord may be attached permanently to an appliance or may be in the form of a separable cord set with means for connection to the appliance.

4.4.1.9 A household appliance intended for use with a detachable cord set shall not be provided with pin terminals that will accommodate a standard flatiron or an appliance plug.

4.4.1.10 For a commercial vacuum cleaner, a detachable power supply cord with an IEC 60320 configuration appliance coupler exceeding 60°C (140°F) during the Temperature Test (see Clause 5.8) shall be of the special use type. See Clauses 3.1, 4.4.1.11, 10.4.19, 10.4.20, and 11.2.10, including Annex A.

4.4.1.11 With reference to Clause 4.4.1.10, the appliance coupler temperature shall not exceed 70°C (158°F) and the rating of the coupler insulating material shall be at least 5°C (9°F) greater than the maximum measured temperature on the material.

4.4.1.12 Other than as noted in Clauses 4.4.1.15 and 4.4.1.16, the length of an attached flexible power supply cord for a vacuum cleaner or blower cleaner shall not be less than 6 ft (1.82 m) from the face of the attachment plug cap to the point at which the cord enters the appliance.

Exception: For a central vacuum cleaner, the length of the flexible power supply cord shall not be less than 3 ft (0.9 m). For required installation instructions see Clause 11.5.9.

4.4.1.13 A household-use floor finishing machine shall be provided with either a detachable or a nondetachable power supply cord not less than 15-ft (4.57-m) long, including fittings.

4.4.1.14 The length of a cord set, including fittings, shall not be less than 6 ft (1.82 m) except as specified in Clause 4.4.1.16.

4.4.1.15 A portable commercial appliance, portable outdoor use appliance or portable hand-supported blower cleaner shall be provided with not more than 18 in (457 mm) of permanently attached flexible power-supply cord or with a connector base (motor-attachment plug) if:

- a) the appliance is marked in accordance with Clause 10.3.15 or provided with instructions in accordance with Clause 11.5.3; or
- b) the manufacturer furnishes a detachable cord set, 6 ft (1.82 m) or more in length, with the appliance.

4.4.1.16 The length of the power-supply cord or cord set on a wet pick-up appliance that is supported by the body of a person but not solely handheld shall be not less than 20 ft (6.1 m).

4.4.1.17 The means for connection (such as the attachment plug cap or connector base) of a wet pick-up appliance intended for use with a detachable cord set in accordance with Clause 4.4.1.8 or 4.4.1.15 shall be of the locking type.

4.4.1.18 An accessory, such as a detachable, electric power-driven brush, shall not be provided with a general purpose attachment plug.

Exception No. 1: An accessory intended for use with a central vacuum cleaning system may be provided with a general purpose attachment plug provided the accessory is marked in accordance with Clause 10.3.14.

Exception No. 2: An accessory intended for use with an extraction-type carpet cleaning system intended for commercial use may be provided with a general purpose attachment plug.

4.4.1.19 A motorized nozzle intended to be connected to an appliance that is intended for wet pick-up shall be provided with:

- a) an attached flexible power-supply cord of such length as to plug directly into the appliance without the use of an intermediate connection such as a detachable cord set; or
- b) a cord-and-hose assembly that has been investigated and found to be acceptable for the application without creating a risk of fire, electric shock, or injury to persons when exposed to moisture.

4.4.1.20 An appliance incorporating a special-use connector and plug as a disconnecting means, such as a special use cord connector in the supply cord of a vacuum cleaner between the handle and the motor, shall have no exposed live parts under any normal condition as determined by the requirements in accessibility of live parts, Clause 4.1.4.

4.4.1.21 A 3- to 2-wire grounding type adaptor shall not be provided with an appliance.

4.4.2 Pin terminals

4.4.2.1 An appliance provided with pin terminals shall have no live parts exposed to unintentional contact either during or after placement of a plug that is intended for the purpose on the pins in the normal manner.

4.4.2.2 A pin guard shall be provided that will restrict contact with any current-carrying pin by:

- a) a straight edge placed in any position across and in contact with edges of the plug opening without the plug in place to reduce the likelihood of mechanical damage to the pins; and
- b) the probe illustrated in Figure 2 while the probe is inserted through any opening with the appliance in any position, with the plug aligned with the pins and the face of the plug in the plane perpendicular to the axis and tangent to the end of the farthest projecting current-carrying pin.

4.4.3 Strain relief

4.4.3.1 Supply cords shall be provided with strain relief that reduces the likelihood of mechanical stress on the external portion of the cord from being transmitted to internal wiring, splices and terminals. The strain relief means shall comply with the test requirements specified in Clause 5.14.

4.4.3.2 Unless known to be acceptable for the purpose, a clamp of any material – metal or otherwise – shall not be used on a Type SVT cord or on cords of similar or lighter construction. For harder usage types of thermoplastic-insulated cord, clamps may be employed. In such cases, auxiliary insulation is not required unless it is determined that the cord grip may damage the insulation of the cord.

Exception: A clamp may be used on Type SVT (or similar) cord protected by varnished cloth tubing, phenolic, vulcanized fiber, or the equivalent under the cord grip, subject to the investigation described in Clause 5.14.3. Thermoplastic tubing is not acceptable over thermoplastic cords.

4.4.3.3 If a knot in a flexible cord serves as strain relief, a surface that the knot may contact shall be free from projections, sharp edges, burrs, fins, and the like that can cause abrasion of the insulation on the conductors.

4.4.3.4 It shall not be possible for flexible cords to be pushed into the appliance through the cord-entry holes, if such displacement

a) can subject the cords to mechanical injury or to exposure to a temperature higher than that for which the cord is intended; or

b) is liable to reduce spacings (such as from uninsulated live parts to a metal strain relief clamp) below the specified minimum values.

4.4.3.5 The flexible cord shall be restrained from any rotation that could cause movement of the internal wiring at splices and terminals.

4.4.4 Bushings

4.4.4.1 Holes in sheet-metal walls through which insulated conductors pass shall be provided with smoothly rounded bushings or shall have smooth, well-rounded surfaces upon which such conductors may bear.

4.4.5 Permanently connected equipment

4.4.5.1 General

4.4.5.1.1 An appliance intended to be fastened or secured in position shall be provided with field-wiring terminals or leads for the connection of power-supply conductors, and shall have means for connection of a permanent wiring system.

4.4.5.1.2 Where openings for conduit are provided in sheet metal enclosures, the metal thickness shall be not less than 0.032-in (0.81-mm) thick if of sheet steel or 0.043-in (1.09-mm) thick if of nonferrous metal.

4.4.5.1.3 Terminal boxes or wiring compartments in which supply connections are made shall be located so that the connections will be accessible for inspection when the vacuum cleaner is installed as intended.

4.4.5.1.4 The compartment mentioned in Clause 4.4.5.1.3 shall be located so that, during conduit connections, internal wiring and electrical components will not be exposed to mechanical damage or strain.

4.4.5.1.5 A terminal compartment intended for connection of a supply raceway shall be attached to the appliance so as to be prevented from turning.

4.4.5.2 Wiring terminals and leads

4.4.5.2.1 A permanently connected appliance shall be provided with wiring terminals for the connection of conductors having an ampacity rated for the appliance; or the appliance shall be provided with leads for such connection.

4.4.5.2.2 An appliance required to be grounded and equipped with terminals or leads for field connections of power-supply conductors shall be provided with a terminal or lead for connection of an equipment-grounding conductor.

4.4.5.2.3 A wiring terminal shall be considered to be a terminal to which a wire may be connected in the field, unless the wire, and a means of making the connection – a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or the like – factory-assembled to the wire, are provided as a part of the appliance.

4.4.5.2.4 A terminal solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size necessary for the particular application. Solder alone shall not be used for connecting an equipment-grounding conductor.

4.4.5.2.5 A wiring terminal shall be provided with a soldering lug or with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm²) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

4.4.5.2.6 A wiring terminal shall be prevented from turning.

4.4.5.2.7 The free length of a lead inside an outlet box or wiring compartment shall not be less than 6 in (152 mm) if the lead is intended for field connection to an external circuit.

Exception: The lead may be less than 6-in (152-mm) long if it is evident that the use of a longer lead might result in a risk of fire or electric shock.

4.4.5.2.8 A lead to be connected to a power-supply conductor in the field shall not be smaller than 18 AWG (0.82 mm²) and the insulation shall be thermoplastic with a wall thickness of at least 1/32 in (0.8 mm) or the equivalent.

4.4.5.3 Wire-binding screws

4.4.5.3.1 The size of a screw shall be not less than:

- a) No. 10 if for use with conductors larger than 14 AWG (2.1 mm²);
- b) No. 8 if for use with 14 AWG (2.1 mm²) conductors; or
- c) No. 6 if for use with conductors smaller than 14 AWG (2.1 mm²).

4.4.5.3.2 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size indicated in Clause 4.4.5.3.1 under the head of the screw or washer.

4.4.5.3.3 Wire-binding screws shall thread into metal.

4.4.5.4 Terminal plates and threading

4.4.5.4.1 Terminal plates through which wire binding screws are threaded shall have a thickness at least equal to twice the pitch of the thread of the screw but not less than 0.030 in (0.78 mm), and shall have at least two complete clean-cut full threads.

4.4.5.4.2 Screws engaging threaded holes in plates shall have not fewer than two full threads engaging under any reasonably foreseeable condition of service.

4.4.5.5 Identification of terminals and leads

4.4.5.5.1 A permanently connected appliance rated 125 or 125/250 V – 3-wire – or less and employing a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent-protective device other than an 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 the one that is electrically connected to a screw shell of a lampholder and to which no switch or overcurrent protective device of the single-pole type other than an automatic control without a marked OFF position is connected.

4.4.5.5.2 A terminal intended for the connection of a grounded power supply conductor shall be of, or plated with, metal that is substantially white in color and shall be readily distinguishable from the other terminals, or identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for connection 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.

4.4.5.5.3 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

4.4.5.5.4 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G", "GR", "Ground", or the like, or by a marking on a wiring diagram provided on the appliance. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during normal servicing of the appliance.

4.5 Current-carrying parts

4.5.1 A current-carrying part shall be of silver, copper, a copper alloy, stainless steel or other similar metal acceptable for the application.

4.5.2 Ordinary iron or steel shall not be used as a current-carrying part.

Exception: Ordinary iron or steel provided with a corrosion-resistant coating may be used for a current-carrying part if acceptable in accordance with Clause 3.1.

4.6 Internal wiring and interconnecting cords

4.6.1 Mechanical protection

4.6.1.1 The wiring and connections between parts of an appliance shall be protected or enclosed. See Clause 4.6.1.3.

Exception: A length of flexible cord may be employed for external interconnections if flexibility is essential. See Clause 4.6.1.2.

4.6.1.2 Any exposed cord shall be of a type at least as serviceable as the power supply cord on the appliance unless located or protected so as to reduce the likelihood of mechanical damage.

4.6.1.3 For the purpose of these requirements, internal wiring of an appliance shall be considered to be all the interconnecting wiring beyond the point where the power-supply cord of a cord-connected appliance enters the enclosure, or beyond the wiring terminals or leads for power supply connection of a fixed appliance, even though some of the wiring may be flexible cord.

4.6.1.4 With reference to exposure of insulated wiring through an opening in the enclosure of an appliance, the protection of such wiring required by Clause 4.6.1.1 shall be considered to exist if, when determined as though it were film-coated wire, the wiring would comply with accessibility of live parts, Clause 4.1.4. Internal wiring not so protected shall be secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

4.6.1.5 If the wiring of an appliance is located so that it may be subjected to mechanical damage, it shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or otherwise protected.

4.6.1.6 Wires within an enclosure, compartment, raceway, or the like shall be disposed or protected so that no damage to insulation of a conductor can result from contact with any rough, sharp, or moving parts.

4.6.1.7 A flexible cord used for external interconnection as mentioned in the Exception to Clause 4.6.1.1, shall be provided with strain relief in accordance with Clause 4.4.3 unless the construction is such that the cord will be protected from stress or motion.

Exception: An external interconnecting cord located in a part of the enclosure that is capable of being opened or removed by the user without using a tool, such as a dust bag compartment, shall employ a strain-relief means that complies with the strain relief test, Clause 5.14, when subjected to a force of 20 lbs (89 N).

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

4.6.1.9 Internal wiring shall consist of conductors with a type of insulation rated for the particular application, when considered with respect to:

- a) temperature and voltage to which the wiring will be subjected;
- b) exposure to oil or grease; and
- c) other conditions of service to which it is liable to be subjected.

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4.6.1.10 Wiring routed between the handle and the base of an upright-type vacuum cleaner that can be subjected to flexing or movement during normal operation of the appliance shall comply with Clause 5.18, wire flexing.

4.6.2 Polarization of connectors

4.6.2.1 If a device required to be connected to a specific supply conductor (see Clauses 4.9.7, 4.11.3, and 4.12.8) is employed in an externally interconnected part, such as a motorized nozzle, the connections shall employ terminal fittings that can only mate such that the required connection to the proper supply conductor is maintained.

4.6.3 Splices and connections

4.6.3.1 Splices and connections shall be mechanically secure and shall provide adequate and reliable electrical contact. Soldered connections shall be made mechanically secure before being soldered, if breaking or loosening of the connections can result in a risk of fire, electric shock, or injury to persons. Splices shall be provided with insulation equivalent to that of the wires involved if permanency of spacing between splices and other metal parts will in some cases not be maintained.

4.6.3.2 In an appliance in which excessive vibration is likely to occur, the requirement in Clause 4.6.3.1 will necessitate the use of lock-washers or other means to prevent wire-binding screws and nuts from becoming loosened.

4.6.3.3 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice if the voltage involved is less than 250 V. In determining if splice insulation consisting of coated-fabric, thermoplastic or other type of tubing is acceptable, consideration shall be given to such factors as its dielectric properties, resistance to heat, resistance to moisture, and the like. Thermoplastic tape wrapped over a sharp edge shall not be used.

4.6.3.4 Where stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be positively prevented from contacting other uninsulated live parts that are not always of the same polarity as the wire and from contacting non-current carrying metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other reliable means.

4.6.3.5 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the point of connection.

4.6.3.6 With reference to Clause 4.6.3.5, if a wire-binding screw construction or a pressure wire connector is used as a terminating device, it shall be rated for use with aluminum under the conditions involved, for example, temperature, heat-cycling, and vibration.

4.6.4 Separation of circuits

4.6.4.1 Conductors of circuits operating at different potentials shall be reliably separated from each other unless they are each provided with insulation rated for the highest potential involved.

4.6.4.2 An insulated conductor shall be reliably retained so that it cannot contact an uninsulated live part of a circuit operating at a different potential.

4.6.4.3 In a compartment that is intended for the field installation of conductors, and that contains provision for connection of extra-low voltage circuit conductors, and Class 1, power, or lighting circuit conductors, a barrier shall be provided to separate the conductors of the different circuits, or the arrangement of the compartment shall be such that a minimum spacing of 1/4 in (6.4 mm) can be maintained between the conductors of the different circuits including the conductors to be field installed.

4.7 Electrical insulation

4.7.1 Current-carrying parts shall be supported on heat-resistant and moisture absorption-resistant insulating materials such as porcelain or phenolic composition.

4.7.2 Polymeric material employed to support a live part, in direct contact with a live part, or within 1/32 in (0.8 mm) from a live part shall be rated for use at the operating temperature involved and shall have the following material properties, all determined in accordance with the standard for polymeric material properties, see Annex A:

- a) volume resistivity of at least $50 \times 10^6 \Omega\text{-cm}$;
- b) comparative tracking index (CTI) of at least 100 V (PLC 4 – see note (a) of Table 4); and
- c) a high current arc ignition (HAI) and hot-wire ignition (HWI) as specified in Table 4.

Exception No. 1: In lieu of volume resistivity, compliance with the end-product leakage-current requirements (Clause 5.3) is acceptable. Leakage current measurement shall be taken from accessible surfaces of the polymeric material in question. If the polymeric part in question is not accessible, the leakage current shall be measured in accordance with Clauses 5.3.3 and 5.3.4.

Exception No. 2: A material with a HAI property less than that required in Table 4 may be used when the spacing over the surface of the material is at least 1/2 in (12.7 mm) between:

- a) live parts of opposite polarity;*
- b) live parts and grounded noncurrent-carrying metal; and*
- c) live parts and exposed noncurrent-carrying metal.*

Exception No. 3: A material that does not comply with the requirements specified in Table 4 for HAI shall be evaluated using the power (current, voltage, and power factor) of the circuit in the end product by conducting a short-circuit test in accordance with end-product arc resistance, Clause 5.25.

Exception No. 4: Materials that do not comply with the minimum HWI requirements specified in Table 4 shall comply with the abnormal overload test, Clause 5.26.

Exception No. 5: Foamed thermoplastic material employed for sound reduction that is in direct contact with an uninsulated live part or is within 1/32 in (0.8 mm) of an uninsulated live part shall be rated HF-1 and is not required to be evaluated for CTI, HWI, and HAI.

4.7.3 Thermoplastic parts employed to support live parts shall be subjected to the mold stress-relief distortion test, Clause 5.21.3. As a result of the test, required spacings shall be maintained and the live parts shall remain reliably secured in place.

4.7.4 Fiber shall not be used as the sole support for uninsulated current-carrying parts if shrinkage, moisture absorption, or warping can introduce current leakage or a risk of electric shock, fire, or injury to persons. Untreated fiber shall not be used in contact with live parts where moisture absorption can result in a leakage current greater than that specified in Clauses 5.3 and 5.4.

4.7.5 Small molded parts such as brush caps shall be constructed so as to have adequate mechanical strength and rigidity to withstand the most severe stresses that they are liable to be subjected to in service. As an alternative, such parts may have additional mechanical protection. (See Clause 5.19.4.)

4.8 Motors

4.8.1 General

4.8.1.1 Motors shall be of a type suitable for the particular application. They shall be capable of carrying the normal load (see Clause 5.2) without exceeding the permissible temperatures when the appliance is tested in accordance with the temperature test, Clause 5.8.

4.8.1.2 A motor winding shall resist the absorption of moisture.

4.8.1.3 With reference to the requirement in Clause 4.8.1.2, film-coated wire is not required to be additionally treated to reduce the likelihood of absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to reduce the likelihood of moisture absorption.

4.8.1.4 A polymeric material employed in a Class 105 (A) insulation system that isolates the windings from dead metal parts shall be unfilled or glass-reinforced nylon, polycarbonate, polybutylene terephthalate, polyethylene terephthalate, phenolic or acetal, and shall have a relative or generic thermal index for electrical properties of 105°C (221°F) minimum. Leads shall be rated 90°C (194°F) minimum. Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446. Motors employing thermoplastic materials shall be subjected to the tests in thermoplastic motor insulation systems, Clause 5.24.

Exception No. 1: Other polymeric materials used in a Class 105 (A) insulation system shall comply with the requirements for thermal aging in Clause 5.24.4.

Exception No. 2: Slot liners of polyethylene terephthalate that are 0.007-in (0.18-mm) thick minimum are not required to be subjected to the tests in Clause 5.24.

4.8.2 Brushes and brush holders in commutator motors

4.8.2.1 A brush cap shall be recessed, enclosed, or otherwise protected from mechanical damage that might occur during normal use of the appliance unless the part performs acceptably in the impact test described in Clause 5.19.4.

4.8.2.2 A brush cap that is accessible to the user without the removal of a guard or enclosure shall be provided with a positive means that will prevent its disengagement from the brush holder assembly. Screw threads only on the brush cap are not considered a positive means.

4.8.2.3 A brush holder assembly shall be so constructed that when a brush is no longer capable of performing its function, the brush, spring, and other parts of the assembly will be retained to the degree necessary to prevent accessible noncurrent-carrying metal parts from becoming energized and to prevent live parts from becoming accessible.

4.8.3 Overload protection

4.8.3.1 A motor shall be provided with overload protection when it is:

- a) automatically or remotely controlled;
- b) permanently connected and manually started;
- c) in an unattended appliance;
- d) in a cord-connected, portable, shop-type vacuum cleaner provided with a receptacle as specified in the Exception to Clause 4.12.1; or
- e) in a coin-operated appliance.

4.8.3.2 A product as mentioned in Clause 4.8.3.1 shall have motor-overload protection as specified in (a) or (b):

- a) thermal protection complying with the applicable requirements in the standard for thermal protectors, see Annex A; or

Exception No. 1: The locked-rotor temperature test on a manually reset device shall be continued for four operations (that is three resets, four trips) of the protective device.

Exception No. 2: 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, is not required to have running-overload protection.

Exception No. 3: A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1 A or smaller difference between no-load and locked-rotor current shall be considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

- b) impedance protection complying with the applicable requirements in the standard for impedance-protected motors, see Annex A, when the motor is tested as used in the product under stalled-rotor conditions.

4.8.3.3 For a multispeed motor of any of the types mentioned in Clause 4.8.3.1 that employs a separate overload protective device to provide running-overload protection, the requirements in Clause 4.8.3.2 apply at all speeds at which the motor is intended to operate.

4.8.3.4 The motor of an appliance with load characteristics likely to result in an overload or stalled condition that will not be evident to the user shall incorporate thermal or overload protection in accordance with the requirements in Clause 4.8.3.2.

4.8.3.5 A thermal or overload protective device shall not open the circuit during the temperature test, Clause 5.8.

4.8.3.6 The functioning of a motor-protective device provided as part of an appliance, whether such device is required or not, shall not result in a risk of fire, electric shock, or injury to persons.

4.8.3.7 Fuses employed for motor-running overload protection shall be located in each ungrounded conductor.

4.8.3.8 Devices other than those that are inherent in a motor employed for motor-running overload protection shall be located in each ungrounded conductor.

4.9 Switches, relays, and similar controls

4.9.1 Switches, relays, and similar controls shall be suitable for their particular application, and shall have current and voltage ratings not less than those of the circuits controlled.

4.9.2 With reference to the requirement in Clause 4.9.1, the ampacity of a switch that controls an inductive load other than a motor, such as a transformer or an electric discharge-lamp ballast, shall not be less than twice the rated full-load current of the inductive load unless the switch has been investigated and found to be acceptable for the application.

4.9.3 A switch or other control shall be guarded or located so that it is not likely to be damaged during use of the appliance. A through-cord switch shall not be employed unless:

- a) it cannot contact the floor during use of the appliance; or
- b) it has been investigated for such abuse as may occur during use.

4.9.4 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall have been investigated and found acceptable for use with tungsten-filament lamps, or shall have a direct-current rating at least ten times the maximum tungsten load that it controls or an alternating-current rating at least six times the maximum tungsten load that it controls.

4.9.5 A motor control switch shall be provided in a cord-connected appliance that employs a motor rated more than 1/3 hp (249 W output). The switch shall be in a readily accessible location.

4.9.6 A switch, relay, or similar control that controls a motor shall be subjected to the test in Clause 5.15.

4.9.7 A switch or an overcurrent-protective device of the single pole type shall be electrically connected to the ungrounded conductor of the supply circuit.

Exception No. 1: An automatic control without a marked OFF position need not be connected to the ungrounded conductor.

Exception No. 2: For an appliance with a main ON-OFF switch any subsequent switch that does not control the entire appliance need not be connected to the ungrounded conductor.

4.9.8 Flexible switch actuators

4.9.8.1 A switch or control that is actuated by a flexible thermoplastic material (such as used in a membrane-type switch) and that functions as a main ON-OFF switch, shall comply with Clause 5.15.3, in addition to complying with the other applicable switch requirements in Clause 4.9.

4.9.8.2 With respect to Clause 4.9.8.1, a membrane-type switch is considered to be a momentary switching device in which at least one contact is on, or made of, a flexible substrate.

4.10 Capacitors

4.10.1 A capacitor provided as part of a capacitor/motor combination, and a capacitor connected across-the-line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container so that mechanical damage to the plates is unlikely to occur and so that there will be no emission of flame or molten material resulting from breakdown or malfunction of the capacitor. The container shall be of metal providing strength not less than that of uncoated steel having a thickness of 0.020 in (0.51 mm).

Exception: The container of a capacitor may be made of sheet metal having a lesser thickness or may be of material other than metal, if the capacitor is mounted in an enclosure that houses other parts of the appliance, and if such box, case, or the like is acceptable for the enclosure of current-carrying parts as specified in Clause 4.1.1.

4.10.2 In an appliance that is intended to be automatically or remotely controlled, if a capacitor that is not a part of a capacitor/motor combination or a capacitor-start motor is connected so that capacitor breakdown or malfunction would result in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the appliance.

4.10.3 If an appliance employs a combination consisting of a rectifier and an electrolytic capacitor, no risk of fire, electric shock, or injury to persons shall result if either the rectifier or the capacitor is short-circuited.

4.10.4 If an appliance is intended to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit, such a capacitor or unit shall be supplied with the appliance. See Clause 10.3.4.

4.10.5 Under both normal and abnormal conditions of use, a capacitor employing a dielectric medium more combustible than askarel shall not result in risk of fire or electric shock, and shall be constructed to reduce the likelihood of expelling the dielectric medium.

4.10.6 A capacitor complying with the applicable requirements for protected oil-filled capacitors specified in the standard for capacitors (see Annex A) shall be considered to be constructed to reduce the likelihood of expelling the dielectric medium.

4.10.7 For a capacitor employing a liquid dielectric medium more combustible than askarel and provided with an expansion mechanism to reduce the likelihood of expelling the dielectric medium, the spacing from a terminal of the capacitor, including an assembled wire connector, to:

- a) an electrically isolated part or a part constructed of a nonconductive material shall be at least 1/2 in (12.7 mm); or
- b) an uninsulated live part of opposite polarity or an uninsulated noncurrent-carrying metal part that is either accessible or grounded shall not be less than the sum of the appropriate value from Table 5 and 1/2 in (12.7 mm).

4.11 Lampholders

4.11.1 Lampholders for extra-low-voltage lamps (that is, lamps rated at 30 V or less) shall not be tapped across parts of motor windings if the motor rating is more than 150 V.

4.11.2 Lampholders and lamps shall be adequately secured and protected from mechanical injury.

4.11.3 An Edison-base lampholder shall be wired so that the screw-shell will be electrically connected to the grounded conductor of the power-supply circuit.

4.12 Receptacles

4.12.1 A cord-connected, portable appliance shall not be provided with a general-use receptacle.

Exception: A cord-connected, portable, shop-type vacuum cleaner may be provided with a general-use receptacle that is specifically intended for connection of a portable tool that has provision for connection to a vacuum cleaner hose, if it complies with Clauses 4.12.2 – 4.12.8, and with the following:

- a) the vacuum cleaner shall have a provision for grounding in accordance with Clause 4.14;*
- b) the vacuum cleaner shall be provided with a minimum 3-position switch that controls the power to the receptacle, such that a tool plugged into the receptacle can only be energized with the switch in the auto position. The switch shall have marked on, off and auto positions. With the switch in the auto position, the vacuum cleaner shall not operate when the on/off switch of the tool is in the off position;*
- c) a polymeric material that encloses uninsulated live parts that are energized when the main switch is in the auto position and the tool is not operating shall comply with Clause 4.1.1.5 (c);*
- d) the vacuum cleaner shall be rated as specified in Clause 10.1.3, and the attachment plug cap shall be rated in accordance with Clause 4.4.1.4 for the load of the appliance including the maximum marked ampere rating of the receptacle;*
- e) the vacuum cleaner motor shall employ overload protection that complies with Clauses 4.8.3.2 – 4.8.3.8;*
- f) the vacuum cleaner shall be marked with the cautionary markings specified in Clause 10.4.18; and*

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g) the normal load for tests as described in Clause 5.2 shall also include a representative tool plugged into the receptacle and energized.

4.12.2 A general-use receptacle shall be of the grounding type.

4.12.3 If an appliance includes one or more attachment-plug receptacles intended for general use, and if the overcurrent protection of the branch circuit to which the appliance will properly be connected exceeds that acceptable for the receptacle or receptacles, each receptacle circuit shall have suitable overcurrent protection provided as a part of the appliance.

4.12.4 A fuseholder provided in accordance with Clause 4.12.3 shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable Type S adaptor.

4.12.5 The face of a general-use receptacle shall:

- a) be flush with or project beyond a nonconductive surrounding surface; or
- b) project at least 0.015 in (0.38 mm) beyond a conductive surrounding surface.

4.12.6 Ground-fault circuit protection (Class A) shall be provided for general-use receptacles that are part of an appliance intended to be used outdoors.

4.12.7 An attachment-plug receptacle of an appliance intended for wet pick-up shall be located so that it is unlikely to be wetted.

4.12.8 A general-use receptacle for use on a nominal 120 V circuit shall have the grounded supply conductor connected to the terminal that is substantially white in color or otherwise marked to indicate that it is intended for connection to the grounded supply conductor.

4.13 Spacings

4.13.1 Except as permitted in Clauses 4.13.5 and 4.13.6, spacings shall not be less than those specified in Table 5 or Table 6. If uninsulated live parts are not rigidly supported by means other than friction or if movable noncurrent-carrying metal parts are in proximity to uninsulated live parts, the construction shall be such that the minimum spacings specified will be maintained under all conditions.

4.13.2 Spacings at wiring terminals to which supply connections are made in the field shall comply with Table 5:

- a) between uninsulated live parts of opposite polarity;
- b) between uninsulated live parts and noncurrent-carrying metal parts; and
- c) between line voltage parts and extra low voltage parts.

4.13.3 At a terminal screw and stud to which connection may be made in the field by means of a wire connector, an eyelet, or the like, it is required that the spacings be not less than those specified in Table 5 when such connector, eyelet, or the like is in such position that minimum spacings – between opposite polarity and to noncurrent-carrying metal – exist.

4.13.4 Spacings shall comply with Table 6 at points other than as specified in Clause 4.13.2 or 4.13.3 that are:

- a) between uninsulated live parts of opposite polarity;
- b) between uninsulated live parts and noncurrent-carrying metal parts including the enclosure; and
- c) between line voltage parts and extra low voltage parts.

4.13.5 The spacings within motors, snap switches, lampholders, or other devices supplied as part of the equipment shall comply with the requirements of the standard for that component. See Clause 3.1.

Exception: The spacings within a motor complying with Table 6 need not comply with the component spacings requirements in the Standard for Motors and Generators, CSA C22.2 No. 100.

4.13.6 An insulating barrier or liner may be used to obtain the required spacings if it is:

- a) of adequate dielectric strength and resistance to moisture;
- b) not adversely affected by arcing and suitable for the temperatures encountered;
- c) of adequate mechanical strength and permanently retained in place by means other than adhesives, unless evaluated per Clause 4.1.3.1; and
- d) not less than 1/32-in (0.8-mm) thick if vulcanized fiber, except that it may be not less than 1/64-in (0.4-mm) thick if used in conjunction with a through-air spacing not less than one-half of that required.

4.13.7 Spacings are not specified for the following types of circuits:

- a) an extra low voltage circuit – see Clause 2;
- b) between traces on a printed wiring board in circuits that:
 - 1) are located on a part of a printed wiring board provided with conformal coating that complies with the requirements for such coatings (see Annex A); or
 - 2) are connected to the load side of a resistor such that a short circuit from that point to the other side of the supply does not result in the wattage rating of the resistor being exceeded.

4.13.8 All uninsulated live parts connected to different line- or extra low-voltage circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in Clause 4.13.2 and shall be judged on the basis of the highest voltage involved.

4.13.9 In applying Table 6 to an appliance incorporating two or more motors of different sizes, the spacings in the appliance are judged on the basis of the size of the largest motor in the appliance.

4.13.10 In applying Table 6 to a motor not rated in horsepower, use shall be made of the appropriate table of the Electrical Code (see Clause 1) that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor shall be used if the appliance is marked for use on alternating current only; otherwise, the table applying to direct-current motors shall be used.

4.13.11 Spacings to polymeric enclosures

4.13.11.1 The spacings between the polymeric enclosure and:

- a) a nonarcing uninsulated live part (a bus bar, a connecting strap, a terminal, or the like) shall be no less than 1/32 in (0.8 mm). If less than a 1/32 in (0.8 mm) spacing is provided, the enclosure material shall comply with the requirements for support of live parts described in Clause 4.7.2, unless an acceptable insulating barrier is employed; or
- b) an arcing part (at a commutator, unenclosed switch contacts, and the like) shall not be less than 1/2 in (12.7 mm) except as indicated in Clause 4.13.11.3.

4.13.11.2 The spacing mentioned in Clause 4.13.11.1(b) shall be measured from the source of the arc – that is, from the interface of the brush and the commutator or from the interface of the switch contacts, and the like.

4.13.11.3 The spacing mentioned in Clause 4.13.11.1(b) may be less than 1/2 in (12.7 mm) but not less than 1/32 in (0.8 mm) if the material has a minimum high-current arc ignition (HAI) as noted in Table 4. If the spacing is less than 1/32 in (0.8 mm), the material shall comply with all of the requirements for support of live parts described in Clause 4.7.2.

4.14 Grounding and bonding

4.14.1 An appliance of one or more of the following types shall have provision for grounding:

- a) an appliance intended to be used on a circuit operating at more than 150 V to ground – see Clause 4.14.2;
- b) a central vacuum cleaner;
- c) a commercial vacuum cleaner or blower cleaner;
- d) a household shop-type vacuum cleaner or blower cleaner;
- e) a wet pick-up vacuum cleaner;
- f) a household use floor finishing machine; or
- g) a cord-connected, portable, shop-type vacuum cleaner provided with a general-use receptacle for use with a portable tool as specified in the Exception to Clause 4.12.1.
- h) an electrified wall valve assembly (see Clause 8.2.6).

Exception: A cord-connected appliance, other than as described in (g), provided with a system of double insulation as specified in double insulation, Clause 6, is not required to have provision for grounding.

4.14.2 With reference to Clause 4.14.1, a 2-wire appliance intended to operate at a nominal potential of 240 V and any other potential greater than 150 V, shall be provided with means for grounding in accordance with Clauses 4.14.4 and 4.14.5 unless the marked rating on the appliance is 120/240 V or the appliance is otherwise marked to indicate that it is to be connected to a circuit operating at 150 V or less to ground.

4.14.3 If a grounding means is provided, whether required or not, it shall be in accordance with Clause 4.14.4 and if the appliance is cord connected it shall comply with the requirements in Clause 4.14.5. All exposed noncurrent-carrying metal parts and all noncurrent-carrying metal parts within the enclosure that are exposed to contact during any user servicing operation and are likely to become energized shall be reliably connected to the means for grounding. Hinged or pivoting joints are not considered acceptable for bonding unless they are provided with an additional conductive connection, such as a bonding jumper.

4.14.4 The following are considered acceptable means for grounding:

- a) in an appliance intended to be permanently connected by a metal-enclosed wiring system – a knockout or equivalent opening in the metal enclosure of the appliance. See Clause 4.4.5.1.1;
- b) in an appliance intended to be permanently connected by a nonmetal-enclosed wiring system, for example, nonmetallic sheathed cable – an equipment-grounding terminal or lead, see Clauses 4.4.5.2.2 and 4.4.5.2.4; and
- c) in a cord-connected appliance – an equipment-grounding conductor in the cord.

4.14.5 The grounding conductor of a flexible cord shall be green with or without one or more yellow stripes. The grounding conductor shall be secured to the frame or enclosure of the appliance by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by other equivalent means. A quick-connect terminal with a detent as a means for latching mating parts and a current-carrying capacity at least equivalent to that of the current-carrying conductors of the flexible cord is considered to be equivalent means. Solder alone shall not be used for securing the grounding conductor. The grounding conductor shall be connected to the fixed member of a grounding-type attachment plug, except that the grounding member of the plug on a portable hand-guided or supported appliance may be of the movable, self-restoring type. Servicing as mentioned in this Clause includes repair of the appliance by a qualified service person.

4.14.6 A separable connecting device provided with a grounding connection shall be such that the equipment-grounding connection is made before connection to and broken after disconnection from the supply circuit.

Exception: Interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made.

4.14.7 If an appliance is intended to be grounded and is provided with means for separate connection to more than one power supply, each such connection shall be provided with a means for grounding.

4.14.8 An appliance marked as being provided with double insulation shall not be provided with a means for grounding.

4.14.9 A double-insulated motorized nozzle may be employed with a vacuum cleaner having a means for grounding provided the nozzle is marked in accordance with item 8 of Table 17.

4.15 Protective devices

4.15.1 The screw shell of a plug type fuseholder and the cap end of an extractor post type fuseholder shall be connected toward the load.

4.15.2 A protective device, such as a fuse, the normal function of which requires renewal or replacement, shall be in a readily accessible location, other than as noted in Clause 4.15.4.

4.15.3 A protective device shall be wholly inaccessible from outside the appliance without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the appliance enclosure.

4.15.4 The protective device mentioned in Clause 4.15.2 need not be in a readily accessible location if:

- a) the appliance, with the protective device shunted out of the circuit, would comply with all applicable requirements in this standard; and
- b) the presence of the protective device would ordinarily be unknown to the user of the appliance because of its location and the omission of reference to the device in the operating instructions, circuit diagram, and the like for the appliance.

4.16 Protection against injury to persons

4.16.1 General

4.16.1.1 If the operation and maintenance of an appliance by the user involves a risk of injury to persons, protection shall be provided to reduce the risk.

4.16.1.2 When judging an appliance with respect to the requirement in Clause 4.16.1.1, consideration shall be given to reasonably foreseeable misuse of the appliance.

4.16.1.3 The adequacy of a guard, a release, an interlock, and the like, and whether such a device is required, shall be determined from an investigation of the complete appliance, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any one component, but not more than one component at a time, unless one event contributes to another. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component shall be investigated for reliability.

4.16.1.4 Specific constructions, tests, markings, guards, and the like are detailed for some common designs. Specific features and appliances not covered shall be given appropriate consideration. See marking, Clause 10.

4.16.2 Sharp edges

4.16.2.1 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons during normal maintenance and use.

4.16.3 Enclosures and guards

4.16.3.1 The rotor of a motor, a pulley, a belt, a gear, a fan, or other moving part that could cause injury to persons shall be enclosed or provided with other means to reduce the likelihood of unintentional contact. An opening in an enclosure or guard shall comply with either (a) or (b).

- a) For an opening that has a minor dimension less than 1.375 in (34.9 mm), such a moving part shall not be contacted by the probe illustrated in Figure 2. See Clause 4.1.4.5 and Annex C.
- b) For an opening that has a minor dimension of 1.375 in (34.9 mm) or more, such a moving part shall not be contacted by the probe illustrated in Figures 25 and 26. See Clause 4.1.4.5 and Annex C.

Exception No. 1: A moving part or portion of a moving part that is necessarily exposed to perform the work function need not be enclosed but, when necessary, guarding shall be provided.

Exception No. 2: An opening in the integral enclosure of a motor employed in an appliance intended for commercial use, that is not used in either a hand-held appliance or a hand-supported portion of an appliance, is acceptable if a moving part cannot be contacted by the probe illustrated in Figure 4.

4.16.3.2 During the examination of an appliance to determine whether it complies with the requirements in Clause 4.16.3.1, a part of the enclosure that can be removed without the use of a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

Exception: A part need not be opened or removed if it is marked in accordance with Clause 10.4.13.

4.16.3.3 During the examination of a central vacuum cleaner or a dust extraction system to determine whether the appliance complies with the requirements in Clause 4.16.3.1, all the attachments and fittings recommended in the installation manual shall be installed as intended. For a central vacuum marked in accordance with Clause 10.3.12, the exhaust piping shall also be in place during this examination.

4.16.3.4 With respect to both intended operation of the appliance and reasonably foreseeable misuse, a moving part that may involve a risk of injury to persons shall be considered with respect to:

- a) the degree of exposure necessary to perform the intended function;
- b) the sharpness of the moving part;
- c) the likelihood of unintentional contact;
- d) the speed of the moving part; and

e) the likelihood that a part of the body would be endangered or clothing would become entangled by the moving part.

4.16.3.5 An enclosure or guard over a moving part shall retain:

a) a part that, because of breakage or other reasons, can become loose or can separate from the moving part; and

b) a foreign object that can be struck and propelled by the part.

4.16.4 Surface temperatures

4.16.4.1 During the temperature test, Clause 5.8, the temperature of a surface that can be contacted by the user shall not be more than the value specified in Table 7. If the test is conducted at a room temperature of other than 25°C (77°F), the results shall be corrected to that temperature.

4.16.5 Stability

4.16.5.1 A portable appliance of the water-containing type or the wet pick-up type shall be tested as described in stability, Clause 5.13, and shall not overturn.

Exception: An upright-type appliance that is hand guided while in use is not required to be tested. An upright-type appliance provided with facilities for non-hand guided operation, such as a hose, shall be tested with the appliance arranged for such non-hand guided operation.

4.16.6 Strength of handles

4.16.6.1 A handle used to carry an appliance shall withstand a force of four times the empty weight of the appliance without damage to the handle, its securing means or that portion of the enclosure to which the handle is attached. See strength of handles, Clause 5.20.

4.16.7 Interlocks, switches, and controls

4.16.7.1 An appliance shall be constructed so as to reduce the likelihood of unexpected operation of any parts capable of causing injury to persons.

4.16.7.2 Each function of a multiple-function appliance shall be taken into consideration in determining whether the appliance complies with the requirement in Clause 4.16.7.1.

4.16.7.3 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.

4.16.7.4 With reference to Clause 4.16.7.3, a switch shall be considered to be located or guarded so that unintentional operation is unlikely if it is:

a) mounted in an upright vacuum cleaner or motorized nozzle (including the hose or wand) and the switch is not actuated when the appliance is placed on both flat carpeted and noncarpeted surfaces in any position in which the rotating brush is accessible for maintenance. During this examination, the appliance may be moved around on, but is not to be lifted from, the surface. The carpeting shall be as described in Clause 5.2.1.2; or

b) located on a canister vacuum cleaner that controls the motorized nozzle.

4.16.7.5 The actuator of a switch may be guarded by recessing, ribs, barriers, or the like.

4.16.7.6 Automatic-reset types of protective devices shall not be used in appliances if the automatic restarting of the appliance could result in any risk of fire, electric shock, or injury to persons.

4.16.7.7 The requirement in Clause 4.16.7.6 necessitates the use of an interlock in an appliance if moving parts or the like are likely to present a risk of injury to persons upon automatic starting of the appliance.

4.16.7.8 The actuator of an interlock shall be located so that unintentional operation is unlikely.

4.16.7.9 Operation of an interlock during use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

4.16.7.10 An interlock shall not be likely to be defeated by materials that could accumulate during use of the appliance.

4.16.7.11 An interlock shall be such that it can only be defeated by:

- a) damaging the appliance;
- b) making wiring connections or alterations; or
- c) using materials that are not readily available.

4.16.7.12 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirement in Clause 4.16.7.8.

4.16.8 Blower Cleaner Impellers

4.16.8.1 The impeller of a blower cleaner shall have the necessary strength and rigidity to resist the abuses likely to be encountered during normal service.

4.16.8.2 The blower cleaner shall be tested as described in blower cleaner impeller tests, Clause 5.27, without parts of the impeller being ejected from the blower, without cracks or other damage to the impeller that are visible to the naked eye upon inspection, and without the occurrence of any other condition that would increase the risk of injury to persons resulting from operation of the blower.

4.16.8.3 The visual inspection described in Clause 4.16.8.2 indicates a visual inspection conducted without using a device to magnify the area in question, by a person with normal vision (1x vision) or corrected to normal vision.

5 Tests

5.1 General

5.1.1 The appliance shall be subjected to the applicable tests for the type of appliance and its application.

5.1.2 Unless otherwise specified, the test voltage shall be as specified in Table 8 and maintained at that voltage throughout the test.

5.1.3 An appliance rated ac/dc or dc-60 Hz shall be tested on direct current or 60 Hz alternating current, whichever results in the most unfavorable operating conditions for the particular test.

5.2 Normal loads

5.2.1 General

5.2.1.1 Normal load shall be considered to be that load which approximates as closely as possible the most severe conditions of normal use but is not a deliberate overload. A multifunction appliance shall be tested individually for each applicable normal load.

5.2.1.2 The carpet employed for tests shall be level-looped, woven-through-the-back type, having a 216 pitch, eight wires per 1 in (25.4 mm), 1/4-in (6.4-mm) high three-ply wool yarn fiber pile. The carpet shall have a finished weight of 74.7 oz/yd² (253 g/m²), consisting of a face weighing 43.9 oz/yd² (149 g/m²), and backed by a synthetic and jute material weighing 15.4 oz/yd² (52 g/m²). A carpet that provides equivalent performance characteristics for the test being conducted may be used in place of this test carpet. The carpet shall be installed over 60–68 oz/yd² (2.0 – 2.3 kg/m²) sponge rubber padding.

5.2.1.3 For the tests, the appliance shall be operated continuously with a clean dust bag or filter, if provided, in place. For each condition, the appliance shall be operated until constant temperatures are attained.

5.2.2 Portable vacuum cleaners

5.2.2.1 The vacuum cleaner shall be operated with the air intake closed off sufficiently to maintain a mean wattage input to the appliance. For upright type vacuum cleaners provided with an integral port for connection of above floor cleaning tools, this attachment port shall be used for this test condition. See Clause 5.2.2.2.

5.2.2.2 Mean wattage input is the mathematical average of the wattage input noted with the air intake wide open and with the air intake completely blocked. All inputs shall be noted on a thoroughly heated appliance with any detachable hose removed. The wattage input for the intake sealed condition shall be noted 15 – 20 s after the intake has been completely closed off. The method of closing shall not impose a mechanical load on the movement of a brush, if provided. If an appliance employs a mechanical valve that operates under the blocked inlet condition, the valve shall be prevented from functioning.

5.2.2.3 A vacuum cleaner intended for use with a motorized nozzle shall be additionally operated while connected to a motorized nozzle that is operated as described in Clause 5.2.4.1.

5.2.2.4 A vacuum cleaner employing a motor driven brush (or similar device) shall be additionally operated on the test carpet described in Clause 5.2.1.2. During operation, the product shall be moved forward and backward on the carpet simulating normal use. If a carpet height adjustment is provided, it shall be adjusted in accordance with the instructions provided with the product to the lowest position for the test carpet.

5.2.2.5 A vacuum cleaner that has provision to be operated as a blower shall be additionally operated as specified in Clause 5.2.5.

5.2.2.6 A dust collector shall be operated with the air intake completely opened. When the product employs a flow-thru type motor, where ventilating air is dependent on the working air flow, the product shall be additionally tested in accordance with Clause 5.2.2.1.

5.2.3 Central vacuum cleaners

5.2.3.1 A central vacuum cleaner shall be mounted in the intended manner in a 3/8-in (9.5-mm) thick, black-painted plywood corner alcove consisting of a floor, a 90° wall angle formed by two vertical plywood sheets, and an 8-ft (2.44-m) high ceiling with all surfaces of the alcove extending not less than 2 ft (0.61 m) beyond the physical limits of the appliance. The appliance shall be located as close to the walls and to the floor or ceiling as its construction will allow unless marked in accordance with Clauses 10.3.10, 10.3.11 or 10.3.12, as applicable. Other than as noted in Clause 5.2.3.2, the exhaust opening shall be pointed in the direction that results in maximum temperatures on the appliance. The inlet of the central vacuum cleaner shall be piped 9 ± 3 in (22.9 ± 7.6 cm) beyond the alcove. The appliance shall be operated with the air intake blocked off sufficiently to maintain a mean wattage input to the appliance. See Clause 5.2.2.2.

5.2.3.2 If a central vacuum cleaner is provided with a means for connecting an outdoor exhaust and is marked in accordance with Clause 10.3.12, the exhaust piping shall be in place during the test described in Clause 5.2.3.1.

5.2.4 Motorized nozzles

5.2.4.1 A motorized nozzle, with a vacuum cleaner attached, shall be operated continuously until constant temperatures are reached. While operating, the nozzle shall be moved forward and backward, simulating normal use over a carpet as described in Clause 5.2.1.2. If the motorized nozzle has a carpet-height adjustment, it shall be adjusted in accordance with the manufacturer's instructions to the lowest position for the test carpet.

5.2.5 Blower cleaners

5.2.5.1 A blower cleaner and a vacuum cleaner that has provision to also operate as a blower shall be operated with the air intake and exhaust completely open and without a hose, fitting, or blower tube connected, unless such hose, fitting, or tube is required to activate the blower operation. For an appliance, where the cooling air is dependent on the working air flow, the appliance shall be additionally operated with the tube or accessory attached to result in the maximum air restriction. Operation shall continue until constant temperatures are attained for each condition.

5.2.5.2 A blower cleaner provided with a connector base (motor-attachment plug cap) or a power-supply cord 18-in (457-mm) long or less shall be connected to the source of supply using a 25-ft (7.62-m) long cord set. The cord set shall be the minimum gauge size for use with the product's rating.

5.2.6 Household floor finishing machines

5.2.6.1 Each household floor finishing machine shall be tested on a previously polished composition-tile surface in the operation for which it is intended that produces maximum intended load for 1 h of continuous operation, or until constant temperatures are attained, whichever is less.

5.3 Leakage current

5.3.1 The leakage current of a single-phase cord-connected appliance when tested in accordance with Clauses 5.3.3 – 5.3.6 shall not be more than:

- a) 0.5 MIU for an ungrounded, 2-wire, portable appliance;
- b) 0.5 MIU for a grounded, 3-wire, portable appliance;
- c) 0.75 MIU for a grounded, 3-wire, stationary appliance employing a standard attachment plug rated 20 A or less; or
- d) that specified in Clause 6.12 for an appliance marked to indicate that it employs double insulation. See Clause 10.3.8.

5.3.2 Leakage current refers to all currents, including capacitively coupled currents, that can be conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces of an appliance.

5.3.3 All exposed conductive surfaces shall be tested for leakage currents. The leakage currents from these surfaces shall be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible and from one surface to another where simultaneously accessible. Parts shall be considered to be exposed surfaces unless guarded by an enclosure considered acceptable to reduce a risk of electric shock. Surfaces shall be considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at extra low voltages that are not considered to involve a risk of electric shock.

5.3.4 If a surface other than metal is used for the enclosure or part of the enclosure, the leakage current shall be measured using a metal foil with an area of 3.9 by 7.8 in (10 by 20 cm) in contact with the surface. Where the surface is less than 3.9 by 7.8 in (10 by 20 cm), the metal foil shall be the same size as the surface. The metal foil shall not remain in place long enough to affect the temperature of the appliance.

5.3.5 The measurement instrument shall be as described in the Standard for Leakage Current for Appliances, UL 101, and if applicable, shall be set to reaction mode. The measurement circuit shall be as illustrated in Figure 6.

5.3.6 The sample shall be at room temperature at the start of the test. It shall be energized and operated under conditions of normal load described in Clause 5.2 until thermal stabilization is obtained. Before, during and after this operation, the leakage current shall be monitored. Appliances with controls for speed, temperature, and the like shall be tested with such controls in all of their various operating positions. For the test, the leakage current shall be noted using both positions of switch S2 and with switch S1 both open and closed.

5.3.7 The grounding conductor of cord-connected equipment shall not be connected to ground except through the test meter.

5.3.8 For an appliance employing discharge-path resistors as described in Clause 4.1.4.7, the resistors shall be shorted one at a time during the test.

5.4 Leakage current following humidity conditioning

5.4.1 A cord connected appliance shall comply with the requirements for leakage current, Clause 5.3, following conditioning for 48 h in moist air having a relative humidity of $88 \pm 2\%$ at a room temperature of $32.0 \pm 2.0^\circ\text{C}$ ($89.6 \pm 3.6^\circ\text{F}$):

- a) the appliance shall be at a temperature just above the test chamber temperature when it is placed in the humidity chamber;
- b) the appliance shall remain in the humidity chamber for 48 h;
- c) following this exposure, while still in the test chamber, the sample shall be tested unenergized (that is, switch S1, open);
- d) the sample shall then be tested energized, except that the test may be discontinued when the leakage current has stabilized or decreased.

5.4.2 This test may be conducted in the humidity chamber or immediately after the sample has been removed from the humidity chamber.

5.4.3 For an appliance employing discharge-path resistors as described in Clause 4.1.4.7, the resistors shall be shorted one at a time during the test.

5.5 Leakage current – abnormal operating conditions

5.5.1 During and after operation as described in Clauses 5.5.2 – 5.5.4, the leakage current of a portable, cord connected, vacuum cleaner or motorized nozzle shall not exceed 5.0 MIU.

5.5.2 For each applicable operating condition in Clauses 5.5.3 and 5.5.4, each sample of the appliance shall be tested for leakage current starting with the as-received condition. Following this, each sample shall be subjected to each applicable operating condition as described in Clauses 5.5.3 and 5.5.4 while being monitored continuously for leakage current. The power to the appliance shall be controlled by a remote switching device. The leakage current shall be evaluated using the method described in Clauses 5.3.3 – 5.3.7.

5.5.3 Three samples of an appliance shall be subjected to the applicable operating condition in (a) or (b):

- a) for an appliance having a rotating agitator, operation for 30 s with the agitator locked in place; or
- b) for an appliance having a dirty-air-fan system, operation for 30 s with the dirty-air-fan locked in place.