



UL 73

STANDARD FOR SAFETY

Motor-Operated Appliances

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UL Standard for Safety for Motor-Operated Appliances, UL 73

Tenth Edition, Dated March 2, 2011

Summary of Topics

This revision of ANSI/UL 73 dated December 14, 2022 includes clarification on the temperature limit of the capacitor; [Table 46.1](#).

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated November 11, 2022.

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The Department of Defense (DoD) has adopted UL 73 on May 11, 1976. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover motor-operated appliances to be employed in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover small utilization appliances, such as vibrators in which motion of an operating part is produced by electrical means.

1.3 These requirements do not cover appliances rated more than 600 V; nor do they cover appliances involving universal motors rated more than 250 V.

1.4 These requirements do not cover equipment intended particularly for the control of electric motors; separator motors; nor electric clocks, fans, clothes dryers, washing machines, hair dryers, tools, waste disposers, dishwashers, office appliances and business equipment, refrigerators, air conditioners, vending and amusement machines, hair clippers and shavers, snow movers, automotive and garage equipment, or other motor-operated appliances that are covered by individual requirements.

1.5 An appliance that utilizes some other source of energy, such as gas or steam, in addition to electric energy will be investigated under these requirements and under such additional requirements as are applicable to the appliance under consideration.

1.6 Manually operated die-cutting machines without electrical parts need only comply with the following applicable requirements. Industrial machines of this type are not addressed by these requirements.

- a) Protection Against Injury to Persons – Sections [32](#) – [36](#) and [41](#);
- b) Performance – Section [58](#);
- c) Markings – [70.1](#) (excluding electrical rating); and
- d) Instruction Manual – Section [71](#).

1.7 *Deleted*

2 Glossary

2.1 For the purpose of this standard the following definitions apply.

2.2 **APPLIANCE COUPLER** – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug).

2.3 **APPLIANCE INLET (MOTOR ATTACHMENT PLUG)** – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector.

2.4 **APPLIANCE (FLATIRON) PLUG** – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

2.5 **AUTOMATIC SOLAR PANEL CLEANING SYSTEM** – a household or commercial, outdoor use cleaning system primarily comprised of an irrigation controller, motor-operated water pump, electrically operated zone valves, and water nozzles. The system is intended to be hose-connected to a water supply rated less than 100 psig, and the water nozzles and associated zone valves are intended for rooftop or

ground installation near the solar panels. No other electrical equipment of the system is intended for roof mounting.

2.6 AUTOMATICALLY CONTROLLED APPLIANCE – 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.

2.7 COMPONENT – A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to the purpose. When incorporated in an appliance, equipment otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

2.8 COUNTER-SUPPORTED APPLIANCE – An appliance that is physically supported by a counter, table or bench during the performance of its intended function.

2.9 CORD CONNECTOR – A female contact device wired on flexible cord for use as an extension from an outlet to make a detachable electrical connection to an attachment plug or, as an appliance coupler, to an equipment inlet.

2.10 CONTROL, AUTOMATIC ACTION – A control in which at least one aspect is non-manual.

2.11 CONTROL, AUXILIARY – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency control not relied upon to reduce the risk of electric shock, fire, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

2.12 CONTROL, MANUAL – A device that requires direct human interaction to activate or rest the control.

2.13 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a thermal cutout/limiter or another layer of protection would reduce the risk of electric shock, fire, or injury to persons, is considered an operating control.

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

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

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

2.17 FIXED APPLIANCE – Any equipment or appliance that is provided with a facility to be fastened or otherwise secured in a specific location.

2.18 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 V and having circuit characteristics in excess of those of a low-voltage circuit.

2.19 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 V 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 a low voltage circuit.

2.20 PORTABLE APPLIANCE – An appliance that is easily carried or moved from one place to another in normal use.

2.21 RECESSED ULTRASONIC CLEANER – An ultrasonic cleaner that is intended to be installed with the top portion of the appliance above a countertop, and with the bottom and all sides of the enclosure located beneath the countertop. The appliance controls (such as on/off switches) and top cover (safety door) are located above the countertop.

2.22 REMOTELY CONTROLLED APPLIANCE – An appliance that is out of sight of the operator who is at the starting device.

2.23 STATIONARY APPLIANCE – An appliance that is not easily moved from one place to another in normal use or is located in a dedicated space, but is not fastened in place.

3 Units of Measurement

3.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

4 References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

5 General

5.1 An appliance shall employ materials that are acceptable for the application.

6 Components

6.1 General

6.1.1 A component of a product covered by this standard shall:

- a) Comply with the requirements for that component as indicated in [6.2](#) – [6.26](#);
- b) Be used in accordance with its rating(s) established for the intended conditions of use;
- c) Be used within its established use limitations or conditions of acceptability;
- d) Additionally comply with the applicable requirements of this end product standard; and
- e) Not contain mercury, unless used within a fluorescent, high intensity discharge, or neon lamp bulb.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product,*
- b) Is superseded by a requirement in this end product standard, or*
- c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.*

Exception No. 2: A component that complies with a UL component standard other than those specified in [6.2](#) – [6.26](#) is acceptable if the:

- a) Component also complies with the applicable component standard of [6.2](#) – [6.26](#); or*
- b) UL component standard:*
 - 1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, NFPA 70, where applicable;*
 - 2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, and*
 - 3) Any use limitations of the other component standard are identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.*

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

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

6.1.3 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in [6.2](#) – [6.26](#), and that involves a risk of electric shock, fire, or

personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with items (b) – (e) of [6.1.1](#).

6.1.4 With regard to [6.1.3](#), reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of the requirements of this end product standard.

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

6.2 Attachment plugs, receptacles, connectors, and terminals

6.2.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See [6.2.9](#).

Exception No. 1: Attachment plugs and appliance couplers integral to cord sets or power supply cords are investigated in accordance with the requirements of the Standard for Cord Sets and Power-Supply Cords, UL 817 and need not comply with the Standard for Attachment Plugs and Receptacles, UL 498.

Exception No. 2: A fabricated pin terminal assembly(ies) need not comply with the Standard for Attachment Plugs and Receptacles, UL 498 if it complies with Mechanical Assembly, Section [9](#); Accessibility, Section [11](#); Current-Carrying Parts, Section [13](#); Electrical Insulation, Section [14](#); Spacings, Section [28](#) of this end-product standard; and the applicable performance requirements when tested in the end-product.

6.2.2 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception No. 1: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception No. 2: A connector that complies with the Standard for Electrical Quick-Connect Terminals, UL 310 may be used with an appropriately sized tab that complies with Section [16](#). The connector is the part of a quick-connect terminal that is pushed onto the male tab, and the tab is the part that receives the female connector.

6.2.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977. See [6.2.9](#).

6.2.4 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

6.2.5 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

6.2.6 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459. See [6.2.9](#).

6.2.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

6.2.8 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

Exception: A fabricated part performing the function of a terminal block need not comply with the Standard for Terminal Blocks, UL 1059 if the part complies with the requirements of Wiring Terminals and Leads, [12.3.3](#); Current-Carrying Parts, Section [13](#); Electrical Insulation, Section [14](#); and Spacings, Section [28](#) of this end-product standard; and the applicable performance requirements when tested in the end-product. This exception does not apply to protective conductor terminal blocks.

6.2.9 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, an appliance coupler that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

6.3 Batteries and battery chargers

6.3.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in the Standard for Lithium Batteries, UL 1642.

6.3.2 Rechargeable nickel cadmium (Ni-Cad) cells and battery packs shall comply with the applicable construction and performance requirements of this end product standard.

6.3.3 Rechargeable nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the applicable construction and performance requirements of this end product standard, or the applicable requirements for secondary cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

6.3.4 Primary batteries (non-rechargeable) that comply with the relevant UL standard and [6.1.3](#) are considered to fulfill the requirements of this Standard.

6.3.5 A Class 2 battery charger shall comply with one of the following:

- a) The Standard for Class 2 Power Units, UL 1310; or
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

6.3.6 A non-Class 2 battery charger shall comply with one of the following:

- a) The Standard for Power Units Other Than Class 2, UL 1012; or
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

6.3.7 To reduce the risk of injury due to battery ingestion, an appliance covered by this Standard, or any accessory of the appliance, intended for use with one or more single cell batteries, shall comply with [6.3.8](#) if the batteries are:

- a) Single cell batteries of lithium technologies;

- b) Diameter of 1.25 inch (32 mm) or less; and
- c) Height that is less than its diameter.

6.3.8 An appliance provided with one or more batteries as specified in [6.3.7](#) shall comply with the Standard for Products Incorporating Button or Coin Cell Batteries of Lithium Technologies, UL 4200A or shall be intended for Industrial use only and provided with a marking to indicate "Industrial Use Only".

6.4 Boxes and raceways

6.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of the National Electrical Code, NFPA 70 and that comply with the relevant UL standard (such as the Standard for Metallic Outlet Boxes, UL 514A, the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C, the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D, and [6.1](#) are considered to comply with the requirements of this end product standard.

6.5 Capacitors and filters

6.5.1 The component requirements for a capacitor are not specified. A capacitor complying with the Standard for Capacitors, UL 810, is considered to fulfill the requirements of [18.1](#).

6.5.2 Electromagnetic interference filters with integral enclosures that comply with one of the following standards are considered to comply with the requirements in [18.1](#):

- a) The Standard for Electromagnetic Interference Filters, UL 1283; or
- b) The Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

6.6 Controls

6.6.1 General

6.6.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and the requirements in Controls – End Product Test Parameters, Section [27](#), unless otherwise specified in this end product standard; see [6.6.1.4](#).

Exception: Auxiliary controls evaluated to the requirements in Supplement [SA](#).

6.6.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in [6.6.2](#) – [6.6.7](#) and the parameters in Section [27](#), unless otherwise specified in this end product standard; see [6.6.1.4](#).

Exception: Operating controls evaluated to the requirements in Supplement [SA](#).

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

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

6.6.1.3 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in [6.6.2](#) – [6.6.7](#), and if applicable, the parameters in Section [27](#), unless otherwise specified in this end product standard.

Exception: Protective controls evaluated to the requirements in Supplement [SA](#).

6.6.1.3.1 Solid-state protective controls that do not rely upon software as a protective component shall comply with:

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except Controls Using Software.

Exception: Solid-state protective controls evaluated to the requirements in Supplement [SA](#).

6.6.1.3.2 Solid-state protective controls that rely upon software as a protective component shall comply with:

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and the Standard for Software in Programmable Components, UL 1998; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

Exception: Solid-state protective controls evaluated to the requirements in Supplement [SA](#).

6.6.1.4 An electronic auxiliary or operating control (e.g. a non-protective control), the failure of which would not increase the risk of electric shock, fire, or personal injury, need only be subjected to the applicable requirements of this end product standard or the requirements in Supplement [SA](#).

6.6.2 Electromechanical and electronic controls

6.6.2.1 A control, other than as specified in [6.6.3](#) – [6.6.7](#), shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or
- d) The circuit requirements in Supplement [SA](#).

6.6.3 Liquid level controls

6.6.3.1 A liquid level control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2;

d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls, UL 60730-2-15; or

e) The circuit requirements in Supplement [SA](#).

6.6.3.2 A switch employed as part of a water level detection mechanism is to comply with one of the switch standards specified in [6.23](#).

6.6.4 Motor and speed controls

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

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2;

d) The Standard for Power Conversion Equipment, UL 508C;

e) Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1;

f) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, or

g) The circuit requirements in Supplement [SA](#).

6.6.5 Pressure controls

6.6.5.1 A pressure control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2;

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls – Part 2-6: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6, or

d) The circuit requirements in Supplement [SA](#).

6.6.6 Temperature controls

6.6.6.1 A temperature control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2;
- d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9, or
- e) The circuit requirements in Supplement [SA](#).

6.6.6.2 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with:

- a) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9, with Annex J; or
- b) The Standard for Thermistor-Type Devices, UL 1434.

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

6.6.7 Timer controls

6.6.7.1 A timer control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7; or
- c) The circuit requirements in Supplement [SA](#).

6.7 Cords, cables, and internal wiring

6.7.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

6.7.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to fulfill this requirement when preassembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

6.7.3 Internal wiring composed of insulated conductors shall comply with the Standard for Appliance Wiring Material, UL 758.

Exception No. 1: Insulated conductors need not comply with the Standard for Appliance Wiring Material, UL 758 if they comply with one of the following:

- a) *The Standard for Thermoset-Insulated Wires and Cables, UL 44;*
- b) *The Standard for Thermoplastic-Insulated Wires and Cables, UL 83;*
- c) *The Standard for Fixture Wire, UL 66; or*
- d) *The applicable UL standard(s) for other insulated conductor types specified in Chapter 3 (Wiring Methods and Materials) of the National Electrical Code, NFPA 70.*

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

6.8 Cord reels

6.8.1 A cord reel shall comply with "special use cord reel" requirements of the Standard for Cord Reels, UL 355.

6.9 Film-coated wire (magnet wire)

6.9.1 The component requirements for film coated wire and Class 105 (A) insulation systems are not specified.

6.9.2 Film coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

6.10 Gaskets and seals

6.10.1 Gaskets and seals that comply with the Standard for Gaskets and Seals, UL 157, are considered to fulfill the requirements of [10.2](#) and [50.2.2](#).

6.11 Ground-fault, arc-fault, and leakage current detectors/interrupters

6.11.1 Ground-fault circuit-interrupters (GFCI) for protection against electrical shock shall comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943. The following statement, or equivalent, shall be included as a marking near the GFCI, or as an instruction in the manual: "Press the TEST button (then RESET button) every month to assure proper operation."

6.11.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B. An ALCI is not considered an acceptable substitute for a GFCI when a GFCI is required by the National Electrical Code, NFPA 70.

6.11.3 Equipment ground-fault protective devices shall comply with the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053, and applicable requirements of the Standard for Ground-Fault Circuit-Interrupters, UL 943.

6.11.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Section [24](#).

6.11.5 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Section [24](#).

6.12 Heaters and heating elements

6.12.1 Electric resistance heating elements shall comply with the construction requirements of:

- a) The Standard for Electric Heating Appliances, UL 499; or
- b) The Standard for Sheathed Heating Elements, UL 1030.

Exception: Heating wire (e.g. rope heater) that complies with the Standard for Appliance Wiring Material, UL 758, and the requirements of this end product standard are considered to fulfill this requirement.

6.12.2 Thermistor-type heaters (e.g. PTC and NTC heaters) shall comply with the Standard for Thermistor-Type Devices, UL 1434.

6.13 Insulation systems

6.13.1 Materials used in a Class 105 (A) insulation system shall comply with [22.3](#).

6.13.2 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.

6.13.3 All insulation systems employing integral ground insulation shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

6.14 Light sources and associated components

6.14.1 Lampholders and indicating lamps with integral lamp/lampholder (e.g. neon pilot lamp) shall comply with the Standard for Lampholders, UL 496.

Exception: Lampholders forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

6.14.2 Lighting ballasts shall comply with:

- a) The Standard for Fluorescent-Lamp Ballasts, UL 935, or
- b) The Standard for High-Intensity Discharge Lamp Ballasts, UL 1029.

Exception No. 1: Ballasts forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

Exception No. 2: Ballasts for other light sources shall comply with the applicable UL standard(s).

6.14.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

Exception No. 2: Individual LED light sources mounted on printed wiring boards and intended for indicating purposes need not comply with Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750, but shall comply with the applicable requirements of this end product standard.

6.15 Marking and labeling systems

6.15.1 A marking and labeling system shall comply with Standard for Marking and Labeling Systems, UL 969, under the specified environmental conditions.

Exception: A marking or labeling system that complies with Section [59](#) of this standard is considered to fulfill the requirement.

6.16 Motors and motor overload protection

6.16.1 General

6.16.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in [6.16.2](#). This includes fractional HP motors rated up to 1 HP (typically NEMA frame sizes 42, 48, or 56), and integral HP motors rated 1 HP and greater (typically NEMA frame sizes 140 – 449T).

6.16.1.2 Motors not enclosed, or partially enclosed, by the end product enclosure shall comply with the requirements specified in [6.16.2](#).

6.16.1.3 Component type motors completely enclosed within the end product enclosure shall comply with the requirements specified in [6.16.2](#) or [6.16.3](#).

6.16.1.4 Motors located in a low voltage circuit are evaluated for the risk of fire and personal injury in accordance with the applicable requirements of this end product standard.

6.16.1.5 Low voltage component fans that comply with the Standard for Electric Fans, UL 507, are considered to fulfill the requirements of Section [22](#).

6.16.2 General-purpose type motors

6.16.2.1 A general-purpose type motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

6.16.3 Component type motors

6.16.3.1 Component type motors shall comply with either [6.16.3.2](#) or [6.16.3.3](#).

6.16.3.2 The motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 except as noted in [Table 6.1](#):

Table 6.1
Superseded requirements

UL 1004-1 exempted requirement	Superseded by the requirements in this end product standard
Current and Horsepower Relation	22.3.3
Cord-Connected Motors	12.2
Factory Wiring Terminals and Leads	Section 15
Electrical Insulation	Section 14

Table 6.1 Continued on Next Page

Table 6.1 Continued

UL 1004-1 exempted requirement	Superseded by the requirements in this end product standard
Non-Metallic Functional Parts	Sections 7 , 14 , 22
Solid-State Controls, 7.2	6.6
Non-metallic enclosure thermal aging, 9.1.4	7.14
Motor enclosure (Cast Metal Enclosures, Sheet Metal Enclosures, and Polymeric Enclosures)	Section 7
Grounding	Section 19
Ventilation Openings: only applicable where the openings are on surfaces considered to be the appliance enclosure.	7.15
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts	Section 11
Protection Against Corrosion	Section 10
Available fault current ratings for motor start and running capacitors, 26.6: not applicable for cord and plug connected appliances.	Section 18
Switch: not applicable to centrifugal starting switches	Section 26
With the exception of the Resilient Elastomer Mounting and Electrolytic Capacitor Tests requirements, the performance tests are not applicable	All applicable performance tests.
Only the following marking requirements are applicable: manufacturer's name or identification; rated voltage; rated frequency; number of phases if greater than 1; and multi-speed motors, other than a shaded-pole or a permanent-split-capacitor motor, shall be marked with the amperes and horsepower at each speed	70.1

6.16.3.3 The motor shall comply with the applicable component requirements in this section, the following construction requirements, and the applicable performance requirements (when tested in conjunction with the end product), of this end product standard:

- a) Protection Against Corrosion, Section [10](#);
- b) Terminal Compartment, Section [12](#) ([12.3.2.3](#));
- c) Electrical Insulation, Section [14](#);
- d) Internal Wiring, Section [15](#);
- e) Capacitors, Section [18](#);
- f) Grounding, Section [19](#);
- g) Motors, Section [22](#); and
- h) Spacings, Section [28](#).

6.16.4 Motor overload protection

6.16.4.1 Thermal protection devices integral with the motor shall comply with:

- a) The Standard for Overheating Protection for Motors, UL 2111;
- b) The Standard for Thermally Protected Motors, UL 1004-3;

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Thermal Motor Protectors, UL 60730-2-2; in conjunction with the Standard for Thermally Protected Motors, UL 1004-3 (to evaluate the motor-protector combination), or

d) Electronic protection complying with the tests of UL 1004-3 and the circuit requirements of Supplement [SA](#).

6.16.4.2 Impedance protection shall comply with:

a) The Standard for Overheating Protection for Motors, UL 2111; or

b) The Standard for Impedance Protected Motors, UL 1004-2.

6.16.4.3 Electronic protection integral to the motor shall comply with the Standard for Electronically Protected Motors, UL 1004-7, or the requirements in Supplement [SA](#).

6.16.4.4 Except as indicated in [6.16.4.3](#), electronically protected motor circuits shall comply with one of the following. See [6.6.4](#) for basic control requirements.

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the Standard for Tests for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. If software is relied upon to perform a safety function, it shall be considered software Class B; or

c) The Standard for Power Conversion Equipment, UL 508C, when no software is relied upon to perform a safety function. If software is relied upon to perform a safety function, the circuit shall additionally comply with applicable requirements in (a) or (b) of this section; or

d) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1, when no software is relied upon to perform a safety function. If software is relied upon to perform a safety function, the circuit shall additionally comply with applicable requirements in (a) or (b).

Exception: Compliance with the above standards is not required for an electronically protected motor circuit if there is no risk of fire, electric shock, or injury to persons during abnormal testing with the motor electronic circuit rendered ineffective; compliance with the applicable requirements of this end product standard is then required.

6.17 Overcurrent protection

6.17.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and the applicable Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable standard for the fuse are considered to comply with this requirement.

6.17.2 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9).

6.17.3 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

6.17.4 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

6.17.5 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

6.17.6 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

6.18 Polymeric materials and enclosures

6.18.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.18.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

6.19 Power supplies

6.19.1 A Class 2 power supply shall comply with one of the following:

- a) The Standard for Class 2 Power Units, UL 1310; or
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

6.19.2 A non-Class 2 power supply shall comply with one of the following:

- a) The Standard for Power Units Other Than Class 2, UL 1012;
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or
- c) The requirements in Supplement [SA](#).

6.20 Printed wiring boards

6.20.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed-Wiring Boards, UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in the Standard for Printed-Wiring Boards, UL 796 if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

6.20.2 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for insulating materials in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

6.20.3 Unless otherwise specified, the flammability class and temperature rating shall be that specified for insulating materials in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.21 Semiconductors and small electronic components

6.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard of Safety for Electrically Isolated Semiconductor Devices, UL 1557. If considered necessary, the dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Section [48](#).

6.21.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with the Standard for Safety for Optical Isolators, UL 1577. If considered necessary, the dielectric voltage withstand tests required by UL 1577 shall be conducted applying the criteria of Section [48](#). The dielectric test voltage is to be applied between the input and output terminals of the optical isolator.

6.21.3 Except as specified in [6.21.4](#), component requirements are not specified for small electronic components on printed wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

6.21.4 Where an electronic component is determined to be a critical component during the testing of the Abnormal Operation Test, Section [54](#), one of the following standards shall be applied. See [27.4](#) for the test parameters to be used.

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and as applicable, the Standard for Software in Programmable Components, UL 1998 for controls that rely upon software as a protective component; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

6.21.5 A critical component is a component that performs one or more safety-related functions whose failure results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end product application.

6.21.6 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with the Failure-Mode and Effect Analysis (FMEA) of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

6.21.7 Portions of a circuit comprised of a microcontroller or other programmable device that performs a back-up, limiting, or other safety function intended to reduce the risk of fire, electric shock, or injury to persons shall comply with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, Annex H.

6.22 Supplemental insulation, insulating bushings, and assembly aids

6.22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to comply with [15.2.6](#) or a performance requirement of this Standard. In such cases:

- a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;
- b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441;
- c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

6.22.2 Wire positioning devices shall comply with Electrical Insulation, Section [14](#), and Separation of Circuits, Section [17](#). A device that complies with the Standard for Positioning Devices, UL 1565, is considered to comply with this requirement.

6.22.3 Insulating bushings that comply with [6.1](#) and the Standard for Insulating Bushings, UL 635, are considered to comply with the requirements of this Standard. Tests specified in this standard (e.g. Strain Relief Test) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

6.23 Switches

6.23.1 Switches shall comply with one of the following, as applicable:

- a) *Deleted*
- b) The Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;
- c) The Standard for General Use Snap Switches, UL 20;
- d) The Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 733A; or
- e) The circuit requirements in Supplement [SA](#).

Exception: Switching devices that comply with the applicable UL standard for specialty applications (e.g. transfer switch equipment), industrial use (e.g. contactors, relays, auxiliary devices), or are integral to another component (e.g. switched lampholder) need not comply.

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

- a) The Standard for Clock-Operated Switches, UL 917; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

6.23.3 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, shall comply with the requirements for an operating control with Type 1 action for 6,000 cycles of operation, or as a manual control for 5,000 cycles of operation, in accordance with the following:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7; or
- c) The circuit requirements in Supplement [SA](#).

6.23.4 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, that functions as a protective control, shall comply with the requirements for a protective control; see [6.6.1.3](#).

6.24 Transformers

6.24.1 General-purpose transformers shall comply with the Standard for Low Voltage Transformers: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers: General Purpose Transformers, UL 5085-2.

Exception No. 1: A transformer that is completely enclosed within the end product enclosure, and that meets the applicable construction and performance requirements of this end product standard when tested in conjunction with the end product, meets the intent of this requirement. See Section [62](#).

Exception No. 2: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component, meets the intent of this requirement.

6.24.2 Class 2 and Class 3 transformers shall comply with the Standard for Low Voltage Transformers: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers: Class 2 and Class 3 Transformers, UL 5085-3.

Exception: Transformers located in a low voltage circuit that do not involve a risk of fire or personal injury need not comply with this requirement.

6.25 Valves (electrically operated) and solenoids

6.25.1 Electrically operated valves shall comply with:

a) The Standard for Electrically Operated Valves, UL 429

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, UL 60730-2-8.

Exception: Automatic valves intended for use with natural gas, manufactured gas, LP-gas or LP-gas-air mixtures shall comply with the Standard for Automatic Valves for Gas Appliances, ANSI Z21.21a/CSA 6.5a.

6.25.2 Solenoids shall comply with the applicable construction and performance requirements of this end-product standard, or with the Outline of Investigation for Solenoids, UL 906.

6.26 Video and audio components

6.26.1 A video component (e.g. a television or video) or an audio component (such as a CD player, radio, MP3 player, or audio sound system) provided with a motor-operated appliance shall comply with the following:

a) The Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, UL 60065; or

b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

6.26.2 The location, orientation, and intended use of a video or audio component shall be evaluated with the motor-operated appliance to ensure that the component(s) does not increase the risk of shock, fire, or personal injury. Examples include, but are not limited to, the mechanical mounting of the component, and the effect of the audio and video component on the overall leakage current of the appliance.

7 Frame and Enclosure

7.1 An appliance shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing the risk of fire, electric shock or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

7.2 For unreinforced, flat surfaces in general, cast metal shall not be less than 1/8 in (3.2 mm) thick, except that malleable iron may be not less than 3/32 in (2.4 mm) and die cast metal may be not less than 5/64 in (2.0 mm) thick. Corresponding thicknesses of not less than 3/32, 1/16 (1.6 mm), and 3/64 in (1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size, or both, of the surface is such that the necessary mechanical strength is provided.

7.3 An enclosure of sheet metal shall be judged with respect to its size, shape, thickness of metal, and its application, considering the intended use of the complete appliance. The use of sheet steel having a thickness of less than 0.026 in (0.66 mm) if uncoated or 0.029 in (0.74 mm) if galvanized or of nonferrous sheet metal having a thickness of less than 0.036 in (0.91 mm) is not recommended, except for relatively small areas or for surfaces that are curved or otherwise reinforced.

7.4 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 in (0.81 mm) if uncoated steel, not less than 0.034 in (0.86 mm) if galvanized steel, and not less than 0.045 in (1.14 mm) if nonferrous.

7.5 Among the factors that shall be taken into consideration when judging a nonmetallic enclosure or an enclosure of magnesium 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.

7.6 The enclosure of a remotely or automatically controlled appliance shall reduce the risk of molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the appliance is supported.

7.7 The requirement in [7.6](#) will necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the appliance enclosure. It will also necessitate the use of a barrier of noncombustible material:

- a) Under a motor unless:
 - 1) The structural parts of the motor or of 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 is to be applied before the motor is energized, and the rotor is to be locked;

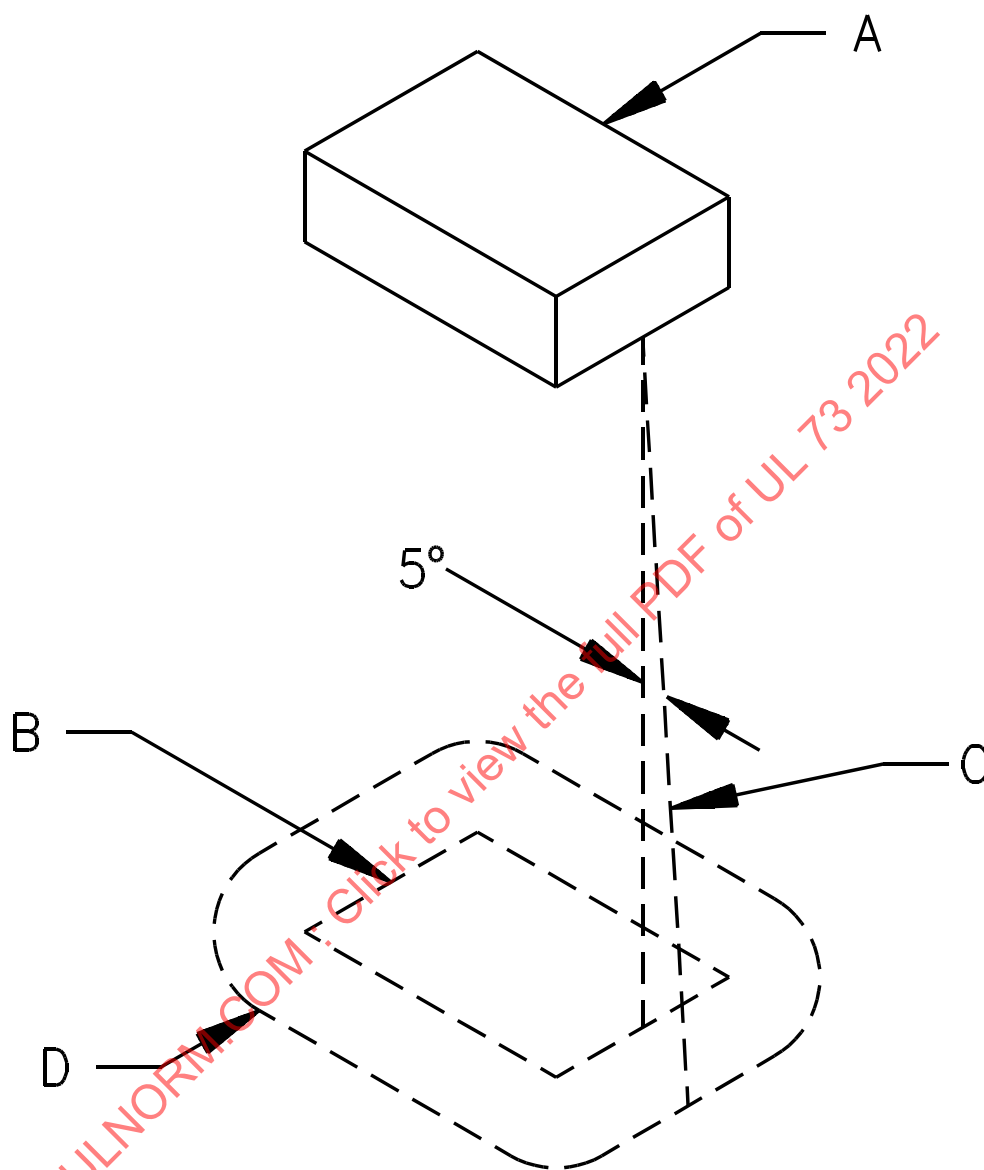
3) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will reduce the risk of the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector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

4) The motor complies with the requirements in the Standard for Overheating Protection for Motors, UL 2111, and the temperature of the motor winding will not exceed 150°C during the first 72 h of operation with the rotor of the motor locked.

b) Under wiring, unless it is neoprene, cross-linked polyethylene, or thermoplastic insulated.

7.8 The barrier mentioned in [7.7](#) shall be horizontal, shall be located as illustrated in [Figure 7.1](#), and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and the like may be employed in the barrier, provided such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 7.1
Location and extent of barrier



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NOTES –

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

B – Projection of outline of component on horizontal plane.

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

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

7.9 A door or a cover of an enclosure that provides access to any overload protective device that requires resetting or renewal shall be hinged or otherwise attached in an equivalent manner.

7.10 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.

7.11 A cord-connected appliance that is provided with keyhole slots, notches, hanger holes, or the like, for hanging on a wall shall be constructed in such a manner that the hanging means is not accessible without removing the appliance from the supporting means.

7.12 To determine whether a product complies with the requirement in [7.11](#), any part of the enclosure or barrier that can be removed without the use of tools to gain access to the hanging means is to be removed.

7.13 An opening in the appliance provided for hanging 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.
- e) Any other part likely to create a risk of fire or electric shock.

7.14 An enclosure of polymeric material shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The polymeric enclosure material of an appliance for outdoor-use shall be subjected to the Ultraviolet Light Exposure Test and the Cold Impact Test.

Exception: For an outdoor use appliance marked in accordance with [70.8.2](#), the Ultraviolet Light Exposure Test is not applicable and the conditioning for the Cold Impact Test is conducted at $0 \pm 2^\circ\text{C}$.

7.15 The polymeric housing of a component is not considered to be an appliance enclosure unless this part is the sole insulation (excluding air) between a live part and an external surface of the appliance.

7.16 An appliance intended for outdoor use shall comply with Water Spray Test, Section [50.1](#).

Exception: This requirement is not applicable if the appliance is marked in accordance with [70.8.2](#).

7.17 Polymeric enclosure and insulating materials, internal wiring, and other polymeric component parts shall be acceptably resistant to degradation when exposed to ultraviolet light, if degradation of the part would result in non-compliance with other requirements of this Standard. To determine whether a part is acceptably resistant to ultraviolet light, the part shall be subjected to the Ultraviolet Light Exposure Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8 Adhesives Used to Secure Parts

8.1 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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.2 The requirement in [8.1](#) also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

- a) Energize an accessible dead metal part,
- b) Make a live part accessible,
- c) Reduce spacings below the minimum acceptable values, or
- d) Short-circuit live parts.

8.3 Whether the conditions mentioned in [8.2](#)(a) – (d) can occur is to be considered with respect to both:

- a) A part inside the device, and
- b) A part on the outside of the device that may affect equipment in which the device is to be installed.

9 Mechanical Assembly

9.1 An appliance shall be assembled so that it will not be adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise constructed to reduce the risk of loosening.

9.2 A switch other than a through-cord switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be securely mounted and shall be prevented from turning. See [9.4](#).

Exception No. 1: A switch need not be prevented from turning provided:

- a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during normal operation of the switch;*
- b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;*
- c) The spacings are not reduced below the minimum required values if the switch rotates; and*
- d) The normal operation of the switch is by mechanical means rather than by direct contact by persons.*

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum required values.

9.3 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 may result in a reduction of spacings below the minimum acceptable values.

9.4 The means for preventing the turning or shifting mentioned in [9.2](#) and [9.3](#) is to consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

10 Protection Against Corrosion

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

Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion if the oxidation of the metal due to the exposure to air and moisture is not likely to be appreciable. The thickness of metal and temperature are also to be considered.

Exception No. 2: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

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

11 Accessibility of Uninsulated Live Parts and Film-Coated Wire

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

- a) For an opening that has a minor dimension (see [11.5](#)) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in [Figure 11.1](#).
- b) For an opening that has a minor dimension of 1 in or more, such a part or wire shall be spaced from the opening as specified in [Table 11.1](#).

Exception: A motor 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 [11.2](#).

Table 11.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minimum dimension ^a of opening, in (mm) ^b		Minimum distance from opening to part, in (mm) ^b	
3/4 ^c	(19.1)	4-1/2	(114)
1 ^c	(25.4)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
	^d	30	(762)

^a See [11.5](#).
^b Between 3/4 and 2-1/8 in, interpolation is to be used to determine a value between values specified in the table.
^c Any dimension less than 1 in applies to a motor only.
^d More than 2-1/8 in, but not more than 6 in (152 mm).

11.2 With respect to a part or wire as mentioned in [11.1](#), in an integral enclosure of a motor as mentioned in the Exception to [11.1](#):

a) An opening that has a minor dimension (see [11.5](#)) less than 3/4 in (19.1 mm) is acceptable if:

- 1) Film-coated wire cannot be contacted by the probe illustrated in [Figure 11.3](#);
- 2) In a directly accessible motor (see [11.6](#)), an uninsulated live part cannot be contacted by the probe illustrated in [Figure 11.4](#); and
- 3) In an indirectly accessible motor (see [11.6](#)), an uninsulated live part cannot be contacted by the probe illustrated in [Figure 11.2](#).

b) An opening that has a minor dimension of 3/4 in or more is acceptable if a part or wire is spaced from the opening as specified in [Table 11.1](#).

Figure 11.2
Straight probe

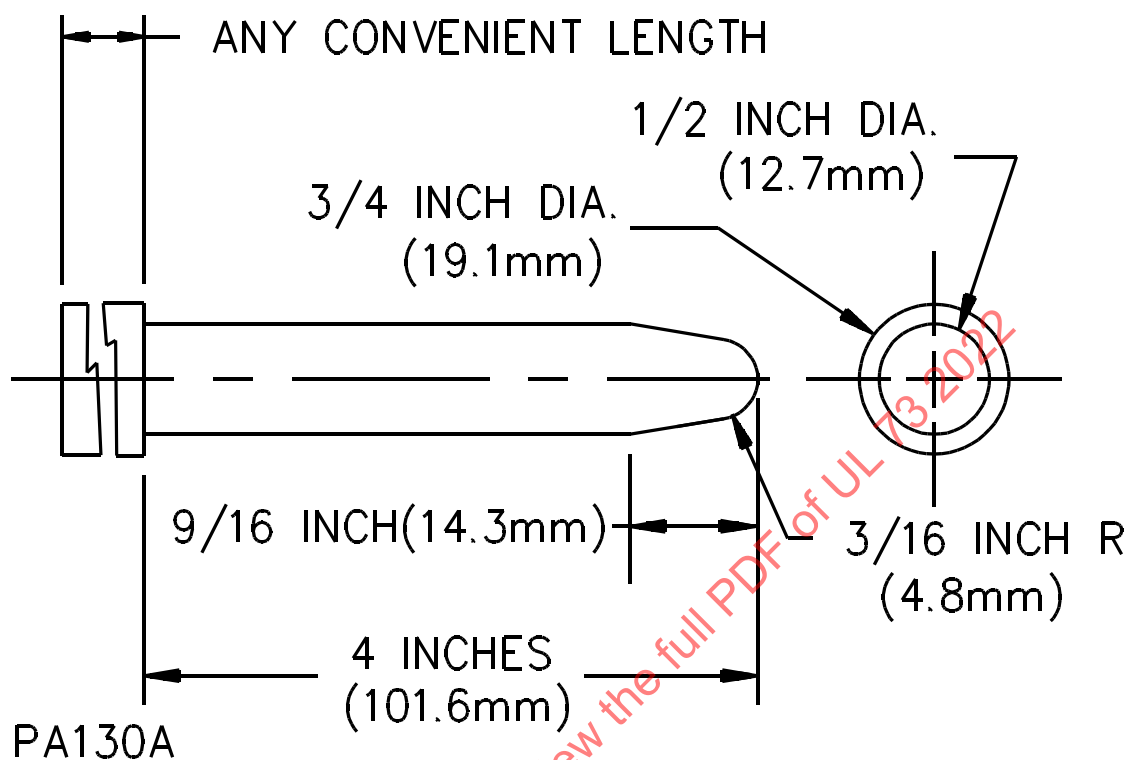
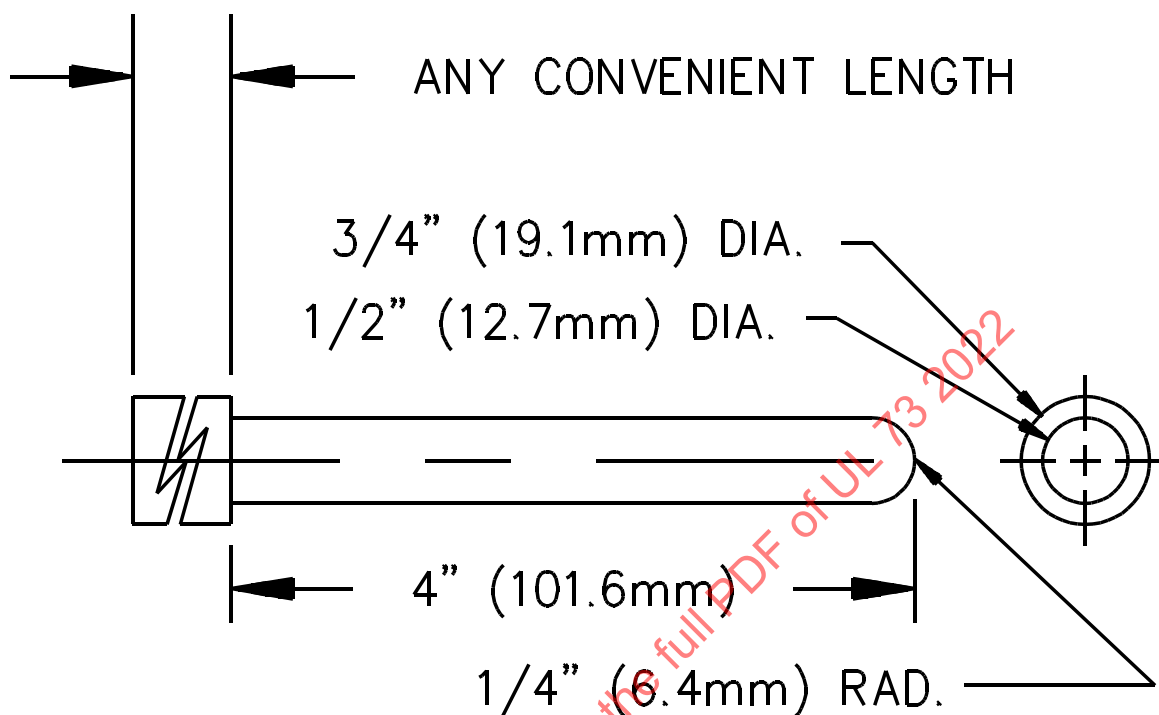


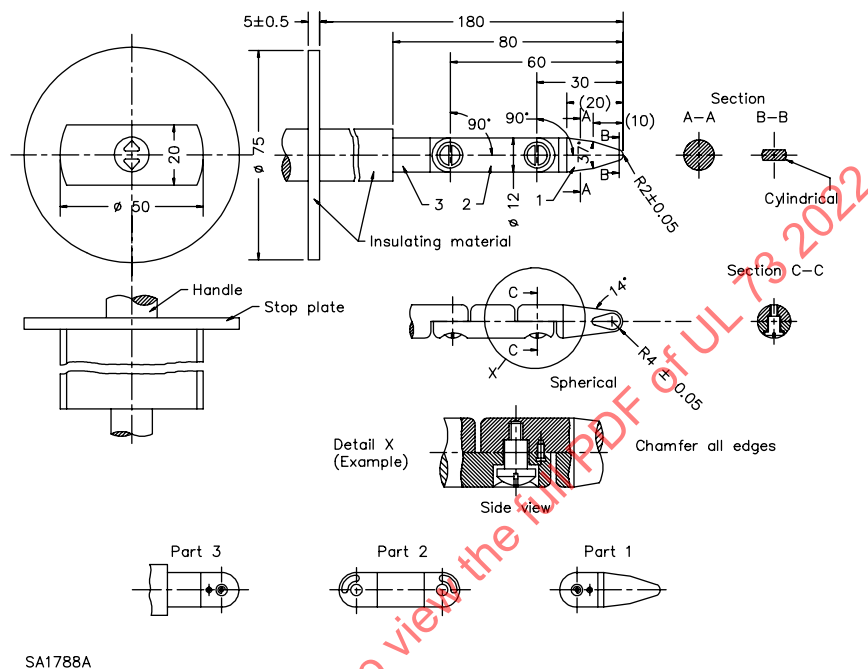
Figure 11.3
Straight probe



PA140A

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Figure 11.4
International Electrotechnical Commission (IEC)
Articulate accessibility probe with stop plate
All dimensions in millimeters
Courtesy of IEC



11.3 The probes mentioned in [11.1](#) and [11.2](#) and illustrated in [Figure 11.1](#) – [Figure 11.4](#) 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 probe illustrated in [Figure 11.1](#) and [Figure 11.4](#) shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

11.4 The probes mentioned in [11.3](#) and [11.5](#) shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

11.5 With reference to the requirements in [11.1](#) and [11.2](#), 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.

11.6 With reference to the requirements in [11.2](#), an indirectly accessible motor is a motor that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, than can be opened or removed without using a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted. A directly accessible motor is a motor that can be contacted without opening or removing any part or that is located so as to be accessible to contact.

11.7 During the examination of an appliance to determine whether it complies with the requirements in [11.1](#) or [11.2](#), a part of the enclosure that may be opened or removed by the user without a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

11.8 With reference to the requirements in [11.1](#) and [11.2](#), insulated brush caps are not required to be additionally enclosed.

12 Supply Connections

12.1 General

12.1.1 An ultrasonic cleaner provided with a mechanical connection (such as a threaded or soldered plumbing connection) that does not permit the ready removal of the appliance for maintenance or repair, shall not be provided with a flexible cord for connection to the electrical supply.

12.1.2 The appliance described in [12.1.1](#) shall have provision for permanent electrical connection. See [12.3.2](#) and [12.3.3](#).

12.2 Cord-connected appliances

12.2.1 Carbonators

12.2.1.1 A carbonator that is connected to the electrical supply by a flexible cord shall comply with the following:

- a) All waterline connections shall be by means of flexible hose or equivalent;
- b) The flexible cord shall be of Type SJT or of a Type equally serviceable, shall not be longer than 10 ft (3.05 m), and shall have a grounding conductor and a grounding type attachment plug; and
- c) In addition to complying with the other applicable requirements in the standard, the wiring compartment shall be constructed and the cord attached so a permanent connection is able to be made to the power supply. The construction shall comply with the following conditions:
 - 1) The cord shall enter the wiring compartment through a 7/8-in (22.2-mm) diameter hole that, after the cord and any bushing or fitting provided have been removed, provides an opening for attachment of a wiring system that is intended for the appliance; and
 - 2) The power-supply cord is connected to the internal wiring by a device such as a terminal block, pressure cable connector, or a similar device, that accommodates permanent wiring having an ampacity rated for the appliance, and that complies with [12.3.2](#) – [12.3.4](#).

12.2.2 Cords and plugs

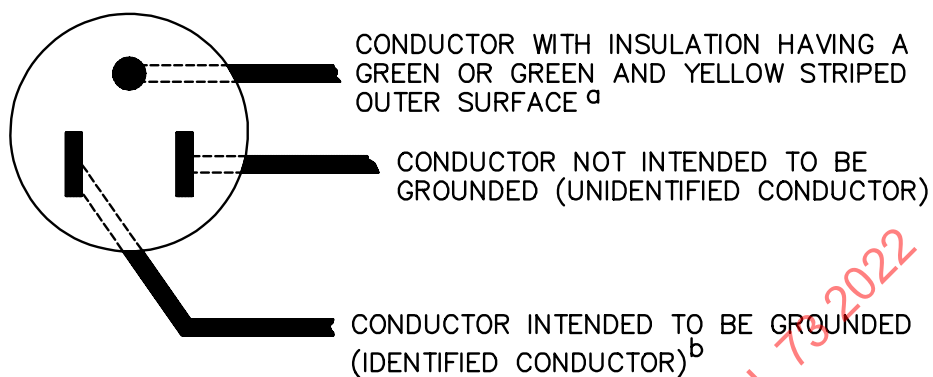
12.2.2.1 An appliance intended to be connected to the power-supply circuit by means of a flexible cord shall be provided with a flexible cord and an attachment plug for connection to the supply circuit.

12.2.2.2 The attachment plug of 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 [21.2](#), [25.2](#), and [26.3](#) shall be a polarized type. The connections to the attachment plug shall be in accordance with [Figure 12.1](#). The polarity identification of the supply cord shall be in accordance with [Table 12.1](#). See [73.4](#).

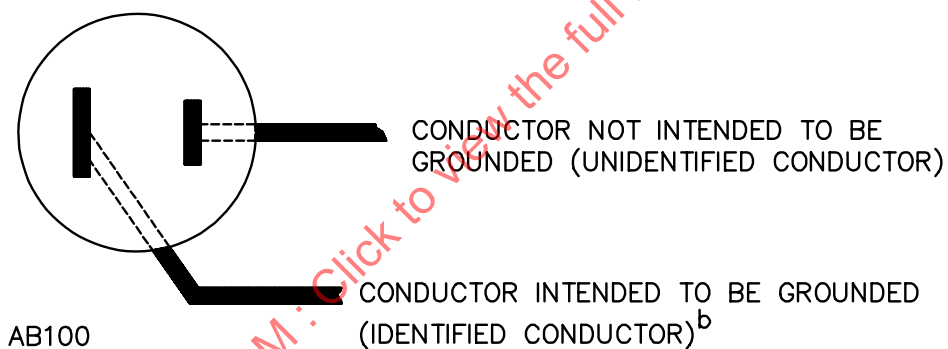
Figure 12.1

Connections to attachment plugs

CONNECTIONS OF CORD CONDUCTORS TO GROUNDING – TYPE ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



CONNECTIONS OF CORD CONDUCTORS TO POLARIZED ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



NOTES –

^a In the above illustration, the blade to which the green conductor is connected may have a U-shape instead of a circular cross section.

^b Signifies a conductor identified in accordance with [Table 12.1](#).

Table 12.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Conductor intended to be grounded ^{a, b}	All other conductors ^a
Color of braids on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	Color other than white or gray – with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	Solid white or gray ^c	Solid color other than white or gray
	Solid light blue ^d	Solid color other than light blue, white or gray
Color of separators	Solid white or gray ^e	Solid color other than white, or gray
Other means	Tin or other white metallic coating on all strands of the conductor ^e	No tin or other white metallic coating on the strands of the conductor
	A stripe, ridge, or groove on the exterior surface of the cord ^e	
^a A conductor finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment-grounding conductor. See 19.2.1 and Figure 12.1 . ^b The grounded (identified) conductor is the neutral supply conductor. ^c Only for cords – other than Types SP-2, SPE-2, and SPT-2 – having no braid on any individual conductor. ^d For jacketed cords. ^e Only for cords having insulation on the individual conductors integral with the jacket, such as Types SP-2, SPE-2, and SPT-2 cords.		

12.2.2.3 An appliance that is required to employ a polarized attachment plug as specified in [12.2.2.2](#), and that is provided with a separate or detachable cord set as specified in Exception No. 1 of [12.2.2.7](#) and [12.2.2.9](#) shall also employ an appliance connector of the polarized type.

12.2.2.4 The flexible cord shall have a voltage rating not less than the rated voltage of the appliance, and shall have an ampacity that is not less than the current rating of the appliance.

12.2.2.5 Type SJ, SJE, SJO, SJOO, SJT, SJTO, or SJTOO cord is required when a portable appliance is intended for commercial or industrial use, and Type SP-2, SPE-2, or SPT-2 when a portable appliance is intended for household use. A cord type at least as serviceable may be used.

Exception No. 1: Portable, commercial, indoor use jewelry and ultrasonic cleaners may employ minimum 18 AWG (0.82 mm²), Type SPT-2 supply cord if:

- a) The appliance is counter-supported;*
- b) The cord cannot contact motorized moving parts and is not subject to motion under normal use; and*
- c) The cord is unlikely to be subjected to mechanical abuse.*

Exception No. 2: Commercial indoor use insect control equipment may employ minimum 18 AWG, Type SPT-2 or HPN supply cord if:

- a) The appliance is intended for commercial cooking establishments;*
- b) The appliance is for wall mounting but not for permanent attachment to the building structure (e.g. key slots are used to mount the equipment);*
- c) The weight of the appliance is not more than 15 pounds (6.8 kg);*

- d) *The cord is not exposed to oil;*
- e) *The cord cannot contact motorized moving parts and is not subject to motion under normal use; and*
- f) *The cord is unlikely to be subjected to mechanical abuse.*

12.2.2.6 A stationary appliance (see [2.23](#)) may be provided with 6 ft (1.83 m) to 8 ft (2.44 m) of Type S, SE, SO, SOO, ST, STO, or STOO cord and an attachment plug for supply connection. A cord type at least as serviceable may be used.

Exception No. 1: A stationary appliance employing isolated ground type receptacles shall not be cord connected.

Exception No. 2: For a checkout stand connected to the electrical supply by a flexible cord, the wiring compartment shall be constructed and the cord attached such that the cord can be easily removed to allow the checkout stand to be connected to a permanent wiring system in accordance with [12.3](#). See also [73.10](#).

12.2.2.7 The flexible cord shall not be less than 6 ft (1.83 m) long and shall be attached to the appliance.

Exception No. 1: An appliance that is not required to be provided with a grounding conductor may be provided with a separate cord set having means for connection to the appliance and a length of not less than 6 ft.

Exception No. 2: A cord-connected appliance that is required to be equipped with a grounding conductor may be provided with not more than 18 in (457 mm) of permanently attached flexible cord or with a connector base if:

- a) *For an outdoor use appliance, the appliance is marked in accordance with [70.3.5](#) and is provided with installation instructions in accordance with [73.9](#).*
- b) *For other than an outdoor use appliance:*
 - 1) *Usage of the appliance is such that it is necessary to connect the appliance by means of an extension cord during normal operation; the manufacturer makes extension cords available; and a statement indicating the availability of such extension cords is marked on the appliance or is included in an instruction book or the like that is regularly furnished with the appliance; or*
 - 2) *The manufacturer furnishes a detachable cord set, 6 ft or more long, with the appliance.*

Exception No. 3: This requirement does not apply to a cord as described in [12.2.1.1](#) (b).

Exception No. 4: A hand-supported engraver, intended for marking or etching materials, may be provided with not less than 5 ft (1.52 m) of attached flexible cord.

12.2.2.8 The length of an attached flexible cord includes the attachment plug. The length of a cord set includes the fittings.

12.2.2.9 A household appliance intended for use with a detachable cord set shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

12.2.2.10 The attachment plug shall have an ampere rating not less than 125% of the rated current of an appliance, or, when the appliance is not provided with a current rating, the measured input current under

maximum normal load conditions, and a voltage rating equal to the rated voltage of the appliance. If an appliance can be adapted for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the appliance shall be acceptable for the voltage for which the appliance is connected when shipped from the factory. See [70.1.9](#).

Exception No. 1: A stationary appliance, marked in accordance with [70.3.3](#), shall employ an attachment plug rated not less than the current rating of the appliance or, when the appliance is not provided with a current rating, the measured input current under maximum normal load conditions.

Exception No. 2: For electric motor starters for use with internal combustion engines, which are connected to the branch circuit only while starting the engine, the current rating of the attachment plug shall not be less than the current rating of the appliance, or, when the appliance is not provided with a current rating, the measured input current under maximum normal load conditions.

12.2.2.11 A three- to two-wire, grounding-type adapter shall not be provided with an appliance if:

- a) Usage of the appliance is such that it is necessary to connect it by means of an extension cord during normal operation,
- b) The manufacturer makes extension cords available, and
- c) A statement indicating the availability of such extension cords is marked on the appliance or is included in an instruction book or the like that is regularly furnished with the appliance.

12.2.2.12 If an appliance incorporates a disconnecting means, such as a cord connector in the supply cord between the handle and the motor, the arrangement shall be such that no live parts will be exposed under any normal conditions.

12.2.2.13 A flexible cord provided with an appliance intended to be used outdoors shall be rated for outdoor use. Such cords are identified by the letter "W" following the cord type designation marked on the jacket.

12.2.3 Strain relief

12.2.3.1 Strain relief shall be provided so that mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring.

12.2.3.2 A metal strain-relief clamp or band used with Type SP-2, SPE-2, or lighter general-use rubber-insulated cord shall be provided with auxiliary insulation over the cord for mechanical protection.

Exception: The auxiliary insulation may be omitted for Type SV, SVE, SVO, or SVOO cord.

12.2.3.3 A clamp of any material – metal or otherwise – is not acceptable for use on Type SPT-2, SVT, SVTO, or SVTOO cord.

Exception No. 1: A metal clamp is acceptable for strain relief on Types SPT-2, SVT, SVTO and SVTOO flexible cords protected by varnished-cloth tubing, phenolic, vulcanized fiber, or the equivalent between the clamp and the cord, if the combination clamp and cord protection installed as intended complies with [53.3](#). Thermoplastic tubing is not acceptable over thermoplastic cords.

Exception No. 2: A non-metallic clamp is acceptable on Types SPT-2, SVT, SVTO and SVTOO flexible cords without tubing, fiber, or equivalent cord protection between the clamp and the cord, if the clamp complies with [53.3](#).

12.2.3.4 For types of thermoplastic-insulated cord, heavier than Type SPT-2, SVT, SVTO, or SVTOO, a clamp may be employed and the auxiliary insulation is not required unless it is judged that the clamp may damage the cord insulation.

12.2.3.5 Means shall be provided to reduce the risk of a flexible cord from being pushed into an appliance through a cord-entry hole if such displacement may subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is acceptable, or may reduce a spacing, such as to a metal strain-relief clamp, below the minimum acceptable value.

12.2.3.6 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 may cause abrasion of the insulation on the conductors.

12.2.4 Bushings

12.2.4.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear.

12.2.4.2 An insulating bushing shall be provided if:

- a) Type SP-2, SPE-2, SPT-2, or other cord lighter than Type SV or SVE is employed,
- b) The wall or barrier is of metal, or
- c) The construction is such that the cord may be subjected to strain or motion.

Exception: An insulated metal grommet having insulating material that is not less than 1/32 in (0.8 mm) thick and fills completely the space between the grommet and the metal in which it is mounted may be used instead of an insulating bushing.

12.2.4.3 A cord hole in wood, porcelain, phenolic composition, or other nonconducting material and having a smooth, rounded surface is considered to be equivalent to a bushing.

12.2.4.4 Ceramic materials and some molded compositions are generally acceptable for insulating bushings.

12.2.4.5 A separate bushing shall not be made of wood or of hot-molded shellac-and-tar compositions.

12.2.4.6 A vulcanized fiber bushing shall not be less than 3/64 in (1.2 mm) thick and formed and secured in place so that it will not be adversely affected by conditions of ordinary moisture.

12.2.4.7 A separate soft-rubber, neoprene, or polyvinyl chloride bushing shall not be employed in the appliance.

Exception No. 1: A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor provided that the bushing is:

- a) *Not less than 3/64 in (1.2 mm) thick; and*
- b) *Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound employed.*

Exception No. 2: A bushing of any of the materials mentioned above may be employed at any point in an appliance if used in conjunction with a type of cord for which an insulating bushing is not required. If a bushing of one or these materials is used anywhere in the appliance, the edges of the hole in which the bushing is mounted shall be smooth and free from burrs, fins, and the like.

12.2.4.8 At any point in an appliance, a bushing of the same material as, and molded integrally with, the supply cord is acceptable on a Type SP-2 or harder-service cord if the built-up section is not less than 1/16 in (1.6 mm) thick at the point where the cord passes through the enclosure.

12.3 Permanently connected appliances

12.3.1 General

12.3.1.1 A stationary appliance intended for permanent connection to the power supply and a fixed appliance shall have provision for connection of one of the permanent wiring systems that would be acceptable for the appliance. See also [12.2.2.6](#) for cord connection of a stationary appliance.

12.3.2 Terminal compartment

12.3.2.1 A terminal box or compartment in which power-supply connections to a permanently connected appliance are to be made shall be located so that the connections may be readily inspected after the appliance is installed as intended.

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

12.3.2.3 If it is intended that supply connections be made directly to a motor, the terminal compartment on the motor shall comply with the requirements for terminal compartments in the Standard for Rotating Electric Machines – General Requirements, UL 1004-1.

12.3.3 Wiring terminals and leads

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

12.3.3.2 A field-wiring terminal is 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.

12.3.3.3 Wiring terminals for the supply conductors – excluding the grounding conductor – shall be provided with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception No. 1: A soldering lug may be used.

Exception No. 2: A No. 10 (4.8 mm diameter) or larger wire-binding screw or stud-and-nut combination 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.

12.3.3.4 A wiring terminal shall be prevented from turning.

12.3.3.5 The free length of a lead inside an outlet box or wiring compartment shall be 6 in (150 mm) or more if the lead is intended for field connection to an external circuit.

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

12.3.3.6 A wire-binding screw or stud-and-nut combination at a wiring terminal shall not be smaller than a No. 10 (4.8 mm diameter).

Exception No. 1: A No. 8 (4.2 mm diameter) screw or stud-and-nut combination may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm²) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.8 mm²) conductor in a low-voltage circuit.

12.3.3.7 According to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm²) is the smallest conductor that may be used for branch-circuit wiring, and therefore is the smallest conductor that may be anticipated at a terminal for connection of a power-supply wire.

12.3.3.8 A wire-binding screw shall thread into metal.

12.3.3.9 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 in (1.27 mm) thick and shall not have less than two full threads in the metal.

Exception: An alloy plate may be not less than 0.030 in (0.76 mm) thick if the tapped threads have the necessary mechanical strength.

12.3.3.10 A terminal plate formed from stock having the thickness specified in [12.3.3.9](#) may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

12.3.3.11 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in [12.3.3.1](#) under the head of the screw or washer.

12.3.4 Identified terminals and leads

12.3.4.1 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 without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

12.3.4.2 A terminal intended for the connection of a grounded 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 proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

12.3.4.3 A lead intended for the connection of a grounded power-supply conductor shall be finished white or gray color and shall be readily distinguishable from the other leads.

13 Current-Carrying Parts

13.1 A current-carrying part shall be of silver, copper, a copper alloy, stainless steel, or other similar metal.

13.2 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 [6.1](#) or within a motor or associated governor.

14 Electrical Insulation

14.1 Material for mounting an uninsulated live part shall be porcelain, phenolic composition, or other equivalent material.

14.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

14.3 A thermoplastic material in direct contact with uninsulated live parts may be employed if found to have the necessary mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric voltage withstand, and other appropriate properties. See [6.18.1](#). Suitability shall be determined by compliance with the requirements for direct contact with live parts in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. See [14.5](#) for battery operated live parts.

14.4 A small molded part, such as a brush cap, shall be constructed to have the necessary mechanical strength and rigidity to withstand the stresses of actual service. A brush cap shall be secured or located so that it is protected from mechanical damage that may result during intended use. See also [7.15](#).

14.5 The suitability of polymeric materials in contact with or in close proximity to (within 1/32 in.) battery-operated live parts shall be determined by compliance with the tests of [55A.1](#).

Exception: Where the battery pack does not present a risk of fire in accordance with the definition of "Risk of Fire" (3.34) in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or has been evaluated as a Limited Power Source (LPS) per the Limited Power Source Test Section, Section 13, in the Standard for Household and Commercial Batteries, UL 2054.

15 Internal Wiring

15.1 Mechanical protection

15.1.1 Wiring and connections between parts of an appliance shall be protected or enclosed.

Exception: A length of flexible cord may be employed for external connections if flexibility is essential.

15.1.2 Wires within an enclosure, a compartment, a raceway, or the like shall be routed or otherwise protected so that damage to conductor insulation cannot result from contact with any rough, sharp, or moving part.

15.1.3 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of an appliance shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires may bear. A flexible cord used for external interconnection as mentioned in [15.1.1](#) shall be provided with strain relief and bushings in accordance with the requirements in [12.2.3.1](#) – [12.2.4.8](#), and Section [53](#), Strain-Relief Test, unless the construction is such that the cord will be protected from stress and motion.

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

15.1.5 A conductor utilizing beads for insulation shall not be employed outside an enclosure.

15.1.6 Internal wiring shall consist of wires of a type or types that are acceptable for the application, when considered with respect to the temperature and voltage to which the wiring is likely to be subjected and with respect to its exposure to oil, grease, or other conditions of service to which it is likely to be subjected.

15.1.7 With reference to exposure of insulated wiring through an opening in the enclosure of an appliance, the protection of such wiring required by [15.1.1](#) is considered to exist if, when judged as though it were film-coated wire, the wiring would be acceptable according to [11.1](#) and [11.2](#). Internal wiring not so protected may be accepted if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

15.1.8 Wiring that may be located in proximity to combustible material or may be subjected to mechanical damage shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or be otherwise equivalently protected.

15.2 Splices and connections

15.2.1 Each splice and connection shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be mechanically secured before being soldered if breaking or loosening of the connection may result in a risk of fire or electric shock.

15.2.2 For an appliance in which excessive vibration is likely to occur – such as a bin vibrator – the requirement in [15.2.1](#) will necessitate the use of lock washers or other equivalent means to reduce the risk of wire-binding screws and nuts from becoming loosened.

15.2.3 A splice shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts may not be maintained.

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

15.2.5 With reference to the requirements in [15.2.4](#), a wire-binding screw or a pressure wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and the like.

15.2.6 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or of 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 is to be given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

15.2.7 If stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be prevented from contacting other uninsulated live parts that are not always of the same polarity as the wire and from contacting dead 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.

16 Tabs Used in Electrical Quick-Connect Terminals

16.1 General

16.1.1 A tab shall comply with the material requirements in [16.2](#), and the dimensional requirements in [16.3](#).

16.2 Material requirements

16.2.1 A tab shall be made of plain or plated copper alloy, nickel, nickel alloy, or the materials specified in Section [13](#).

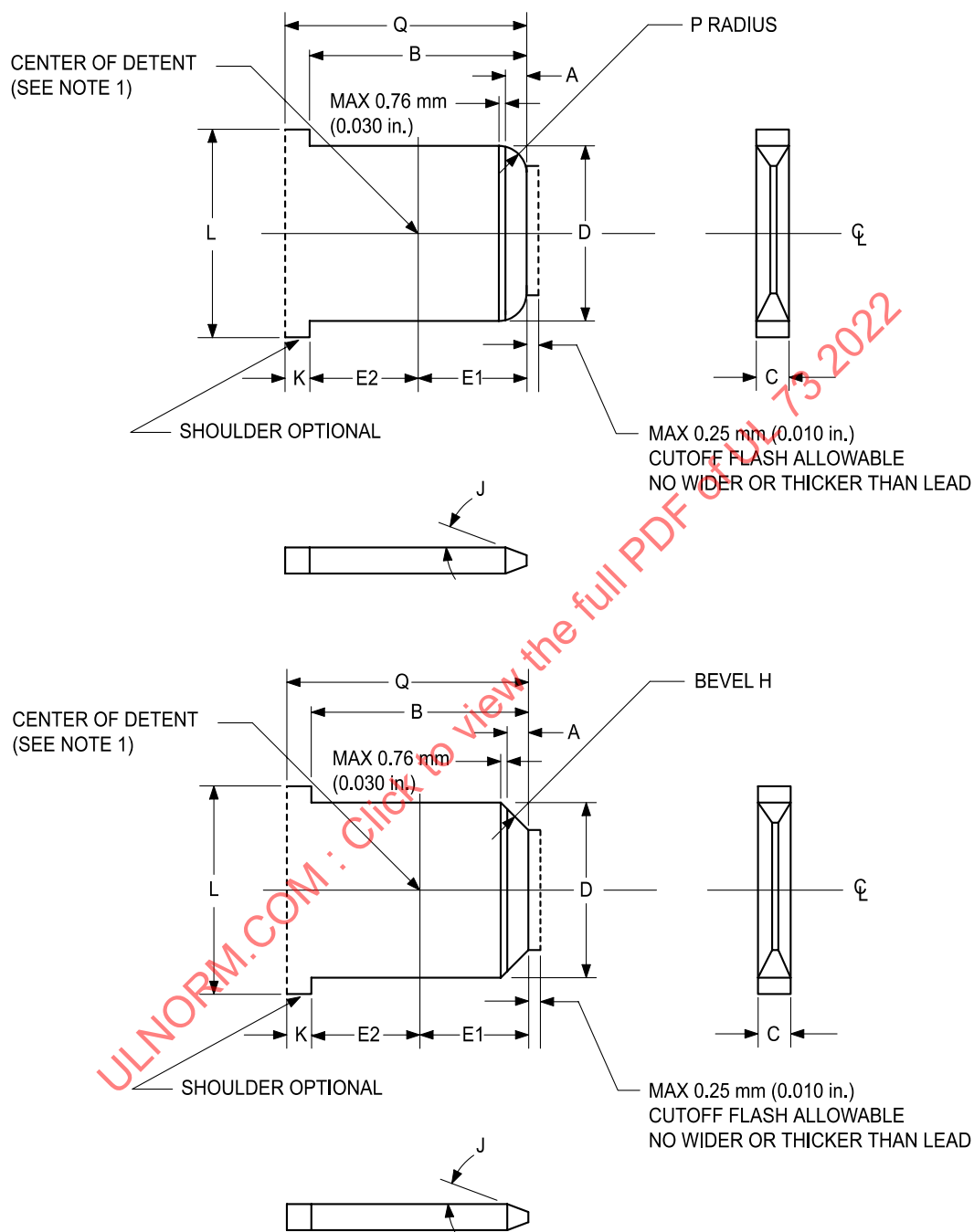
16.2.2 After shearing or removal, a tab that is provided on a feeder strip reel need not be plated on the edge of the connector or tab where it was originally attached to the strip.

16.3 Dimensional requirements

16.3.1 A production tab shall have the configuration shown in [Figure 16.1](#) to [Figure 16.3](#) and the dimensions specified in [Table 16.1](#) and [Table 16.2](#). [Figure 16.2](#) illustrates dimple detents and [Figure 16.3](#) illustrates hole detents.

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Figure 16.1
Tab Dimensions



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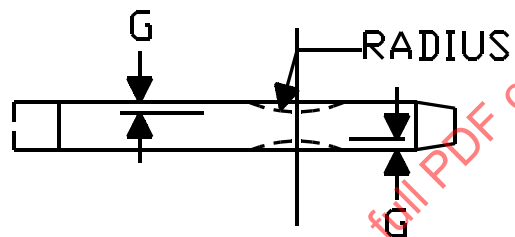
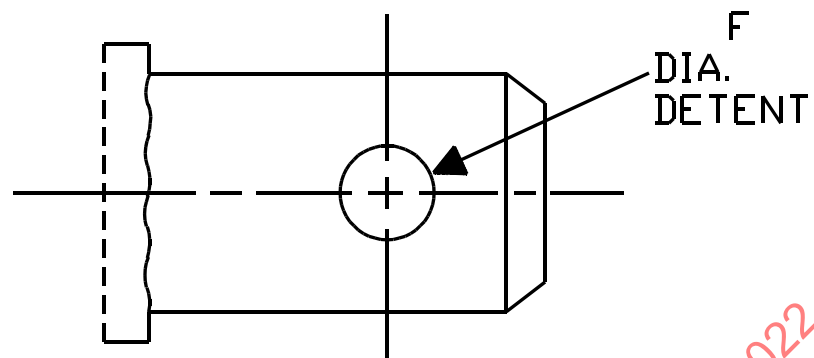
Note 1 – For dimple and hole detent dimensions F, G, M, and N, see [Figure 16.2](#) and [Figure 16.3](#).

Note 2 – Bevel "H" need not be a straight line if it is within the confines shown, and it may be a radius of "P".

Note 3 – "Q" dimension is for tabs without shoulders.

Note 4 – "L" dimension not specified.

Figure 16.2
Dimensions of dimple detents



- OR -

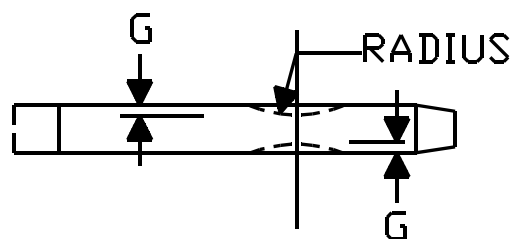
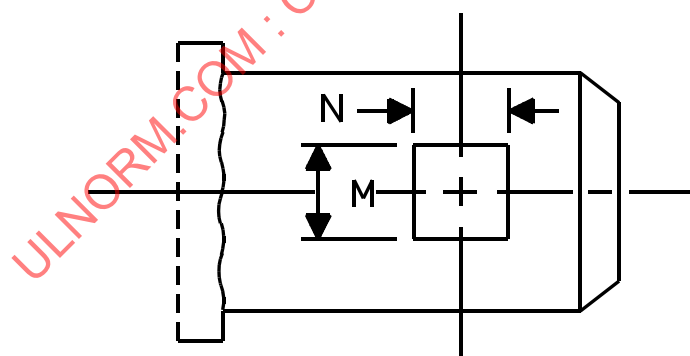
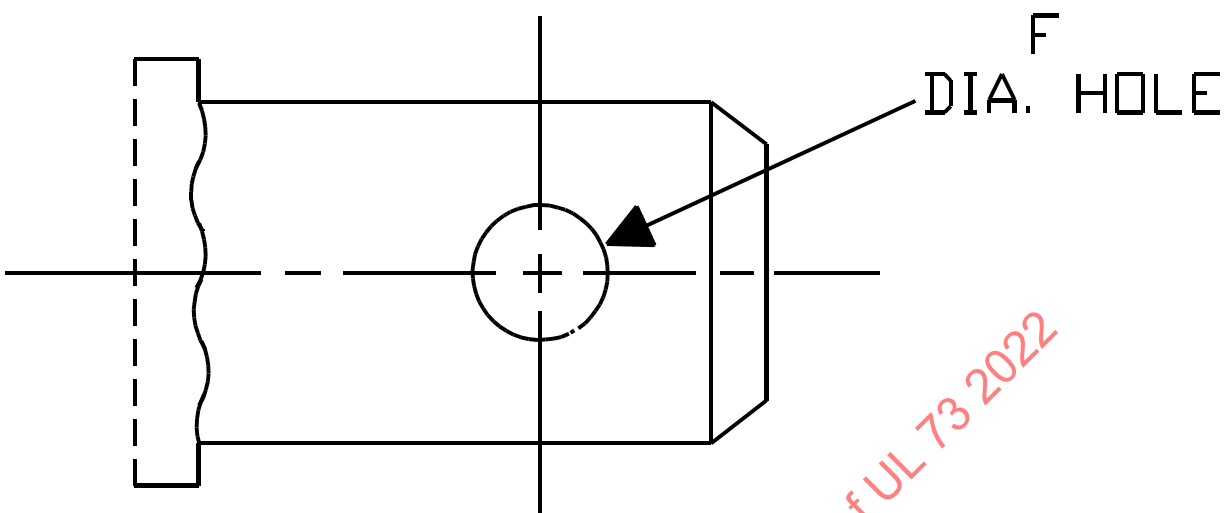


Figure 16.3
Dimensions of hole detents



SM1094A

Table 16.1
Tab dimensions in inches

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
0.110 × 0.020 with dimple	0.024 0.012	0.275	0.021 0.019	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°	0.067 0.055	0.055 0.039	0.055 0.012	0.319
0.110 × 0.020 with hole	0.024 0.012	0.275	0.021 0.019	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°			0.055 0.012	0.319
0.110 × 0.032 with dimple	0.024 0.012	0.275	0.033 0.030	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°	0.067 0.055	0.055 0.039	0.055 0.012	0.319
0.110 × 0.032 with hole	0.024 0.012	0.275	0.033 0.030	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°			0.055 0.012	0.319
0.125 × 0.032 with dimple	0.025 0.015	0.275	0.033 0.031	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°	0.067 0.057	0.053 0.043	0.055 0.015	0.320
0.125 × 0.032 with hole	0.025 0.015	0.275	0.033 0.031	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°			0.055 0.015	0.320
0.125 × 0.020 with dimple	0.025 0.015	0.275	0.021 0.019	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°	0.067 0.057	0.053 0.043	0.055 0.015	0.320

Table 16.1 Continued on Next Page

Table 16.1 Continued

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
0.125 × 0.020 with hole	0.025 0.015	0.275	0.021 0.019	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°			0.055 0.015	0.320
0.187 × 0.020 with dimple	0.035 0.024	0.244	0.021 0.019	0.190 0.181	0.110 0.091	0.153 0.147	0.060 0.050	12° 8°	0.067 0.055	0.059 0.047	0.067 0.024	0.287
0.187 × 0.020 with hole	0.035 0.024	0.244	0.021 0.019	0.193 0.184	0.134 0.117	0.128 0.122	0.060 0.050	12° 8°			0.067 0.024	0.287
0.187 × 0.032 with dimple	0.040 0.027	0.244	0.033 0.030	0.190 0.181	0.110 0.091	0.153 0.147	0.060 0.050	12° 8°	0.067 0.055	0.059 0.047	0.071 0.027	0.287
0.187 × 0.032 with hole	0.040 0.024	0.244	0.033 0.030	0.193 0.184	0.134 0.117	0.128 0.122	0.060 0.050	12° 8°			0.071 0.027	0.287
0.205 × 0.020 with dimple	0.040 0.027	0.244	0.021 0.019	0.210 0.201	0.110 0.091	0.153 0.147	0.075 0.063	12° 8°	0.098 0.086	0.080 0.070	0.067 0.024	0.287
0.205 × 0.020 with hole	0.040 0.027	0.244	0.021 0.019	0.210 0.201	0.134 0.117	0.128 0.122	0.075 0.063	12° 8°			0.067 0.024	0.287
0.205 × 0.032 with dimple	0.040 0.027	0.244	0.033 0.030	0.210 0.201	0.110 0.091	0.153 0.147	0.075 0.063	12° 8°	0.098 0.086	0.080 0.070	0.071 0.027	0.287
0.205 × 0.032 with hole	0.040 0.027	0.244	0.033 0.030	0.210 0.201	0.134 0.117	0.128 0.122	0.075 0.063	12° 8°			0.071 0.027	0.287
0.250 × 0.032 with dimple	0.040 0.027	0.307	0.033 0.030	0.253 0.244	0.161 0.142	0.163 0.157	0.080 0.063	12° 8°	0.098 0.086	0.080 0.070	0.071 0.027	0.350
0.250 × 0.032 with hole	0.040 0.020	0.307	0.033 0.030	0.253 0.244	0.186 0.169	0.137 0.131	0.080 0.063	12° 8°			0.071 0.027	0.350

Table 16.2
Tab dimensions in millimeters

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
2.8 × 0.5 with dimple	0.6 0.3	7.0	0.54 0.47	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.0	1.4 0.3	8.1
2.8 × 0.5 with hole	0.6 0.3	7.0	0.54 0.47	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
2.8 × 0.8 with dimple	0.6 0.3	7.0	0.84 0.77	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.0	1.4 0.3	8.1
2.8 × 0.8 with hole	0.6 0.3	7.0	0.84 0.77	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
3.2 × 0.8 with dimple	0.6 0.3	7.0	0.84 0.79	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.1	1.4 0.3	8.1

Table 16.2 Continued on Next Page

Table 16.2 Continued

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
3.2 × 0.8 with hole	0.6 0.3	7.0	0.84 0.79	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
3.2 × 0.5 with dimple	0.6 0.3	7.0	0.54 0.48	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.1	1.4 0.3	8.1
3.2 × 0.5 with hole	0.6 0.3	7.0	0.54 0.48	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
4.8 × 0.5 with dimple	0.9 0.6	6.2	0.54 0.47	4.80 4.60	2.8 2.3	3.89 3.73	1.5 1.3	12° 8°	1.7 1.4	1.5 1.2	1.7 0.6	7.3
4.8 × 0.5 with hole	0.9 0.6	6.2	0.54 0.47	4.90 4.67	3.4 3.0	3.25 3.10	1.5 1.3	12° 8°			1.7 0.6	7.3
4.8 × 0.8 with dimple	1.0 0.7	6.2	0.84 0.77	4.80 4.60	2.8 2.3	3.89 3.73	1.5 1.3	12° 8°	1.7 1.4	1.5 1.2	1.8 0.7	7.3
4.8 × 0.8 with hole	1.0 0.6	6.2	0.84 0.77	4.90 4.67	3.4 3.0	3.25 3.10	1.5 1.3	12° 8°			1.8 0.7	7.3
5.2 × 0.5 with dimple	1.0 0.7	6.2	0.54 0.47	5.30 5.10	2.8 2.3	3.89 3.73	1.9 1.6	12° 8°	2.5 2.2	2.0 1.8	1.7 0.6	7.3
5.2 × 0.5 with hole	1.0 0.7	6.2	0.54 0.47	5.30 5.10	3.4 3.0	3.25 3.10	1.9 1.6	12° 8°			1.7 0.6	7.3
5.2 × 0.8 with dimple	1.0 0.7	6.2	0.84 0.77	5.30 5.10	2.8 2.3	3.89 3.73	1.9 1.6	12° 8°	2.5 2.2	2.0 1.8	1.8 0.7	7.3
5.2 × 0.8 with hole	1.0 0.7	6.2	0.84 0.77	5.30 5.10	3.4 3.0	3.25 3.10	1.9 1.6	12° 8°			1.8 0.7	7.3
6.3 × 0.8 with dimple	1.0 0.7	7.8	0.84 0.77	6.40 6.20	4.1 3.6	4.14 3.99	2.0 1.6	12° 8°	2.5 2.2	2.0 1.8	1.8 0.7	8.9
6.3 × 0.8 with hole	1.0 0.5	7.8	0.84 0.77	6.40 6.20	4.7 4.3	3.48 3.33	2.0 1.6	12° 8°			1.8 0.7	8.9

16.3.2 All portions of a production tab shall be flat, its surfaces not deviating more than 0.010 in/in (0.010 mm/mm), and free of burrs greater than 10% of the tab thickness, or raised plateaus.

16.3.3 With regard to [16.3.2](#), in an area 0.050 in (1.3 mm) surrounding the detent, a raised plateau over the stock thickness of 0.001 in (0.03 mm) per side is acceptable.

16.3.4 For an optional shoulder, the minimum dimension shall be 0.045 in (1.14 mm). See dimension "K" of [Figure 16.1](#). There shall not be any obstructions within 0.045 in (1.14 mm) of the "K" dimension end of the area defined by dimension "B."

16.3.5 If the detent is located with reference to a shoulder, it shall be located on the tab in accordance with dimension "E2." If no shoulder is provided, the detent shall be located on the tab in accordance with dimension "E1." The center of a hole or detent shall be within 0.003 in (0.08 mm) of the centerline of the tab. The depth of a dimple, dimension "G" on [Figure 16.2](#), shall not be less than 0.003 in (0.08 mm).

16.3.6 Bevel "H" shall be approximately 45°. See Note 2 to [Figure 16.1](#).

16.3.7 Dimensional measurements shall not include plating, burrs, or flatness tolerance.

17 Separation of Circuits

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

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

17.3 In a compartment that is intended for the field installation of conductors, and that contains provision for connection of Class 2 or Class 3 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.

17.4 Class 2 cables provided in an automatic solar panel cleaning system shall be routed separately from, and not be physically attached to, line voltage power supply cords. Class 2 wiring exiting the enclosure and routed to rooftop-mounted or ground-mounted electrically operated zone valves shall be labeled CL2, and shall comply with the applicable requirements of the Standard for Power-Limited Circuit Cable, UL 13. CL2 cable used outdoors shall be suitable for the end use temperature, be rated for outdoor use, and be sun resistant and water resistant.

17.5 Class 2 wires or cables shall not be installed in the same electrical enclosure with line voltage circuit wires or cords unless the line voltage circuit wires or cords are routed to maintain a minimum of spacing of 0.25 in (6 mm) separation from the Class 2 circuit wires or cables.

18 Capacitors

18.1 A capacitor provided as a part of a capacitor motor 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 that will protect the plates against mechanical damage and that will reduce the risk of the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 in (0.51 mm). Sheet metal having a thickness less than 0.026 in (0.66 mm) is not recommended.

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 in thick or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance and provided that such housing is acceptable for the enclosure of live parts.

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

18.3 A capacitor connected from one side of the line to the frame or enclosure of an appliance shall have a capacitance rating of not more than 0.10 μ F. See [42.2](#).

18.4 An appliance that is intended to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such capacitor or unit.

18.5 Under both normal and abnormal conditions of use, a capacitor employing a dielectric medium more combustible than askarel shall not cause a risk of electric shock or fire and shall be protected against expulsion of the dielectric medium.

19 Grounding

19.1 General

19.1.1 An appliance of one or more of the following types shall have provision for grounding.

- a) An appliance for use in damp or wet locations and intended to be used in other than residential occupancies.
- b) An appliance intended to be used on a circuit operating at more than 150 V to ground – see [19.1.2](#).
- c) An upholstery shampooer.
- d) An insecticide sprayer.
- e) An appliance intended to be used outdoors.

Exception: An appliance may be provided with a double insulation system that complies with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097 in place of a provision for grounding.

19.1.2 With reference to [19.1.1\(b\)](#), a two-wire appliance intended to operate at any potential higher than 150 V to ground, shall be provided with means for grounding in accordance with [19.1.5](#) and [19.1.6](#) 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.

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

19.1.4 If a grounding means is provided, whether required or not, it shall be in accordance with [19.1.5](#) and, if the appliance is cord-connected, shall comply with the requirements in [19.1.6](#). All exposed dead metal parts and all dead 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.

19.1.5 The following are 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.
- b) In an appliance intended to be permanently connected by a nonmetal-enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead. See [19.1.10](#) and [70.2.3](#).
- c) In a cord-connected appliance, an equipment grounding conductor in the cord.

19.1.6 The grounding conductor of a supply cord 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. Solder alone shall not be used for securing the grounding conductor. Servicing includes repair of the appliance by qualified service personnel.

19.1.7 The grounding conductor of a cord-connected appliance shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

Exception: The grounding member of the attachment plug on a portable hand-guided or hand-supported appliance may be of the movable, self-restoring type.

19.1.8 A separable connection, such as that provided by an attachment plug and a mating connector or receptacle, shall be such that the equipment-grounding connection is made before connection to and broken after disconnection from the supply conductors.

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

19.1.9 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 equipment grounding complying with [19.1.4](#). All dead metal parts indicated in [19.1.4](#) shall be reliably bonded together and bonded to each equipment grounding means.

19.1.10 A terminal solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size necessary for the application. A connection device that depends on solder alone shall not be provided for connecting the equipment-grounding conductor.

19.1.11 A wire-binding screw or pressure wire connector intended for the connection of an equipment-grounding conductor shall be located so that it is unlikely to be removed during normal servicing of the appliance.

19.1.12 If an isolated ground type receptacle is provided, provision for field wiring connection of a grounding conductor shall be provided. This grounding conductor is not required to be bonded to the equipment grounding conductor. See [70.2.4](#).

19.2 Grounding identification

19.2.1 The surface of the insulation of a grounding conductor of a flexible cord shall be green with or without one or more yellow stripes.

19.2.2 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.

19.2.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or 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," "Grounding," or the like, or by a marking on a wiring diagram provided on the appliance.

20 Heating Elements

20.1 The voltage rating of a heating element employed in an appliance shall not be less than that specified in [Table 20.1](#).

Table 20.1
Rating of heating element

Nominal voltage of circuit	Minimum rating of heating element, V
120	110
208	208
240	220
277	277
480	430
More than 480	Rating of circuit

21 Lampholders

21.1 A lampholder for a low-voltage lamp – for example, a 6-V lamp – shall not be tapped across a part of a winding of a motor if the motor is rated more than 230 V.

21.2 The screw shell of an Edison-base lampholder in a permanently connected appliance, or an appliance equipped with a polarized attachment plug shall be connected to the terminal or lead that is intended to be connected to the grounded conductor of the power-supply circuit.

21A Lamps that Emit Ultraviolet (UV) Radiation

21A.1 Insect and rodent-control equipment shall not employ lamps designed to emit ultraviolet (UV) radiation generating wavelengths less than 250 nm. Incidental UV radiation in wavelengths less than 250 nm is allowed provided that the radiation does not exceed an absolute irradiance level greater than 1% of that generated in the 300-400 nm bands. Care shall be taken in measuring spectral irradiance at wavelengths below 300 nm to exclude instrument noise, which may give an erroneous indication of UV-C radiation. See [66A.5](#) for proper measurements and good laboratory practice.

22 Motors

22.1 Construction

22.1.1 A motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the appliance as described in [46.2.1.1](#) – [46.2.3.1](#) without creating a risk of fire, electric shock, or injury to persons.

22.1.2 A motor winding shall resist the absorption of moisture.

22.1.3 With reference to the requirement in [22.1.2](#), film-coated wire is not required to be additionally treated to resist absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

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

22.2 Brush wear out

22.2.1 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary not to cause accessible dead metal parts to become energized, and live parts to become accessible.

22.3 Overload protection

22.3.1 An appliance shall incorporate thermal or overload protection in accordance with [22.3.2](#) if it is intended to be:

- a) Permanently connected, continuous-duty, and manually started, employing a motor rated 1 hp (746 W output) or less;
- b) Remotely controlled; or
- c) Automatically controlled.

22.3.2 Motor-overload protection required for an appliance shall consist of one of the following:

- a) Thermal protection complying with the requirements specified in [6.16.4.1](#).

Exception No. 1: The duration of the temperature test and endurance test, both under locked-rotor conditions, is not required to comply with the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Thermally Protected Motors, UL 1004-3 when:

- i) The appliance includes a control that positively and reliably limits the length of time the appliance operates; and*
- ii) The total duration of the test is not less than the operating time of the control employed in the appliance.*

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 shaft 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 currents is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

- b) Impedance protection complying with the requirements specified in [6.16.4.2](#), when the motor is tested as used in the appliance under locked-rotor conditions.

- c) Other protection that is shown by test to be equivalent to the protection mentioned in item (a).

Exception: A motor as described in Exception No. 2 to item (a) is not required to have running-overload protection.

- d) Electronic protection complying with the requirements specified in [6.16.4.3](#) or [6.16.4.4](#).

22.3.3 If a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, 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 is to be used if the appliance is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

22.3.4 For a multispeed motor of any of the types mentioned in [22.3.1](#) that employs a separate overload protective device to provide running overload protection, the requirement applies at all speeds at which the motor is intended to operate.

22.3.5 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 [22.3.2](#).

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

22.3.7 Overload devices employed for running overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system and in each ungrounded conductor of a 3-phase supply system.

22.3.8 Fuses employed for motor-running overload protection shall be located in each ungrounded conductor; and in each of the phases of a 3-phase, 3-wire, alternating-current motor.

22.3.9 With reference to [22.3.2\(c\)](#), an overload-protective device conforming with the National Electrical Code, ANSI/NFPA 70, is equivalent to an overload device that is responsive to motor current and is rated or set as specified in column A of [Table 22.1](#). When the rating of the motor-running overload protection determined in accordance with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next higher size, rating, or setting shall be used, and shall not be more than that specified in column B of [Table 22.1](#). For a multispeed motor, each winding connection is to be considered separately.

Table 22.1
Maximum rating or setting of overload-protective device

Type of motor	Ampere rating of device as a percentage of motor full-load current rating	
	A	B
Motor with marked service factor of 1.15 or more	125	140
Motor with marked temperature rise of 40°C or less	125	140
Any other motor	115	130

22.3.10 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in [22.3.2](#).

22.4 Insulation systems

22.4.1 Class A insulation systems shall consist of a combination of magnet wire and major component insulation materials evaluated and found to operate as intended in its end use. Thermoset materials and materials in [Table 22.2](#) at the thicknesses specified are permitted to be used without further evaluation.

Table 22.2
Primary Class A insulating materials and minimum thicknesses

Material	Minimum thickness	
	in	(mm)
Vulcanized fiber	0.028	(0.71)
Polyethylene terephthalate film	0.007	(0.018)
Cambric	0.028	(0.71)

Table 22.2 Continued on Next Page

Table 22.2 Continued

Material	Minimum thickness	
	in	(mm)
Treated Cloth	0.028	(0.71)
Electrical grade paper	0.028	(0.71)
Mica	0.006	(0.15)
Aramid paper	0.010	(0.25)

22.4.2 For Class A insulation systems employing other materials or thinner materials than those indicated in [Table 22.2](#) or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements in [22.4.3](#).

22.4.3 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. Motors employing thermoplastic materials shall be subjected to the tests in thermoplastic motor insulation systems, Section [63](#).

Exception: Other polymeric materials used in a Class 105 (A) insulation system shall comply with the requirements for thermal aging in [63.4](#).

22.4.4 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.

22.4.5 All insulation systems employing integral ground insulation shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

23 Overload- or Thermal-Protective Devices

23.1 An overload- or thermal-protective device shall have a current and voltage rating not less than the load that it controls.

23.2 If the current rating of an appliance is more than 40 A, and there are subdivided circuits within the appliance feeding two or more power-consuming components – motors, motor-control circuits, electric heating elements – connected in parallel with each other across any pair of main-supply terminals or leads, overcurrent protection shall be provided as a part of the appliance for the conductors of each terminal circuit.

Exception: Additional overcurrent protection is not required as a part of the appliance for the conductors of the subdivided circuits described below:

- a) For each separate motor or heating-element circuit supplied by insulated conductors having an ampacity at least one-third that of the protective device in the branch circuit to which the appliance will properly be connected.*
- b) For each separate motor-control circuit supplied by insulated conductors having an ampacity at least one-fifth that of the protective device in the branch circuit to which the appliance will properly be connected.*

23.3 A protective device that requires resetting or replacement after it opens shall be readily accessible.

Exception: The protective device need not be readily accessible provided:

- a) The appliance, with the protective device shunted out of the circuit, complies 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 diagrams, and the like for the appliance.*

23.4 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.

23.5 A fuseholder shall be constructed and installed so that no uninsulated live part other than the screw shell or clips will be exposed to contact by persons removing or replacing fuses.

Exception: The requirement does not apply if 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 diagrams, and the like for the appliance.

23.6 The screw shell of a plug-type fuseholder shall be connected toward the load.

24 Arc-Fault, and Leakage Current Detectors / Interrupters

24.1 When required by this end-product standard, or when provided as part of an end-product, an AFCI or LCDI shall comply with [6.11](#) and [24.2](#) – [24.4](#).

24.2 An arc-fault circuit-interrupter (AFCI) or leakage-current detector-interrupter (LCDI) shall be installed as an integral part of the attachment plug or located in the supply cord within 4 in (102 mm) of the attachment plug.

24.3 Arc fault detection testing shall include the applicable UL 1699 tests required for cord-type arc-fault circuit-interrupters.

Exception: The carbonized path arc clearing time test is not applicable for LCDIs that are provided with shielded power-supply cords.

24.4 An AFCI or LCDI provided as part of an appliance intended for outdoor use shall comply with the applicable outdoor use requirements of this end product standard.

25 Receptacles

25.1 A 15- or 20-A general-use attachment-plug receptacle in an appliance provided with a means for grounding – a permanently wired appliance or a cord-connected appliance with a grounding conductor in the cord – shall be of the grounding type. The grounding contact of the receptacle shall be electrically connected to dead metal that will be grounded when the appliance is in use.

25.2 A general purpose receptacle rated for use on a nominal 120 V circuit shall be of a polarized type. The grounded supply conductor shall be 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.

25.3 Each circuit having an attachment-plug receptacle intended for general use shall have overcurrent protection of not more than 20 A provided as a part of the appliance if the overcurrent protection of the branch circuit to which the appliance will properly be connected exceeds that acceptable for the receptacles. The overcurrent protection provided shall be of the time-delay type.

25.4 A 120-V, single-phase, 15- or 20-A receptacle outlet installed in an appliance intended for outdoor use shall have ground-fault circuit protection.

Exception: A cord-connected portable appliance need not comply with this requirement.

25.5 A fuseholder provided in accordance with [25.3](#) shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable adapter of Type S construction.

25.6 The face of a 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.

26 Switches and Controls

26.1 A switch or other control device shall have a current and voltage rating not less than that of the load that it controls.

26.2 With reference to the requirement in [26.1](#), the current rating 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 transformer or ballast unless the switch has been investigated and found acceptable for the application.

26.3 In an appliance rated 125 or 125/250 V (3-wire) or less, a switch or an overcurrent-protective device of the single pole type other than an automatic control without a marked off position shall be electrically connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

26.4 A manually operated motor-control switch shall be provided in a cord-connected appliance that employs a motor rated more than 1/3 hp (250 W output).

Exception: If the appliance is marked in accordance with [70.3.1](#), the manually operated motor-control switch need not be provided in an appliance where the switch would be inaccessible.

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

26.6 A recessed ultrasonic cleaner that may introduce a risk of electric shock or injury that may not be readily apparent to the user (such as inadvertent exposure to hazardous voltages or ultrasonic energy), shall be provided with a visual indicator (such as a light) that indicates to the user the cleaner is on. This indicator shall be located in an area that is readily visible to the user.

26.7 A recessed ultrasonic cleaner provided with a membrane switch shall comply with the Puncture Test; see Section [52](#). A membrane switch is considered to be a momentary switching device in which at least one contact is on, or made of, a flexible substrate.

26.8 A recessed ultrasonic cleaner that uses a container into which liquid is intended to be added by the user, and that is provided with a water level or water sensor control shall:

- a) Comply with the Abnormal Dry Operation Test with the water level or water sensor control shunted from the appliance circuitry; see [55.3](#); or
- b) The water level or water sensor control shall comply with the Standard for Solid-State Controls for Appliances, UL 244A when investigated as a safety control. If during this investigation, a malfunction or breakdown of an electronic component located in the water level or water sensor control circuit of the appliance results in increased risk of shock, fire, or injury to persons, the circuit and electronic components shall comply with the applicable requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

27 Controls – End Product Test Parameters

27.1 General

27.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in [6.6](#).

27.1.2 Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

27.2 Auxiliary controls

27.2.1 Auxiliary controls shall not introduce a risk of electric shock, fire, or personal injury.

27.2.2 Auxiliary controls shall comply with the requirements of this end product standard.

Exception: An auxiliary control that complies with a component standard(s) specified in [6.6](#) is considered to fulfill this requirement.

27.3 Operating controls (regulating controls)

27.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1:

- a) Control action Types 1 or 2;
- b) Unless otherwise specified this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;
- c) Installation class 2 per the Standard for Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test, IEC 61000-4-5;
- d) For the applicable Overvoltage Category, see [Table 27.1](#);
- e) For the applicable Material Group, see [Table 27.2](#);
- f) For the applicable Pollution Degree, see [Table 27.3](#).

Table 27.1
Overvoltage categories

Appliance	Overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected	II
Control located in low-voltage circuit	I
NOTE – Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would increase the risk of fire or electric shock.	

Table 27.2
Material group

CTI PLC value of insulating materials	Material group
$CTI \geq 600$ (PLC = 0)	I
$400 \leq CTI < 600$ (PLC = 1)	II
$175 \leq CTI < 400$ (PLC = 2 or 3)	IIIa
$100 \leq CTI < 175$ (PLC = 4)	IIIb
NOTE – PLC stands for Performance Level Category, and CTI stands for Comparative Tracking Index as specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.	

Table 27.3
Pollution degrees

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically a hermetically sealed or encapsulated control without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in household or commercial clean environments achieve this degree.	2
Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected. Typically controls located near and may be adversely affected by motors with graphite or graphite composite brushes, or outdoor use appliances achieve this degree.	3

27.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1:

- a) Control action Types 1 or 2;
- b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;
- c) For the applicable Overvoltage Category, see [Table 27.1](#);
- d) For the applicable Material Group, see [Table 27.2](#);

e) For the applicable Pollution Degree, see [Table 27.3](#).

27.4 Protective controls (limiting controls)

27.4.1 An electronic control that performs a protective function shall comply with the applicable requirements in [6.6](#) while tested using the parameters in this section. Examples of protective controls are: a control used to sense abnormal temperatures of components within the appliance; an interlock function to de-energize a motor; temperature protection of the motor due to locked rotor, running overload, loss of phase; or other function intended to reduce the risk of electric shock, fire, or injury to persons.

27.4.2 The following test parameters shall be among the items considered when determining the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1:

- a) Failure-Mode and Effect Analysis (FMEA) or equivalent Risk Analysis method;
- b) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 10°C (18°F) and the maximum ambient temperature determined by conducting the Temperature Test; see Section [46](#);
- c) Surge Immunity Test – installation class 3 shall be used;
- d) Electrical Fast Transient/Burst Test, a test level 3 shall be used;
- e) Electrostatic Discharge Test;
- f) Radio-Frequency Electromagnetic Field Immunity:
 - 1) Immunity to conducted disturbances – When applicable, test level 3 shall be used; and
 - 2) Immunity to radiated electromagnetic fields; field strength of 3 V/m shall be used;
- g) Thermal Cycling Test shall be conducted at ambient temperatures of 10.0 ±2°C (50.0 ±3°F) and the maximum ambient temperature determined by conducting the Temperature Test; see Section [46](#). The test shall be conducted for 14 days;
- h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test; see Section [46](#); and
- i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class B.

27.4.3 The test parameters and conditions used in the investigation of the circuit covered by [27.4.1](#) shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

- a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;
- b) A field strength of 3 V/m is to be used for the Radiated EMI Test;
- c) The Composite Operational and Cycling Test is to be conducted for 14 days at temperature extremes of 0°C (32°F) and 70°C (158°F);
- d) The Humidity Class is to be based on the appliance's intended end use and is to be used for the Humidity Test;

- e) A vibration level of 5 g is to be used for the Vibration Test;
- f) The Computational Investigation is not applicable to appliances covered by this end product standard;
- g) For the Demonstrated Method Test, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5,763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C (77°F) use ambient;
- h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (18°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use;
- i) For the Electrical Fast Transient Burst Test, test level 1 is to be used;
- j) Conduct a failure-mode and effect analysis (FMEA).
- k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

27.4.4 Unless otherwise specified in this standard, protective controls shall be evaluated for 100,000 cycles for Type 2 devices and 6,000 cycles for Type 1 devices with rated current.

27.5 Controls using a temperature sensing device

27.5.1 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control, shall be tested using the following number of cycles when testing a sensing device in accordance with the endurance test:

- a) For a device employed as a operating device – 6,000 cycles,
- b) For a device employed as a protective device – 100,000 cycles, and
- c) For a device employed as a combination operating and protective device – 100,000 cycles.

28 Spacings

28.1 Other than at wiring terminals, the spacing between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part that is exposed to contact by persons or that may be grounded shall not be less than the value specified in [Table 28.1](#).

Exception No. 1: The inherent spacings of a component of the appliance, such as a snap switch, are investigated on the basis of the requirements for the component in question.

Exception No. 2: This requirement does not apply if a spacing complies with the requirements in [28.5](#).

Table 28.1
Spacings at other than field-wiring terminals

Potential involved, V	Diameter of motor used in appliance			
	7 in (178 mm) or less ^a		More than 7 in (178 mm) ^{a,c}	
	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)
0 – 125	3/32 (2.4) ^b	3/32 (2.4) ^b	1/4 (6.4) ^c	1/8 (3.2) ^c
126 – 250	3/32 (2.4)	3/32 (2.4)	1/4 (6.4) ^c	1/4 (6.4) ^c
251 – 600	1/2 (12.7) ^c	3/8 (9.5) ^c	1/2 (12.7)	3/8 (9.5) ^c
^a See 22.1.4 . ^b For an appliance employing a motor rated at 1/3 hp (250 W output) or less, these spacings may be not less than 1/16 in (1.6 mm). ^c Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 in (2.4 mm) over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.				

28.2 If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing will be maintained.

28.3 In an appliance incorporating two or more motors of different sizes, the spacings in the appliance are to be investigated on the basis of the size of the largest motor in the appliance.

28.4 The spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electric Machines – General Requirements, UL 1004-1.

28.5 If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, to a live part and an exposed dead metal part, or to a live part and a dead metal part that may be grounded, the spacing may be not less than 3/64 in (1.2 mm) between the isolated dead metal part and any one of the other parts previously mentioned, provided the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in [Table 28.1](#).

28.6 An insulating lining or barrier of vulcanized fiber or similar materials employed where spacing would otherwise be insufficient shall not be less than 1/32 in (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 1/64 in (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50% of the spacing required for air alone.

Exception No. 2: Thinner insulating material may be used, if upon investigation, it is found to be acceptable for the application.

28.7 All uninsulated live parts connected to different – line- or low-voltage – circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in [28.1](#) and [28.9](#) and shall be investigated on the basis of the highest voltage involved.

28.8 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified for parts of low-voltage circuits.

28.9 The spacing between wiring terminals of opposite polarity, and between a wiring terminal and any other uninsulated metal part – dead or live – not of the same polarity, shall not be less than that specified in [Table 28.2](#). See [12.3.3.2](#).

Table 28.2
Spacings at wiring terminals

Potential involved, V	Minimum spacings, in (mm)		
	Between wiring terminals, through air, or over surface	Between terminals and other uninsulated metal parts not always of the same polarity ^a	
		Over surface	Through air
250 or less	1/4 (6.4)	1/4 (6.4)	1/4 (6.4)
More than 250	1/2 (12.7) ^b	1/2 (12.7) ^b	3/8 (9.5)

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

^b A spacing of not less than 3/8 in, through air and over surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

28.10 At terminal screws and studs to which connection may be made in the field by means of the wire connectors, eyelets, and the like, as described in [12.3.3.2](#), spacings shall not be less than those specified in [Table 28.1](#) when such connectors, eyelets, and the like, are in such position that minimum spacings – opposite polarity and to dead metal – exist.

29 Spacings On Printed Wiring Boards

29.1 As an alternative to the spacing requirements of [Table 28.1](#), the spacing requirements in Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

29.2 The following end use factors from this standard shall be applied:

- a) For the applicable Overvoltage Category, see [Table 27.1](#);
- b) For the applicable Material Group, see [Table 27.2](#);
- c) For the applicable Pollution Degree, see [Table 27.3](#).

29.3 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product. This voltage limiting device or system shall comply with the Standard for Surge Protective Devices, UL 1449.

29.4 All printed wiring boards are identified as having a minimum comparative tracking index (CTI) of 100 without further investigation, for evaluation to Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

30 Components Used in Automatic Solar Cleaning Systems

30.1 In addition to complying with the applicable component requirements of this standard, components used in an automatic solar cleaning system shall comply with [30.2](#) – [30.13](#).

30.2 Irrigation controllers shall comply with the applicable requirements of the Standard for Electric Plumbing Accessories, UL 1951. The controller shall be rated for outdoor use, and shall have Class 2 outputs for connection of components of the automatic solar cleaning system.

30.3 If the irrigation controller is intended for fixed installation, the controller shall not be electrically connected to the supply using a power supply cord and attachment plug. If the controller is intended for

stationary installation using a keyhole slot or the like, then a power supply cord and attachment plug may be used for electrical connection to the power supply; see [12.2.2.6](#) and [12.3.1.1](#).

30.4 Motor-operated water pumps shall comply with the applicable requirements of the Standard for Motor Operated Water Pumps, UL 778. If the pump is located in a box with a non-self restoring cover that can be opened without the use of tools, the pump shall be separately enclosed in an enclosure that meets the requirements of Sections [7](#) and [11](#), or the pump shall be rated for outdoor use.

30.5 An electrical enclosure shall comply with the applicable requirements of the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50; and the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E. The enclosure shall be suitably sized for the number of conductors, and have a suitable environmental rating based on its intended end use.

30.6 A metallic outlet box and cover shall comply with the applicable requirements of the Standard for Metallic Outlet Boxes, UL 514A. The box and cover shall be suitably sized for the number of conductors, and be rated for outdoor use, if applicable.

30.7 Electrically operated valves shall comply with one of the following:

a) Valves connected to a line voltage circuit shall comply with the applicable requirements of the Standard for Electrically Operated Valves, UL 429, and shall be rated for outdoor use if applicable; or

b) Valves connected to the Class 2 output of the irrigation controller shall comply with the applicable requirements of the Standard for Electrically Operated Valves, UL 429; or shall comply with the applicable requirements of this end-product standard and be subjected to the tests in Section [64](#). The electrical leads of the valves shall comply with the Standard for Appliance Wiring Material, UL 758, and be suitably rated for the intended use.

30.8 A relay shall comply with the Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2. The relay shall be suitably rated for the voltage, current, and load being switched/controlled.

30.9 Conduit fittings shall comply with the Standard for Conduit, Cable, and Cable Fittings, UL 514B. The fittings shall be suitably sized for the cord size, and have a suitable environmental rating based on its intended end use (such as liquid tight, wet location, and/or suitable type rating).

30.10 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG (0.33 – 5.3 mm²) copper conductors, having nominal widths of 0.110, 0.125, 0.187, 0.205, and 0.250 in (2.8, 3.2, 4.8, 5.2, and 6.3 mm), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick Connect Terminals, UL 310. The terminals shall be suitably rated for voltage, current, type and size of conductors, and temperatures of the end-use application.

Exception No. 1: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with the Standard for Electrical Quick Connect Terminals, UL 310.

Exception No. 2: A connector that complies with the Standard for Electrical Quick Connect Terminals, UL 310 may be used with an appropriately sized tab that complies with Section [16](#). The connector is the part

of a quick-connect terminal that is pushed onto the male tab, and the tab is the part that receives the female connector.

30.11 Twist-on, splicing wire connectors (wire nuts) shall comply with the Standard for Splicing Wire Connectors, UL 486C. The connectors shall be suitably rated for voltage, current, type and size of conductors, and temperature of the end-use application.

30.12 If the system is provided with a means to inject soap or any other chemical into the water stream, a backflow prevention device shall be provided. The device shall be installed downstream from the last valve (including any solenoid) in the water supply system. The device shall comply with the Performance Requirements for Atmospheric Type Vacuum Breakers, ASSE 1001; or the Performance Requirements for Hose Connection Vacuum Breakers, ASSE 1011. The device shall be suitably rated for the maximum water pressure and temperature of the system.

30.13 A system provided with a reservoir or liquid container intended to be filled by the user shall be subjected to the Flooding Overflow Test in [50.3](#).

31 Flooding of Live Parts

31.1 An appliance that may be used outdoors; or an appliance that uses elastomeric or polymeric parts that may or may not be subjected to flexing; or a recessed ultrasonic cleaner provided with a liquid container or that may be immersed, shall not introduce a risk of fire or electric shock. Compliance shall be determined by the applicable Resistance-to-Water Tests in Section [50](#) as follows:

- a) An outdoor use appliance that is not marked as specified in [70.8.2](#) shall comply with [50.1](#);
- b) An appliance that uses a timer switch or of a float- or pressure-operated switch, a boot or diaphragm, or seals and gaskets, shall comply with [50.2](#);
- c) A recessed ultrasonic cleaner that uses a container into which liquid is intended to be added by the user shall comply with [50.4](#);
- d) A recessed ultrasonic cleaner that may be used in a kitchen sink and may be inadvertently subjected to partial or full immersion shall comply with [50.5](#).

31.2 If the failure of a liquid container provided as part of a recessed ultrasonic cleaner may result in a risk of fire or electric shock, the container shall be of a material which is compatible with the liquid intended to be used therein.

PROTECTION AGAINST INJURY TO PERSONS

32 General

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

32.2 When investigating an appliance with respect to the requirement in [32.1](#), consideration shall be given to reasonably foreseeable misuse of the appliance.

32.3 A functional attachment that is made available or recommended by the manufacturer for use with the basic appliance shall be included in the investigation of the appliance. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be investigated with the appliance.

32.4 Whether a guard, a release, an interlock, or the like is required and whether such a device is adequate 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.

32.5 Specific constructions, tests, markings, guards, and the like are detailed for some common constructions. Specific features and appliances not covered are to be given appropriate consideration.

33 Sharp Edges

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

Exception: This requirement does not apply to a part or portion of a part needed to perform a working function.

34 Enclosures and Guards

34.1 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, and such a part shall not be contacted by the probe illustrated in [Figure 11.1](#).

Exception No. 1: An opening in the integral enclosure of a motor 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 11.2](#).

Exception No. 2: A part or portion of a part that is necessarily exposed to perform the work function need not be enclosed but, when necessary, guarding shall be provided. See [34.4](#).

34.2 During the examination of an appliance to determine whether it complies with the requirements in [34.1](#), a part of the enclosure that may be removed without the use of a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

Exception: A part need not be opened or removed provided the appliance is marked in accordance with [70.1.7](#).

34.3 Among the factors to be considered in judging the acceptability of an exposed moving part are:

- a) The degree of exposure necessary to perform the intended function,
- b) The sharpness of the moving part,
- c) The likelihood of unintentional contact therewith,
- d) The speed of the moving part, and
- e) The likelihood that a part of the body would be endangered or that clothing would be entangled by the moving part, resulting in a risk of injury to persons.

These factors are to be considered with respect to both intended operation of the appliance and any reasonably foreseeable misuse.

34.4 Some guards are required to be self-restoring. Other features of guards that are to be considered include:

- a) Removability without the use of a tool;
- b) Removability for servicing;
- c) Strength and rigidity;
- d) Completeness;
- e) Creation of a risk of injury to persons such as a pinch point, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and the like; and
- f) Usage – household or commercial.

34.5 An enclosure or guard over a rotating part shall retain a part that, because of breakage or other reasons, may become loose or may separate from a rotating part, and retain a foreign object that may be struck and propelled by the rotating part.

34.6 If complete guarding of a moving part that could obviously cause injury to persons would defeat the utility of an appliance, a control, such as a momentary contact switch, shall be provided; and an appropriate marking shall be provided in the instruction manual warning the user of the potential risk.

34.7 A feeding mechanism, either manual or automatic, shall be constructed or guarded to reduce the likelihood or necessity of the operator's fingers being in an area that could cause injury. If the average inside diameter – one-half the sum of the maximum and minimum dimensions – of the throat of a hopper or tubular feed opening for manual feeding is not more than 2-1/2 in (64 mm), it is considered acceptable, if the cutters are recessed below the plane of the opening.

34.8 A cutting or slicing mechanism shall be guarded.

Exception: If exposure of the blade or equivalent part is necessary for the cutting or slicing operation, guarding need not be provided.

35 Materials

35.1 The material of a part – such as an enclosure, a frame, a guard, or the like – the breakage or deterioration of which may result in a risk of injury to persons shall have such properties as to meet the demand of expected loading conditions.

35.2 The requirement in [35.1](#) applies to those portions of a part adjacent to a moving part considered to involve a risk of injury to persons.

36 Rotating or Moving Members

36.1 A rotating or moving part that, if it should become disengaged, may create a risk of injury to persons shall be provided with a means to retain the part in place under conditions of use.

36.2 A rotating member, the breakage of which may create a risk of injury to persons, shall be constructed to reduce the likelihood of its breakage, or the release or loosening of a part that could become a risk of injury to persons.

36.3 To determine whether an appliance employing a series motor complies with the requirement in [36.2](#), it shall be tested as described in [36.4](#). A part that can become a risk of injury to persons shall not work loose.

36.4 For the test required by [36.3](#), an appliance employing a series motor is to be operated for 1 min at the no-load speed resulting from application of 1.3 times rated voltage. An appliance in which the rotating load may be varied is to be tested for each condition of loading that can occur.

37 Parts Subject to Pressure

37.1 A pressure vessel having an inside diameter more than 6 in (152 mm), subjected to a pressure more than 15 psig (102 kPa), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors shall be marked in accordance with the appropriate boiler and pressure vessel code symbol of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined in accordance with [37.3](#).

37.2 A pressure vessel, because of its application, not covered by the scope of the inspection procedure of the ASME code shall be constructed so that it will comply with requirements in [37.3](#).

37.3 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand a pressure equal to the highest of the following that is applicable:

- a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as a part of the assembly.
- b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with item (a).
- c) Five times the pressure setting of a required pressure-relief device.
- d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly unless the pressure is limited by a pressure-relief device in accordance with item (a).
- e) Five times the working pressure marked on the part.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints, provided the wall thickness of tubing is not less than the value specified in [Table 37.1](#).

Exception No. 2: This requirement does not apply to a pressure vessel bearing the ASME code inspection symbol – other than the UM symbol – provided the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Table 37.1
Wall thickness for copper and steel tubing

Outside diameter		Minimum wall thickness		Maximum pressure to which tubing is subjected, psig (MPa)		
in	(mm)	in	(mm)	Seamless copper	Butt-welded steel	Seamless steel
3/8 or smaller	(9.5)	0.016	(0.41)	500 (3.45)	600 (4.14)	1000 (6.90)
1/2	(12.7)	0.016	(0.41)	400 (2.76)	480 (3.31)	800 (5.52)
5/8	(15.9)	0.016	(0.41)	320 (2.21)	384 (2.65)	640 (4.42)
5/8	(15.9)	0.021	(0.53)	420 (2.90)	504 (3.48)	840 (5.80)
3/4	(19.0)	0.021	(0.53)	360 (2.48)	432 (2.98)	720 (4.97)
3/4	(19.0)	0.025	(0.64)	420 (2.90)	504 (3.48)	840 (5.80)
1	(25.4)	0.021	(0.53)	260 (1.79)	312 (2.15)	520 (3.59)
1	(25.4)	0.025	(0.64)	320 (2.21)	384 (2.65)	640 (4.42)

37.4 If a test is necessary to determine whether a part complies with requirements in [37.3](#), two samples of the part are to be subjected to a hydrostatic pressure test. Each sample is to be filled with water so as to exclude air, and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value, and is to be held at that value for 1 min. The results are not acceptable if either sample bursts or leaks.

Exception: Leakage or rupture of a nonmetallic fluid transfer line and its connections, or at a gasket is acceptable if repeated tests conducted with the media they are intended to contain show no evidence of presenting a risk of injury to persons or of electric shock.

37.5 A part supported or actuated hydraulically that could result in a risk of injury to persons due to pressure loss shall comply with the requirement in [37.4](#) when tested at a pressure equal to five times the maximum pressure capable of being developed in the system.

37.6 In an automatic solar panel cleaning system, parts subjected to water pressure shall be subjected to the hydrostatic pressure test in [37.4](#). The test pressure shall be two times the maximum rated pressure of the system, or two times the water pressure delivered by the system pump to the valve, whichever is greater.

37.7 Electrically operated hydraulic directional controls valves shall have a rated working pressure of at least the pressure corresponding to the rating of the pressure relief device. Electrically operated valves complying with the Hydrostatic Strength Test, conducted at two times the valve rating, in the Standard for Electrically Operated Valves, UL 429 are considered suitable except as indicated in [37.5](#).

37.8 Non-electrical pilot-operated hydraulic directional control valves shall be provided with standard thread configurations for the connection of the hydraulic hoses and shall comply with [37.4](#), with a test pressure of two times the rating of the pressure relief device, except as indicated in [37.5](#).

38 Pressure-Relief Devices

38.1 A means for relieving pressure shall be provided for a part in which pressure might be generated by an external source of heat.

38.2 A pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means may be employed to comply with the requirement in [38.1](#).

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

38.4 There shall be no shutoff valve between the pressure-relief means and the parts that it is intended to protect.

38.5 A vessel having an inside diameter of more than 3 in (76 mm) and subject to air or steam pressure generated or stored within the appliance shall be provided with a pressure-relief device.

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

38.7 A pressure-relief device shall:

- a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect;
- b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and
- c) Have its discharge opening located and directed so that:
 - 1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture, and
 - 2) The likelihood of scalding persons is reduced.

38.8 A pressure-relief device having an adjustable setting is to be investigated on the basis of the maximum setting unless the adjusting means is reliably sealed at a lower setting.

38.9 The control that limits the pressure in a vessel required to have a pressure-relief device shall perform under rated load for 100,000 cycles of operation, and shall operate so that the pressure does not exceed 90% of the relief-device setting under any condition of normal operation.

39 Switches, Controls, and Interlocks

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

39.2 Each function of a multiple-function appliance is to be taken into consideration in determining whether the appliance complies with the requirements in [39.1](#).

39.3 If, when energized, an appliance has a moving part that may cause injury to persons, a motor control switch shall be provided on the appliance. See [70.1.6](#).

39.4 If unintentional operation of a switch can result in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely.

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

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

39.7 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

39.8 An interlock shall not be capable of being defeated by materials such as wood or metal chips that could accumulate in normal use.

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

- a) Without damaging the appliance,
- b) Without making wiring connections or alterations, or
- c) By using materials that are readily available.

39.10 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 requirements in [39.6](#).

39.11 A floor- or ground-supported appliance that can travel or rotate to an extent that could result in injury to persons if left unattended shall be provided with a momentary contact switch that cannot be locked in the on position.

39.12 A device that automatically starts an appliance, such as a timer, an automatically reset overload-protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

39.13 The requirement in [39.12](#) will necessitate the use of an interlock if moving parts or the like could result in a risk of injury to persons upon the automatic starting or restarting of the motor.

40 Specific Appliances

40.1 Self-propelled appliance

40.1.1 A self-propelled appliance weighing more than 50 lb (22 kg) when fully loaded shall be provided with a braking means.

40.2 Recessed ultrasonic cleaner

40.2.1 A recessed ultrasonic cleaner provided with a safety door or guard, which if opened, may expose the user to ultrasonic energy, shall be interlocked as part of an interlock system.

40.2.2 The interlock system shall:

- a) Disconnect power to the transducers immediately after the door or guard is opened.
- b) Comply with the interlock switch requirements in [39.6](#) – [39.10](#);
- c) Still function as intended after being subjected to the Abnormal Operation – Electronic Components Tests in [55.2](#);
- d) Comply with the Interlock System Endurance Test in Section [65](#); and
- e) Comply with the interlock switch requirements in [39.6](#) – [39.10](#) after the 5 ft-lb ball impact and crushing resistance tests in Section [66](#), if the appliance uses a polymeric door or guard.

40.2.3 The circuit and related components that affect the radiated emissions of the transducer shall be subjected to the Abnormal Operation – Electronic Components Test in [55.2](#). As a result of the abnormal operation test, the radiated emissions shall not increase the risk of personal injury, and shall not increase the risk of fire or electric shock.

41 Stability

41.1 If a portable appliance overturns when tested as described in [41.2](#) – [41.4](#), a risk of injury to persons shall not result.

Exception: An appliance that is completely hand supported in normal use need not be tested.

41.1.1 With respect to the Exception to [47.1.1](#), if the flashlight or lantern is intended to be operated while the product is floor- or counter-supported, it shall not overturn when subjected to the test of [41.2](#) – [41.4](#).

41.2 The appliance is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the appliance to overturn. The following conditions are to be such as to result in the least stability:

- a) Position of all doors, drawers, casters, and other movable or adjustable parts, including that of the supply cord resting on the surface supporting the appliance;
- b) Connection of or omission of any attachment made available or recommended by the manufacturer;
- c) Provision of or omission of any normal load if the appliance is intended to contain a liquid or other mechanical load; and
- d) Direction in which the appliance is tipped or the supporting surface is inclined.

41.3 In conducting the stability test, the appliance is to be:

- a) Placed on a plane inclined at an angle of 10° from the horizontal; or
- b) Tipped through an angle of 10° from an at rest position on a horizontal plane.

41.4 With reference to the requirement in [41.3\(b\)](#), for an appliance that is constructed so that while being tipped through an angle of 10° a part or surface of the appliance not normally in contact with the horizontal supporting surface touches the supporting surface before the appliance has been tipped through an angle of 10°, the tipping is to be continued until the surface or plane of the surface of the appliance originally in contact with the horizontal supporting surface is at an angle of 10° from the horizontal supporting surface.

41.5 An appliance not intended to move from its de-energized position to perform its intended function that, when operated, moves from its de-energized position shall be provided with an anchoring means.

41A Protection from Overexposure to Ultraviolet (UV) Radiation

41A.1 Insect and rodent-control equipment shall be investigated for emission of ultraviolet (UV) radiation in accordance with the Ultraviolet Irradiance Test, Section [66A](#). The emission of UV shall not exceed an Effective Irradiance value of 0.1 $\mu\text{W}/\text{cm}^2$ when measured at the general use distance and an Effective Irradiance value of 3 microwatt/ cm^2 when measured at the relamping/servicing distance of 16.85 inches (0.43 m) in [Table 66A.1](#).

Exception No. 1: Products exclusively identified for the use with lamps rated "Exempt Risk Group", ANSI/IESNA RP-27.1, are considered to comply with this requirement without test.

Exception No. 2: Products generating UV in excess of 3 microwatt/cm² when measured at the relamping/servicing distance, are acceptable if the product cannot be operated continuously during relamping or servicing in accordance with [41A.2](#), and need to be subjected to the 0.1 uW/cm² limit at 'general use' distance only.

Exception No.3: Products designed to mount onto the wall and to emit ultraviolet radiation (UV) radiation in an entirely upwards direction only, such as a sconce type unit are to be exempt from the 'general use' test, if they are constructed from metal or a polymeric material that comply with the requirements in [7.17](#). Any UV barrier or decorative cover providing UV deflection shall be permanently attached if it prevents ultraviolet (UV) radiation being emitted anywhere other than upwards. The unit must be mounted so that the distance from the floor to the opening at the top where the ultraviolet (UV) light is emitted is a minimum of 7 ft. The mounting height must be marked on the unit and visible before installation. The mounting height shall also be stated in the installation instructions.

41A.2 Interlocks used to minimize risk of overexposure to ultraviolet (UV) radiation in accordance with the Exception No. 2 of [41A.1](#) shall be reliable, see [41A.3](#). The actuator of an interlock shall be located so the unintentional operation is unlikely and it is not able to be defeated with the articulated probe of [Figure 11.1](#). The interlock shall be reliable, substantial and not easily defeated by improper disassembly or reassembly of the equipment.

41A.3 An interlock that is required to reduce a risk of overexposure to ultraviolet (UV) radiation shall withstand 100,000 cycles of operation controlling a load not less than that controlled in the product, and shall function normally upon completion of the test.

Exception: For interlock which is only intended to limit UV exposure for cleaning and maintenance of insect lamp traps, the requirements are the same as above except for 10,000 cycles of operation.

PERFORMANCE

42 Leakage Current Test

42.1 A household or similar cord-connected appliance rated for a nominal 120-V supply shall be tested in accordance with [42.3](#) – [42.7](#). Leakage current shall not be more than:

- a) 0.5 mA for an ungrounded 2-wire appliance,
- b) 0.5 mA for a grounded 3-wire portable appliance, and
- c) 0.75 mA for a grounded 3-wire appliance;
 - 1) Employing a standard attachment plug rated 20 A or less, and
 - 2) Intended to be fastened in place or located in a dedicated space.

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

42.3 All exposed conductive surfaces are to be tested for leakage currents. If simultaneously accessible, the leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor individually as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section [11](#). Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not present a risk of electric shock.

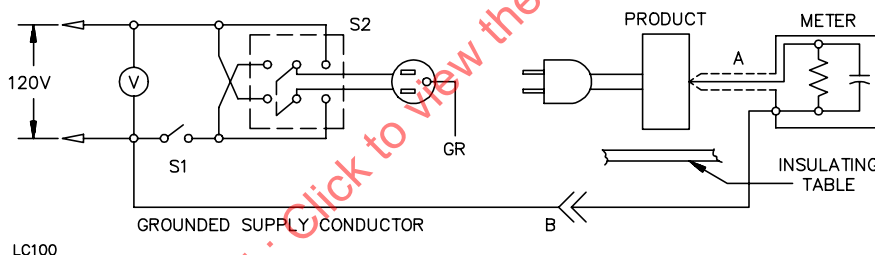
42.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having an area of 10 by 20 cm in contact with the surface. If the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface.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

42.5 The measurement circuit for leakage current is to be as illustrated in [Figure 42.1](#). The measurement instrument is defined in items (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

- a) The meter is to have an input impedance of $1500\ \Omega$ resistive, shunted by a capacitance of $0.15\ \mu\text{F}$.
- b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.
- c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a $1500\text{-}\Omega$ resistor shunted by a $0.15\text{-}\mu\text{F}$ capacitor to $1500\ \Omega$. At an indication of 0.5 or 0.75 mA, the measurement is not to have an error of more than 5% at 60 Hz.

Figure 42.1

Leakage-current measurement circuit



NOTES –

A: Probe with shielded lead.

B: Separated and used as clip when measuring currents from one part of device to another.

42.6 The meter is to be connected to the accessible part and the grounded supply conductor unless the meter is being used to measure leakage between two parts of an appliance.

42.7 A sample of the appliance is to be tested for leakage current starting with the as-received condition but with its grounding conductor, if any, open at the attachment plug. The as-received condition being without prior energization except as may occur as part of the production-line testing. The supply voltage is to be adjusted to 120 V. The test sequence, with reference to the measuring circuit – [Figure 42.1](#) – is to be as follows:

- a) With switch S1 open, the appliance is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the appliance switching devices in all their normal operating positions.
- b) Switch S1 is then to be closed energizing the appliance, and within 5 s, the leakage current is to be measured using both positions of switch S2 with the appliance switching devices in all their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

42.8 Normally, the complete leakage current test program as covered by [42.7](#) is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive tests.

43 Leakage Current Test Following Humidity Conditioning

43.1 An appliance as described in [42.1](#) shall comply with the requirements for leakage current in [42.1](#) following exposure for 48 h to air having a relative humidity of $88 \pm 2\%$ at a temperature of $32 \pm 2^{\circ}\text{C}$ ($90 \pm 4^{\circ}\text{F}$).

43.2 A sample of the appliance is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and conditioned for 48 h under the conditions specified in [43.1](#). Following the conditioning and while still in the chamber, the sample is to be tested unenergized as described in [42.7\(a\)](#). Either while the sample is still in the humidity chamber or immediately after it has been removed from the chamber, the sample is to be energized and tested as described in [42.7\(b\)](#) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

44 Starting Current Test

44.1 An appliance shall start and operate normally on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch circuit to which the appliance should be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the appliance trips.

Exception: The requirement concerning an ordinary fuse does not apply if:

- a) The construction of the appliance or the nature of its usage is such that it is likely to be used continually on the same branch circuit after installation,*
- b) The appliance will start and operate normally on a circuit protected by a time-delay fuse,*
- c) The appliance is marked in accordance with [70.1.13](#),*
- d) A household appliance would normally be used on a 15- or 20-A branch circuit, provided that the appliance starts and operates normally on a circuit protected by a time-delay fuse having an ampere rating corresponding to that of the branch circuit on which the appliance would normally be used.*

44.2 The appliance is to be started three times at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle, in the case of an automatic appliance – and the motor is to be allowed to come to rest between successive starts.

45 Input Test

45.1 The current or wattage input to an appliance shall not be more than 110% of the rated value when the appliance is operated under the condition of maximum normal load as described in [46.2.1.1](#) – [46.2.3.1](#) as applicable and when connected to a supply circuit of maximum rated voltage and rated frequency.

45.2 For an appliance having a single voltage rating, such as 115 V, maximum rated voltage is considered to be that single value of voltage. If the rating is given in terms of a range of voltages, such as 110 – 120 V, maximum rated voltage is considered to be the highest value of the range.

46 Temperature Tests

46.1 General

46.1.1 An appliance shall be tested as described in [46.2.1.1](#) – [46.2.3.1](#) and shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the appliance, or to exceed the temperature rises specified in [Table 46.1](#).

Table 46.1
Maximum temperature rises

Material and component parts	°C	°F
1. Capacitors: ^b		
Electrolytic ^a	40	72
Other types	65	117
2. Fuses		
A. Class G, J, L, T, and CC		
Tube	100	180
Ferrule or blade	85	153
B. Other ^h	65	117
3. Fiber employed as electrical insulation	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 70.2.1 .	35	63
5. A surface upon which an appliance may be fastened in place, and surfaces that may be adjacent to the appliance when so fastened.	65	117
6. Class A insulation system on coil windings of an ac motor having a diameter of more than 7 in (178 mm), of a dc motor, and of a universal motor: ^{c,d}		
A. In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
B. In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
7. Class A insulation systems on coil windings of an a-c motor having a diameter of 7 in or less, not including a universal motor, and on a vibrator coil: ^{c,d}		
A. In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	135
B. In a totally enclosed motor:		
Thermocouple or resistance method	80	144
8. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in, of a dc motor, and of a universal motor: ^{c,d}		
A. In an open motor:		
Thermocouple method	85	153

Table 46.1 Continued on Next Page

Table 46.1 Continued

Material and component parts	°C	°F
Resistance method	95	171
B. In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
9. Class B insulation system on coil windings or an a-c motor having a diameter of 7 in or less not including a universal motor: ^{c,d}		
A. In an open motor:		
Thermocouple or resistance method	95	171
B. In a totally enclosed motor:		
Thermocouple or resistance method	100	180
10. Class F (155°C) insulation system on coil windings or an ac motor having a frame diameter of more than 7 in (178 mm) and of a dc motor, and a universal motor: ^b		
A. In an open motor:		
Thermocouple method	110	198
Resistance method	120	216
B. In a totally enclosed motor:		
Thermocouple method	115	207
Resistance method	125	225
11. Class F (155°C) insulation system on coil windings or an ac motor having a frame diameter of 7 in (178 mm) or less, not including a universal motor: ^b		
A. In an open motor:		
Thermocouple or resistance method	120	216
B. In a totally enclosed motor:		
Thermocouple or resistance method	125	225
12. Class 105 insulation systems on windings of a relay, a solenoid, and the like: ^c		
Thermocouple method	65	117
Resistance method	85	153
13. Class 130 insulation systems on windings of a relay, a solenoid, and the like: ^c		
Thermocouple method	85	153
Resistance method	105	189
14. Class 130 insulation systems on vibrator coils:		
Thermocouple or resistance method	95	171
15. Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock. ^e	125	225
16. Rubber- or thermoplastic-insulated wire and cord. ^{e,f,g}	35	63
17. Sealing compound	40°C (104°F) less than melting point	
18. Varnished-cloth insulation	60	108
19. Wood and other combustible material	65	117
20. Transformers with Class 105 insulation system:		
Thermocouple method	65	117
Resistance method	75	135

^a The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor shall not be more than 65°C (117°F).

Table 46.1 Continued on Next Page

Table 46.1 Continued

Material and component parts		°C	°F
^b A capacitor that is designed and marked to operate at a temperature rise of more than 40°C (72°F) for electrolytic or more than 65°C (117°F) for other types may be judged on the basis of its marked temperature limit. In no case shall a capacitor temperature exceed its marked temperature limit. ^c At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher by the following amount than the maximum specified provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.			
Item		Additional temperature rises	
Part A of item 6		15	27
Part A of item 7		5	9
Part A of item 8		20	36
Part A of item 9		10	18
12		15	27
13		15	27
^d See 22.1.4. ^e The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found acceptable for use at higher temperatures. ^f Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (95°F), provided that a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords. ^g A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration. ^h A fuse that has been investigated and found acceptable for use at a higher temperature may be used at that temperature.			

46.1.2 A thermal- or overload-protective device shall not open the circuit during the temperature test.

46.1.3 All values of temperature rise in Table 46.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

46.1.4 For the temperature test, the voltage of a direct-current supply circuit is to be 115 V or 230 V, and that of an alternating-current circuit is to be 120 V or 240 V, depending on whether the appliance has a nominal voltage rating of 115 or 230 V.

46.1.5 An appliance having a single frequency rating is to be tested at that frequency. An appliance rated ac/dc or dc-60 Hz is to be tested on direct current or 60-Hz alternating current, whichever results in higher temperatures. An appliance rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

46.1.6 Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices – for example, a coil immersed in sealing compound – or unless the coil wrap includes thermal insulation or more than two layers – 1/32 in (0.8 mm) maximum – of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 in (178 mm) or less – items 7 and 9 in Table 46.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

46.1.7 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm²) and not smaller than 30 AWG (0.05 mm²). Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements for special tolerances thermocouples

as listed in the Tolerances on Initial Values of EMF Versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

46.1.8 If an appliance incorporates a reel for the power-supply cord, one-third of the length of the cord is to be unreeled for the temperature test.

46.1.9 For an appliance that is obviously not intended for continuous operation, the probable intermittent or short-time operation of the appliance is to be taken into consideration when conducting the temperature test.

46.1.10 With reference to those tests that are to be continued until constant temperatures are attained, thermal equilibrium is considered to exist when three successive readings taken at intervals of 10% of the previously elapsed duration of the test, but not less than 5-min intervals, indicate no change.

46.2 Maximum normal load

46.2.1 General

46.2.1.1 In tests on an appliance, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions that are recommended by the manufacturer of the appliance. Test loads that have been found to be close approximations of the most severe conditions of normal use are described in [46.2.2.1](#) – [46.2.3.1](#) for some common appliances. However, appliances having features not contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

46.2.2 Carbonators

46.2.2.1 A carbonator is to be operated continuously, until temperatures are constant, with maximum rated carbon dioxide gas pressure – but at not less than 125 psi (861 kPa) pressure – and maximum steady water flow. The pressure and flow may be modified if maximum input occurs at other than maximum rated gas pressure and maximum steady flow.

46.2.3 Engravers

46.2.3.1 The input test on an engraver is to be conducted while engraving steel. For the temperature test, the engraver is to be operated under no load in cycles of 5 min on followed by 5 min off until constant temperatures are attained.

47 Surface Temperature Tests

47.1 Exterior surfaces

47.1.1 A hand-supported appliance shall not attain a temperature of more than 125°C (257°F) on any exterior surface that may be laid on combustible material or against which combustible material may be laid, and there shall be no emission of smoke or molten material.

Exception: For a flashlight or lantern, temperatures may exceed 125°C (257°F) on exterior surfaces in proximity to the light source, if the product is marked per [70.10.2](#), includes the instructions per [74.5.2](#) and complies with the tests of [41.1.1](#) and [55A.3](#) or [55A.4](#), as applicable.

47.1.2 To determine whether an appliance complies with the requirement in [47.1.1](#), the appliance is to be operated at the voltage and frequency specified in [46.1.4](#) and [46.1.5](#) until constant temperatures are attained. The appliance may be stationary during the test, and simulation of actual service conditions need not be attempted.

47.2 Contact surfaces

47.2.1 During the temperature test, the temperature of a surface that may be contacted by a user shall not be more than the applicable value specified in [Table 47.1](#). If the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Table 47.1
Maximum surface temperatures

Location	Composition of surface ^a	
	Metal	Nonmetallic
Handles or knobs that are grasped for lifting, carrying, or holding	50°C (122°F)	60°C (140°F)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding	60°C (140°F)	85°C (185°F)
Surfaces subjected to contact during operation or user maintenance ^b	60°C (140°F)	85°C (185°F)
^a A handle, knob, or the like, made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 in (0.127 mm) or less is considered to be, and is investigated as, a nonmetallic part.		
^b For flashlights and lanterns, temperatures may exceed the limits specified in proximity to the light source, if the product is marked per 70.10.1 and includes the instructions per 74.5.1 .		

48 Dielectric Voltage-Withstand Test

48.1 An appliance shall withstand for 1 min without breakdown the application of a 60-Hz essentially sinusoidal potential between live parts and dead metal parts with the appliance at the maximum operating temperature reached in normal use. The test potential for the primary circuit shall be:

- a) One-thousand volts for an appliance employing a motor rated 1/2 hp (373 W output) or less and 250 V or less.
- b) One-thousand volts plus twice the rated voltage for:
 - 1) An appliance employing a motor rated more than 1/2 hp or more than 250 V, or
 - 2) An appliance applied directly to persons – see item (c).
- c) Twenty-five hundred volts for an appliance that is applied in a wet or moist condition directly to persons.

48.2 The test potential for the secondary circuit of an appliance employing a transformer or autotransformer shall be:

- a) One-thousand volts plus twice the operating voltage if the secondary operates at 251 – 600 V.
- b) One-thousand volts if the secondary operates at 51 – 250 V.
- c) Five-hundred volts if the secondary operates at 50 V or less.

Exception: This does not apply if the secondary circuit is supplied from a Class 2 transformer.

48.3 A capacitor used for radio-interference elimination or arc suppression shall withstand for 1 min without breakdown the application of a 60-Hz essentially sinusoidal potential between live parts of opposite polarity with the appliance at the maximum operating temperature reached in normal use. The test potential shall be:

- a) One-thousand volts for an appliance employing a motor rated 1/2 hp (373 W output) or less and 250 V or less.
- b) One-thousand volts plus twice the rated voltage for:
 - 1) An appliance employing a motor rated more than 1/2 hp or more than 250 V, or
 - 2) An appliance applied directly to persons.

48.4 To determine whether an appliance complies with the requirements in [48.1](#) – [48.3](#), the appliance is to be tested by means of a 500 VA or larger transformer, having an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 min. The increase in the applied potential is to be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by a voltmeter.

48.5 With reference to the requirement in [48.4](#), a 500 VA or larger capacity transformer need not be used if the transformer is provided with a voltmeter to measure directly the applied output potential.

49 Continuous Operation Test

49.1 When a combination appliance not provided with a momentary contact switch is tested as described in [49.2](#):

- a) Neither the cheesecloth nor the tissue paper shall ignite, and
- b) The 3-A grounding fuse shall not open.

49.2 The appliance is to be:

- a) Placed on a white tissue paper covered softwood surface,
- b) Connected to a 120-V or 240-V, as applicable, 60-Hz supply circuit in series with a 20-A time-delay plug fuse,
- c) Draped with a double layer of cheesecloth over the whole appliance with the cloth within 1/8 in (3.2 mm) of each opening in the enclosure, and
- d) Grounded by means of a 3-A nontime-delay plug fuse connected between exposed metal parts and earth ground.

The appliance is to operate continuously at no load until temperatures stabilize or burnout occurs.

50 Resistance-to-Moisture Test

50.1 Water spray test

50.1.1 An outdoor-use appliance that is not marked as specified in [70.8.2](#) shall be tested as described in [50.1.2](#) and [50.1.3](#):

- a) During and after the test:

- 1) There shall not be wetting of any electrical component; and
- 2) No water shall enter the appliance in a manner that may result in a reduction of spacings; and

b) After the test:

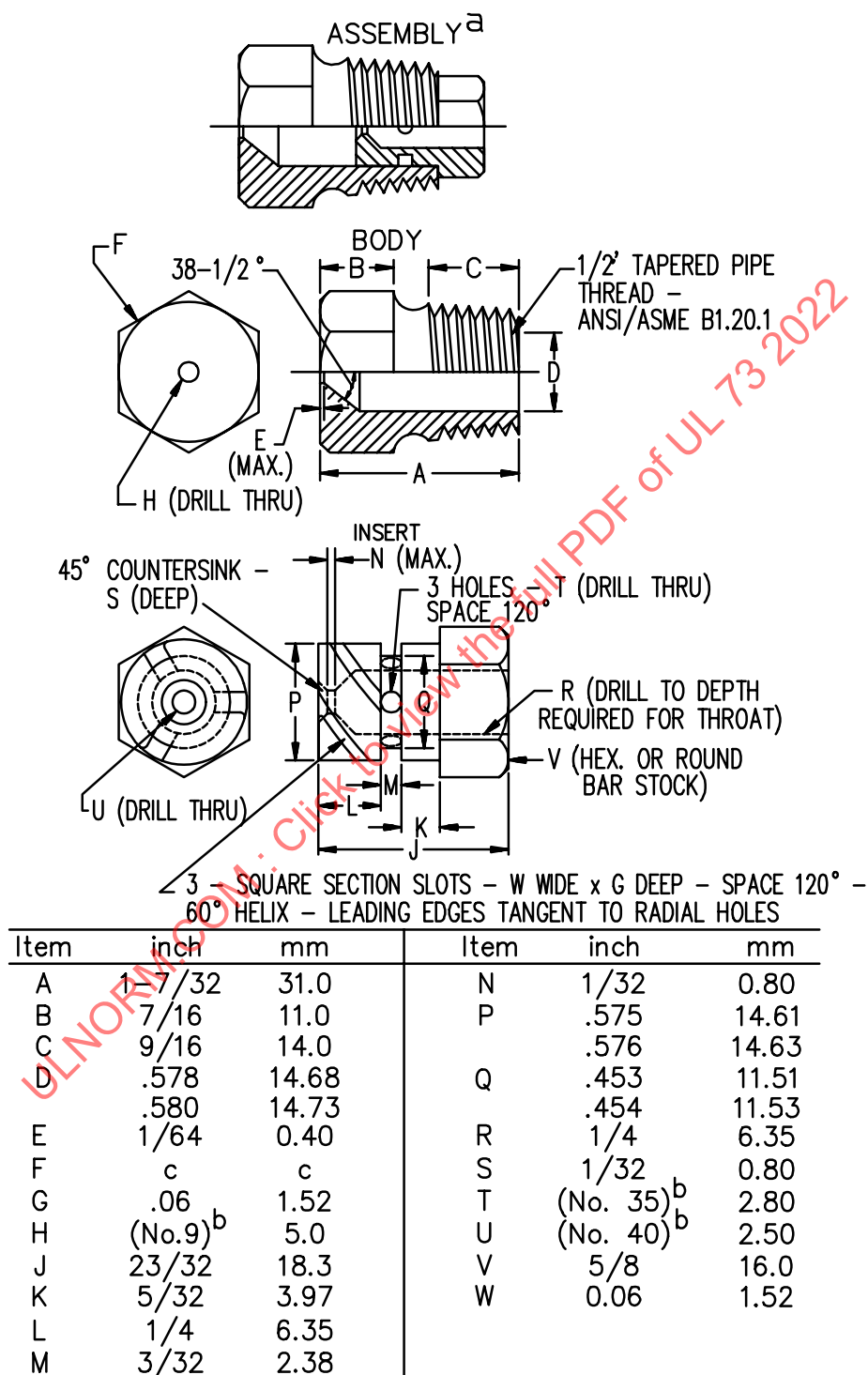
- 1) A cord-connected appliance shall comply with Leakage Current Test, Section [42](#), except that the test shall be discontinued when the leakage current stabilizes; and
- 2) An appliance shall comply with Dielectric Voltage-Withstand Test, Section [48](#), except that the appliance need not be at normal operating temperature.

50.1.2 The appliance shall be operated so that electrical components are energized, and the appliance is tested under the intended conditions of use considered most likely to cause the entrance of water into or onto electrical components. It may be necessary to operate the unit under various modes of operation or to de-energize the appliance, if more adverse conditions could result. In any case, each exposure shall be for 1 h.

50.1.3 The water spray apparatus is to consist of three spray heads constructed in accordance with the details illustrated in [Figure 50.1](#) and mounted in a water supply pipe rack as illustrated in [Figure 50.2](#). The water pressure is to be maintained at each spray head at approximately 5 lbf/in² (34 kPa). The distance between the center nozzle and the appliance is to be approximately 5 ft (1.5 m). The appliance is to be brought into the focal area of the three spray heads in such a position and under such conditions that water will be most likely to enter, except that consideration is to be given to the normal mounting position.

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Figure 50.1
Water-spray-test spray head



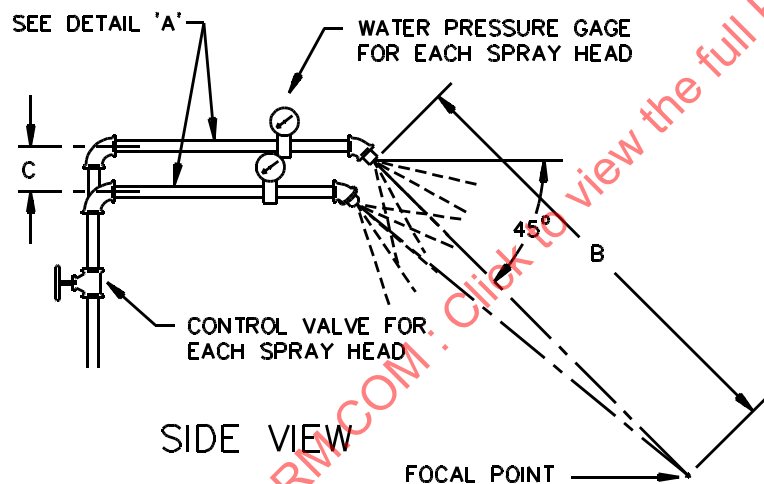
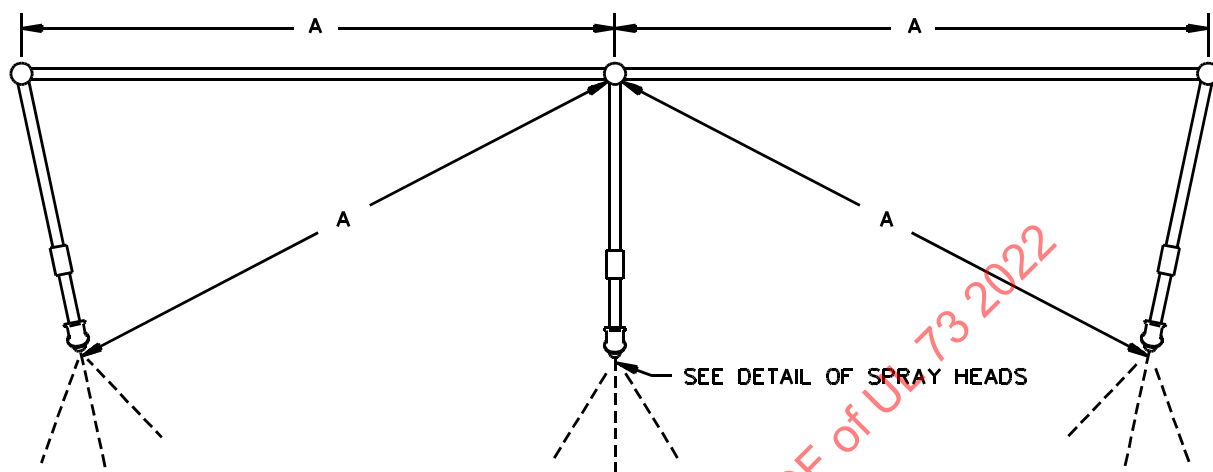
^a Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

^b ANSI B94.11M Drill Size

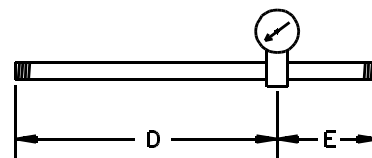
^c Optional - To serve as a wrench grip.

Figure 50.2
Water-spray-head piping

PLAN VIEW



PIEZOMETER ASSEMBLY
DETAIL 'A'



Item	inch	mm
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

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50.2 Flooding of live parts

50.2.1 The malfunction of a timer switch or of a float- or pressure-operated switch, or the deterioration or damage of a boot or diaphragm of rubber or similar material shall not cause flooding of the electrical components of an appliance that employs water or other electrically conductive liquid in its operation.

50.2.2 In a test to determine whether an appliance complies with the requirements in [50.2.1](#) with respect to deterioration or damage of a boot or diaphragm due to flexing, such component is to be removed completely and the appliance operated through one complete cycle of normal operation. If flexing is not present, but if a rubber part is subjected to hot soapy water, the material is to be investigated to determine if deterioration or damage of the part would create a risk of fire or electric shock. This investigation is to include consideration of the effects of heat, air pressure, soap solutions, and other factors contributing to the aging.

50.2.3 Infrequent motion of small amplitude, such as that experienced during normal operation by a diaphragm covering a pressure-sensitive switch, is not considered to constitute flexing.

50.3 Automatic solar panel cleaning systems – flooding overflow test

50.3.1 The system shall be positioned as intended for normal use, and the liquid reservoir or container shall be completely filled with a test solution of salt-water (1/2 gram of NaCl per liter of distilled water). An additional quantity of the test solution equal to 15% of the capacity of the liquid container shall be poured in steadily over a period of 1 min.

50.3.2 The sample shall be operated three times in the following manner. The liquid container shall be filled with the test solution, and the appliance then operated at maximum normal load. In between operations, the sample shall be turned off and the liquid container re-filled with the test solution.

50.3.3 During this conditioning, a cord connected appliance shall comply with the Leakage Current Test in Section [42](#), except that the test shall be discontinued when the leakage current stabilizes.

50.3.4 After this conditioning, the sample shall comply with the Dielectric Voltage-Withstand Test in Section [48](#), except that the appliance need not be at normal operating temperature.

50.3.5 The sample shall then be disassembled and the internal parts visually examined for the presence of water. There shall be no obvious wetting of any uninsulated live part or film-coated wire; and no water shall enter a compartment housing field-installed wiring. Obvious wetting signifies wetting by a stream, spray, or dripping of water on the component that obviously will be repeated during each test, but does not signify wetting by random drops of water that may wet the component by chance.

50.4 Flooding overflow test for recessed ultrasonic cleaners

50.4.1 The recessed ultrasonic cleaner shall be positioned as intended for normal use, and the liquid container completely filled with a test solution of salt-water (1/2 gram of NaCl per liter of distilled water). An additional quantity of the test solution equal to 15% of the capacity of the liquid container shall be poured in steadily over a period of 1 min.

50.4.2 The sample shall be operated three times in the following manner. The liquid container shall be filled with the test solution, and the appliance then operated at maximum normal load. In between operations, the appliance is to be turned off and the liquid container re-filled with the test solution.

50.4.3 During this conditioning, a cord connected appliance shall comply with the Leakage Current Test in Section [42](#), except that the test shall be discontinued when the leakage current stabilizes.

50.4.4 After this conditioning, the sample shall comply with the Dielectric Voltage-Withstand Test in Section [48](#), except that the appliance need not be at normal operating temperature.

50.4.5 The sample shall then be disassembled and the internal parts visually examined for the presence of water. There shall be no obvious wetting of any uninsulated live part or film-coated wire; and no water shall enter a compartment housing field-installed wiring. Obvious wetting signifies wetting by a stream, spray, or dripping of water on the component that obviously will be repeated during each test, but does not signify wetting by random drops of water that may wet the component by chance.

50.5 Flooding immersion test for recessed ultrasonic cleaners

50.5.1 Three samples of the recessed ultrasonic cleaner shall be tested. Each sample shall be positioned and loaded as intended for normal use and placed in a test container representative of a kitchen sink. The test container shall then be filled with a salt-water solution (1/2 gram of NaCl per liter of distilled water) until the container is completely filled and the sample is completely immersed.

50.5.2 The samples shall then be energized and operated at maximum normal load for one complete operating cycle, and then remain immersed for one hour after the operating cycle is complete.

50.5.3 During this conditioning, for a cord connected appliance, each of the samples shall comply with the Leakage Current Test in Section [42](#), except that the test shall be discontinued when the leakage current stabilizes.

50.5.4 After this conditioning, the samples shall be removed from the sink, and each of the samples shall comply with the Dielectric Voltage-Withstand Test in Section [48](#), except that the appliance need not be at normal operating temperature.

50.5.5 The sample shall then be disassembled and the internal parts visually examined for the presence of water. There shall be no obvious wetting of any uninsulated live part or film-coated wire; and no water shall enter a compartment housing field-installed wiring. Obvious wetting signifies wetting by a stream, spray, or dripping of water on the component that obviously will be repeated during each test, but does not signify wetting by random drops of water that may wet the component by chance.

51 Tests on Switches and Controls

51.1 A switch or other device that controls a motor of an appliance, a solenoid, a relay coil, or the like shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation as described in [51.2](#) – [51.4](#) as applicable. There shall be no electrical or mechanical malfunction or breakdown of the device or undue burning or pitting of the contacts, and the fuse in the grounding connection shall not open.

Exception No. 1: This requirement does not apply to a device known to be acceptable for the application.

Exception No. 2: A device interlocked so that it will never break the locked-rotor motor current need not be tested.

51.2 Exposed dead metal parts of the appliance are to be connected to ground through a 3-A plug fuse, and the appliance is to be connected to a grounded supply circuit of rated frequency. During the test, the device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to those concerned.

51.3 When testing a switch or other control device that controls a solenoid, a relay coil or the like, the appliance is to be connected to a supply circuit of rated frequency and 110% of maximum rated voltage.

The load on the device being tested is to be the same as that which it is intended to control in normal service.

51.4 When testing a switch or other control device that controls a motor, the rotor of the motor is to be locked in position and the appliance is to be connected to a supply circuit of maximum rated voltage. See [46.1.4](#). The connection is to be such that any single-pole, current-interrupting device will be located in the ungrounded conductor of the supply circuit. If the appliance is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the appliance are to be connected so as to be positive with respect to a single-pole, current-interrupting control device.

52 Puncture Test for Recessed Ultrasonic Cleaners

52.1 A recessed ultrasonic cleaner provided with a membrane switch shall comply with this test. A butcher knife weighing approximately 1/2 lb (0.2 kg), with a 10-in (25.4-cm) straight stainless steel blade and polymeric handle, shall be dropped onto the membrane switch surface from a height of 3 ft (0.9 m) above the surface of the switch. The knife shall be dropped so the knife point strikes the center of the switch. This test shall be conducted on three separate switch samples.

52.2 At the conclusion of this test, the top portion of the membrane switch samples shall show no signs of cracks, tears, rips, or holes.

52.3 After this testing, for a cord connected appliance, the samples shall comply with the Leakage Current Test in Section [42](#), except that the test shall be discontinued when the leakage current stabilizes. The metal foil described in [42.4](#) is to be applied to the surface of the membrane switches.

52.4 After this testing the samples shall comply the Dielectric Voltage-Withstand Test in Section [48](#), except that the appliance need not be at normal operating temperature.

53 Strain-Relief Test

53.1 The strain relief means provided on an attached flexible cord, when tested in accordance with [53.2](#), shall withstand for 1 min without displacement a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the appliance disconnected.

Exception: The pull applied to a Type TP or TPT cord is to be 20 lbf (89 N).

53.2 A 35- or 20-lb (15.9- or 9.1-kg) weight, as applicable, is to be suspended on the cord and supported by the appliance so that the strain-relief means will be stressed from any angle that the construction of the appliance permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

53.3 To determine if a clamp is acceptable for use as described in Exceptions No. 1 and No. 2 to [12.2.3.3](#), four samples of the clamp that have been applied to the cord and installed in the intended manner shall be subjected to the conditioning and tests specified in (a) and (b). As a result of the tests, the samples shall comply with Dielectric Voltage-Withstand Test, Section [48](#), and Strain-Relief Test, [53.1](#).

a) One sample is to be subjected to the dielectric voltage-withstand and strain-relief tests in the as-received condition.

b) The three remaining samples are to be conditioned in an air-oven for 168 h. The oven temperature is to be 10°C (18°F) higher than the maximum temperature measured on the cord at the strain-relief device under normal operating conditions, but not less than 70°C (158°F) in any case. The samples, after being conditioned in the oven, are to be immediately subjected to the dielectric voltage-withstand test. The potential is to be applied between the conductors and, if the

clamp is metal, the potential is to be applied between the conductors and the clamp. After cooling to room temperature, the conditioned samples shall be subjected to the strain-relief test followed by the dielectric voltage-withstand test.

54 Abnormal Operation Test

54.1 General

54.1.1 Operation under the abnormal conditions specified in [54.2](#) shall not result in a risk of fire or electric shock or increased risk of personal injury. A risk of fire or electric shock or increased risk of personal injury is considered to exist if the test results in any of the following:

- a) Ignition of the cheesecloth or the tissue paper;
- b) The 3-A fuse connected to earth ground specified in [54.1.3](#) opens;
- c) Any opening is developed in the overall enclosure that is larger than those permitted by requirements as specified in Accessibility to Live Parts, Section [11](#);
- d) The appliance does not comply with the Dielectric Voltage-Withstand Test, Section [48](#) (this test is to be completed prior to the replacement of components damaged by the induced faults);
- e) Unexpected operation of the appliance that may involve an increased risk of personal injury; or
- f) An increased risk of personal injury exists if there is an unexpected increase in the speed of the moving part capable of causing injury.

Exception: A control that has been evaluated to the applicable control standard requirements in [6.6](#) is considered to comply with this requirement.

54.1.2 Following the abnormal condition specified in [54.2](#), the sample shall be subjected to the applicable Dielectric Voltage-Withstand Test, Section [48](#).

54.1.3 For the abnormal operation tests specified in [54.2.1](#), the appliance is to be connected to a supply circuit protected by a 30-A time delay fuse. It is to be placed on a white tissue paper covered softwood surface. A single layer of cheesecloth is to be draped loosely over the entire product. Exposed noncurrent-carrying metal parts are to be connected to earth ground through a 3-A nontime delay type fuse. The supply circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

54.2 Electronic components

54.2.1 A single malfunction (short or open) of any circuit component, such as a resistor, capacitor, solid state device, and the like, shall not result in a risk of fire or electric shock or increased risk of personal injury. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, or triac, any combination of terminals taken two at a time shall be open- or short-circuited.

Exception: Abnormal operation testing of multiple terminal circuit devices may be reduced if it can be determined by circuit analysis that an open- or short-circuit of the terminal(s) is not likely to result in a risk of fire, electric shock, or injury to persons.

54.2.2 The Dielectric Voltage-Withstand Test, Section [48](#) need be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

55 Abnormal Operation Tests for Recessed Ultrasonic Cleaners

55.1 General

55.1.1 A recessed ultrasonic cleaner shall not cause a risk of fire or electric shock when operating under the abnormal conditions specified in [55.2](#) and [55.3](#). A risk of fire or electric shock is considered to exist if the test results in any of the following:

- a) Ignition of the cheesecloth or the tissue paper;
- b) The 3-A fuse connected to earth ground opens;
- c) Any opening is developed in the overall enclosure that is larger than those permitted by accessibility requirements as covered by accessibility to live parts; or
- d) The appliance does not comply with the dielectric voltage-withstand test, Section [48](#).

55.1.2 For the test in [55.1.1](#), the sample shall be placed on a white tissue paper covered softwood surface. A single layer of cheesecloth is to be draped loosely over the entire product. Exposed noncurrent-carrying metal parts are to be connected to earth ground through a 3-A nontime delay type fuse. The supply circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

55.2 Electronic components

55.2.1 A single malfunction (short or open) of any circuit component, such as a resistor, capacitor, solid state device, and the like, shall not result in a risk of fire or electric shock or increased risk of personal injury. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, triac, or an integrated circuit device, any combination of terminals taken two at a time shall be open- or short-circuited.

Exception: Abnormal operation testing of multiple terminal circuit devices may be reduced if it can be determined by circuit analysis that an open- or short-circuit of the terminal(s) is not likely to result in a risk of fire, electric shock, or injury to persons.

55.3 Dry operation test

55.3.1 To determine compliance with [55.1.1](#), an appliance that uses a container into which liquid is intended to be added by the user, that if when operated dry, increases the likelihood of a risk of fire or electric shock, shall be operated and tested in accordance with [55.3.2](#).

Exception: An appliance that is provided with a water level or water sensor control that has been investigated to the Standard for Solid-State Controls for Appliances, UL 244A does not have to comply with this requirement.

55.3.2 The sample shall be positioned as intended for normal use. The water sensor provided with the appliance is to be shunted from the circuit. The appliance is then to be energized for one complete operation cycle, or until ultimate results, with no liquid in the container.

55A Rechargeable and Automatic Flashlights and Lanterns

55A.1 With respect to [14.5](#), the product shall be subjected to the following abnormal conditions, as applicable, to represent the worst case heating of the battery-operated live parts in contact with (or close proximity to) the polymeric material without the emission of flame or molten metal or the reduction of electrical spacings resulting in a risk of fire. The "on-off" switch shall be closed so that the circuit is

energized. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, triac, or an integrated circuit device, any combination of terminals taken two at a time shall be opened or shorted.

- a) Shorted Bulb Test – One sample shall be operated with the bulb shorted. The "on-off" switch shall be closed so that the bulb circuit is energized.
- b) Shorted Battery Terminal Test – One sample shall be operated with the battery terminals shorted.
- c) Component Failure Test – Various individual components, such as resistors, capacitors, and solid-state devices, shall be shorted and opened, one at a time.

55A.2 The tests of [55A.1](#) shall each be conducted with the sample resting on a softwood tissue covered supporting surface and draped with one layer of cheesecloth. The tests shall be conducted with a fully charged battery and operation shall continue until ultimate results, but not more than 7 h.

55A.3 With respect to the Exception to [47.1.1](#), if the light source is operable while the product is hand-held or counter supported, there shall be no ignition of the supporting surface when the product is operated continuously for 7 h while positioned as close to and directed towards the softwood supporting surface to the greatest degree permitted and in a position representing the most severe condition by the unit construction. The supporting surface shall be knot free softwood covered with a double layer of white tissue paper.

55A.4 With respect to the Exception to [47.1.1](#), for a direct plug-in flashlight or lantern, if the light source is operable while the product is supported by the receptacle, there shall be no exposure of live parts or ignition of the vertical softwood surface when the product is operated continuously for 7 h while positioned as close to and directed towards a vertical softwood surface to the greatest degree permitted and in a position representing the most severe condition by the unit construction. The vertical surface shall be knot free softwood covered with a double layer of white tissue paper and positioned at 90° from the wall supporting the receptacle.

56 Radiation Test

56.1 An appliance that produces radiation, such as X-rays, microwaves, ultrasonic sound, laser, ultraviolet, or infrared light, shall be investigated with respect to the effects of the radiation on users and service personnel.

57 Ozone Test

57.1 An appliance that produces ozone during normal operation shall not produce an average time weighted concentration above background in excess of 0.1 part per million, nor a transitory concentration of more than 0.3 part per million when tested as described in [57.3](#) – [57.6](#).

57.2 With reference to the requirement in [57.1](#), the normal functioning of electrical contact points is not considered to be capable of generating an unacceptable concentration of ozone.

57.3 Ozone concentration is to be measured at all operating positions while the appliance is located in the center of a closed room of 1000 ft³ (28.3 m³), approximately 8 by 12 by 10 ft (2.4 by 3.7 by 3.0 m). All test room walls are to be covered with sheet polyethylene.

57.4 The room is to be maintained at a temperature of approximately 25°C (77°F) and a relative humidity of 50%. Prior to and immediately after the test, the ozone background level is to be measured with the appliance off. The background level average is to be calculated and subtracted from the maximum measurement during the test.

57.5 During the test, the appliance is to be operated in the same manner and for the length of time specified as for the temperature test described in Section 46. The average time weighted concentration is to be considered as the average concentration of ozone extrapolated for an 8-h operating period.

57.6 If the appliance can be operated with any of its fans, heaters, or the like not functioning, with replaceable charges, filters, or the like removed, or with paper, fluid, or the like exhausted, the test described in 57.3 – 57.5 is to be repeated a sufficient number of times with the various components not operating or with the items removed or exhausted to determine that these conditions do not result in ozone emission exceeding that specified in 57.1.

58 Operational Test

58.1 Operation, as described in 58.2, of an appliance intended for household use shall not increase the risk of fire, electric shock, or injury to persons.

58.2 An as-received sample of the appliance is to be set up or installed in accordance with the manufacturer's instructions. The sample is to be operated in accordance with the manufacturer's instructions with respect to the intended uses of the appliance, including maintenance and cleaning recommended by the manufacturer and lack of such maintenance and cleaning; and with all accessories recommended by the manufacturer for use with the appliance. The appliance is to be manipulated as it would be in actual use, including manipulation of all controls and operation under the various loading conditions that can be expected. The appliance is to be operated for a sufficient length of time or through a sufficient number of cycles to determine that all reasonably foreseeable complications are revealed.

59 Permanence of Marking Test

59.1 A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched metal that is permanently secured, or indelibly stamped lettering on a pressure-sensitive label secured by adhesive that, upon investigation, is found to be acceptable for the application. Ordinary usage, handling, storage, and the like of a product are considered in the determination of the permanence of a marking.

59.2 Unless it has been investigated and found to be acceptable for the application, a pressure-sensitive label or a label that is secured by cement or adhesive and that is required to be permanent shall comply with the applicable requirements in the Standard for Marking and Labeling Systems, UL 969.

60 Permanence of Cord Tag Test

60.1 General

60.1.1 To determine compliance with 70.3.6, a cord tag shall be conditioned and tested as described in 60.1.2. Following the conditionings and test, the tag shall comply with the following:

- a) The tag shall resist tearing for longer than 1/16 in (1.6 mm) at any point;
- b) The tag shall not separate from the power-supply cord;
- c) There shall not be permanent shrinkage, deformation, cracking, or other condition that will render the marking on the tag illegible; and
- d) Overlamination shall remain in place and not be torn or otherwise damaged. The printing shall remain legible.

60.1.2 To determine compliance with [60.1.1](#), a cord tag shall be conditioned in accordance with (a) – (c). Following the conditioning each sample shall be tested in accordance with [60.1.3](#). If a tag is applied by an adhesive, the conditionings and test are to be conducted no sooner than 25 hr after application of the tag.

- a) Three samples, as received, shall be tested in accordance with [60.1.3](#).
- b) Three samples shall be conditioned in an air-circulating oven at $60 \pm 1^{\circ}\text{C}$ ($140 \pm 1.8^{\circ}\text{F}$) for 240 h followed by 30 min of conditioning at a room temperature of $23 \pm 2^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$) and $50 \pm 5\%$ relative humidity then followed by the test in [60.1.3](#).
- c) Three samples shall be conditioned for 72 hr at a humidity of $85 \pm 5\%$ at $32 \pm 2^{\circ}\text{C}$ ($89.6 \pm 3.6^{\circ}\text{F}$) and followed by test in [60.1.3](#) within 1 min after conditioning.

60.1.3 Each sample is to consist of a length of power-supply cord to which the tag has been applied. The power-supply cord, with the attachment plug pointing up, is to be held tautly in a vertical plane. A force of 5 lbf (22.2 N) is to be applied for one minute to the upper-most corner of the tag farthest from the power-supply cord, within 1/4 in (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord. In determining compliance with [60.1.1](#) (d), manipulation is permissible, such as straightening of the tag by hand. To determine compliance with [60.1.1](#) (d), each sample is to be scraped 10 times across printed areas and edges, with a force of approximately 2 lbf (8.9 N), using the edge of a 5/64-in (2.0-mm) thick steel blade held at a right angle to the test surface.

61 Solenoids

61.1 A solenoid shall be investigated as part of the appliance and comply with the requirements of this end product standard. In addition, it shall comply with the following:

- a) A spring shall be protected against abrasion and shall be guided or arranged to reduce binding, buckling, or other interference with its free movement.
- b) Protective devices may be used to interrupt the flow of current to the solenoid coil. If an integral protective device is provided, it shall be located inside the overwrap insulation of the solenoid coil.
- c) Insulation between a crossover lead and the winding to which it is connected is not specified if the coil withstands the induced potential test described in [61.2](#).
- d) A slot in a molded bobbin for guiding the crossover or start-lead – unspliced at the windings – of a magnet-coil is to be filled with an insulating material unless:
 - 1) The slot provides a graduated spacing to the winding increasing to the end turns,
 - 2) The magnet-coil winding withstands the induced potential test described in [61.2](#).

Exception: A solenoid that complies with one of the standards specified in [6.25](#) need not be subjected to these tests.

61.2 Where required in items (c) and/or (d) of [61.1](#), each of three separate magnet-coil-winding samples shall withstand without breakdown an induced potential. They shall be operated under conditions representing those attained during the Normal Temperature Test. While still heated, the coil winding shall be subjected to an alternating potential of twice the rated voltage at any suitable frequency – typically 120 Hz or higher – for 7,200 electrical cycles or for 60 s, whichever is less. The required test voltage is to be obtained by starting at one-quarter or less of the full value and increasing to the full value in not more than 15 s. After being held for the time specified, the voltage is to be reduced within 5 s to one-quarter or less of the maximum value, and the circuit is to be opened.

61.3 There shall be no emission of flame or molten metal after a solenoid has operated for 7 h within the appliance while energized at the voltage specified for the Normal Temperature Test, Section [46](#), and with the plunger blocked in the de-energized position at the maximum stroke length specified for the assembly. For the test, the supply source to the appliance shall include appropriate branch circuit protection and grounded, if applicable. Following this test, the solenoid shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section [48](#).

Exception: The winding may open in a shorter period of time, provided that there is no emission of flame or molten metal.

62 General Purpose Transformers

62.1 General

62.1.1 In addition to the end-product Temperature Test and Dielectric Voltage-Withstand Test, a general purpose transformer shall also be subjected to the tests of [62.2](#) – [62.4](#).

Exception: A transformer that complies with the standard specified in Section [6.24](#) need not be subjected to these tests.

62.2 Voltage measurement test

62.2.1 For purposes of comparison with voltages measured as described in the Overload Test of [62.3](#), each secondary open-circuit voltage shall be measured with the primary connected to a test voltage and frequency supply source as indicated in [45.2](#).

62.3 Overload test

62.3.1 A transformer shall be subjected to the test conditions described in [62.3.2](#). The stabilized surface or core temperature recorded on the transformer during the second 50% load operation shall not be more than 5°C(9°F) greater than the stabilized core temperature obtained during the initial 50% of load operation. The open-circuit output voltage determined following the final 50% load operation shall be within 2% of the output voltage measured during the Voltage Measurement Test in [62.2](#). As an option, a protective device, if provided, may be bypassed when conducting this test.

62.3.2 The transformer shall be operated as described in the Temperature Tests, Section [46](#), except that the load shall be 50% of the rated value, until the core, or surface temperatures if encapsulated, stabilize. After stabilization, the load shall be adjusted until 200% of rated secondary current is reached. After 2 min of operation, the load shall be readjusted, if necessary, to restore the current to 200% but no further adjustment is to be made thereafter. The duration of this overload shall be 30 min. The load is then to be restored to the original 50% of rated value. It shall be held at that value until the core temperature again stabilizes or until the temperature drops to within 5°C (9°F) of the original stabilized 50% load-current temperature (whichever occurs first). This temperature value shall be compared with the original 50% load stabilized condition, as specified in [62.3.1](#). Then, the secondary load shall be removed. With the primary energized, the secondary voltage(s) shall be measured and compared with the original output voltage measurements.

62.3.3 When the core of the transformer is not accessible for direct temperature measurement (due to the transformer construction or reasons such as encapsulation or filling with electrical insulating material), the surface of the transformer enclosure shall be used. The portion of the enclosure surface used to measure this temperature shall be the hottest spot occurring in the 100% load heating test.

62.3.4 A protective device, when provided, shall be bypassed when the device opens while the load is adjusted after the surface temperatures have stabilized.

62.4 Repeated dielectric voltage-withstand test

62.4.1 Following the Overload Test, [62.3](#), the transformer shall be subjected to a repeated dielectric voltage-withstand test. The test potential shall be 65% of the value originally specified. After this test, the transformer shall perform as intended.

63 Thermoplastic Motor Insulation Systems

63.1 General

63.1.1 Motors that employ thermoplastic materials to electrically isolate the windings and similar live parts from other live parts or noncurrent-carrying metal parts are to be subjected to the tests in [63.2](#) and [63.3](#).

Exception No. 1: A motor that functions to move air only with a direct mounted fan need not be subjected to the test in [63.3](#).

Exception No. 2: A double-insulated appliance is to be tested in accordance with abnormal operation and overload test on motors in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

Exception No. 3: A motor that uses Class A insulation materials and has been subjected to the locked rotor cycling test in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 need not be subjected to these tests.

Exception No. 4: A motor that complies with the Standard for Overheating Protection for Motors, UL 2111, or Standard for Thermally Protected Motors, UL 1004-3, need not be subjected to these tests.

63.2 Abnormal conditioning

63.2.1 The motor is to be subjected to the abnormal conditioning described in [63.2.2](#) and shall comply with all of the following conditions:

- a) The 3-A fuse shall remain intact; and
- b) The material under test shall withstand without breakdown, the dielectric voltage-withstand potential specified in Section [48](#) immediately following the conditioning specified in [63.2.2](#) and with the 3-A fuse removed from the circuit.

63.2.2 The motor is to be operated with the armature locked until ultimate results have been determined or for 7 h, whichever occurs first. Noncurrent-carrying metal parts of the motor that are insulated by the material under test are to be connected to ground through a 3-A, quick-acting, plug type fuse.

63.2.3 With reference to [63.2.2](#), when the length of the test is limited by an external factor – such as the functioning of a reliable, nonuser-serviceable device (such as a fuse or circuit breaker), or the functioning of the maximum-size branch-circuit protective device that the equipment is likely to be connected (but not less than 30 A) – the test shall be terminated when the limiting device functions to open the circuit, if the device complies with the applicable component standard in Section [6](#).

63.3 Overload-burnout conditioning

63.3.1 Thermoplastic insulating material employed in motors with a stalled-rotor current greater than twice the normal operating current shall comply with the following after the overload-burnout conditioning described in [63.3.2](#):

- a) The 3-A fuse shall remain intact; and
- b) The thermoplastic material under test shall comply with the dielectric voltage-withstand test described in Section [48](#) immediately following the overload-burnout conditioning.

63.3.2 Each of three samples of the motor is to be subjected to operation at normal load for 1 h. Immediately following operating at normal load, the load is to be increased in steps of 10% of the rated current for each of four successive 1-h periods, followed by two 1/2-h periods, followed by eight 1/4-h periods, followed by such additional periods of 5 min until the motor burns out. During the test, noncurrent-carrying metal parts of the motor that are insulated by the material under test are to be connected to ground through a 3-A, quick-acting fuse.

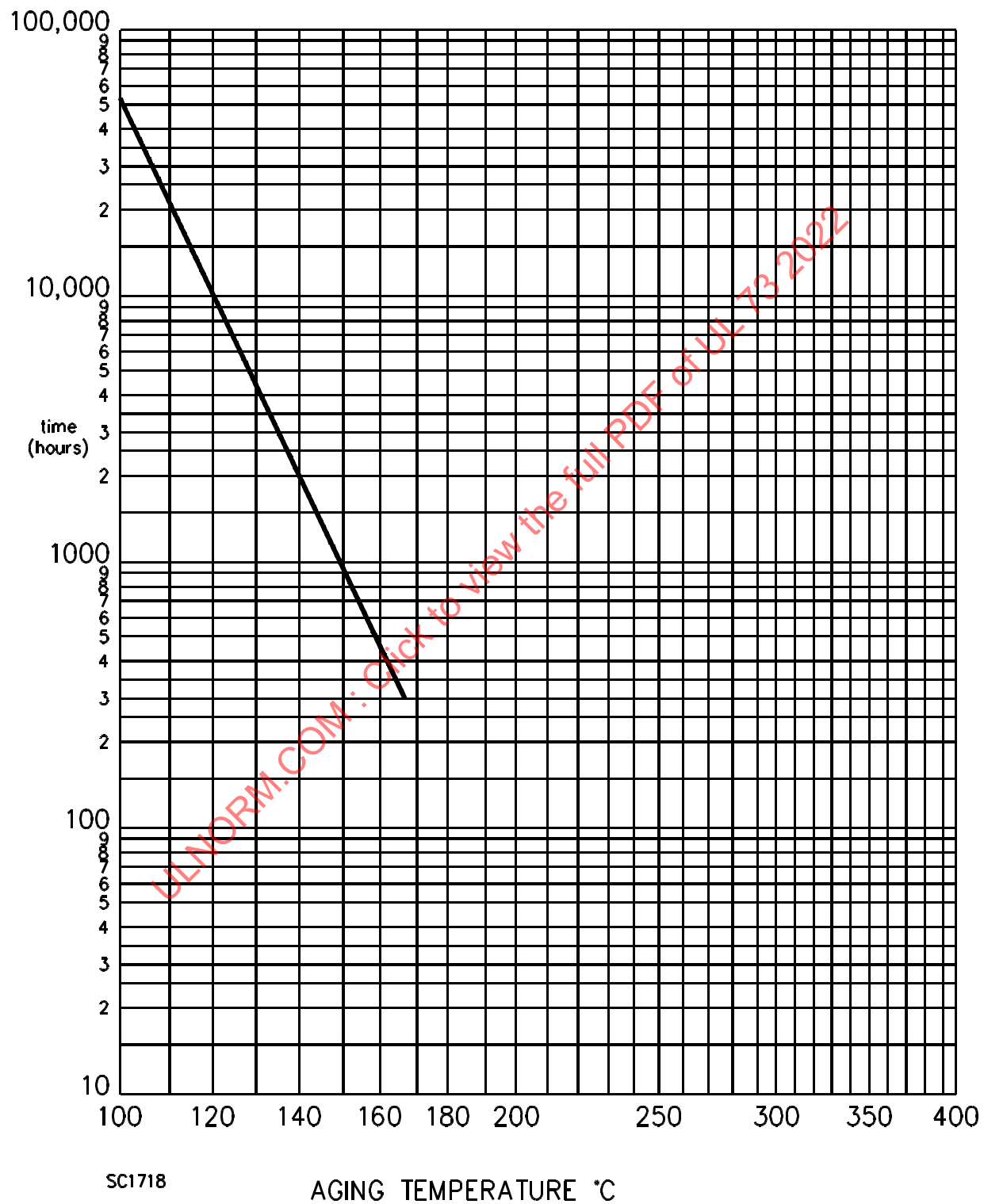
63.3.3 With reference to [63.3.2](#), the operation of an overtemperature or overcurrent protective device that complies with the applicable component standard in Section [6](#) is considered an acceptable end of test.

63.4 Thermal aging

63.4.1 A polymeric material employed in a Class 105 (A) motor insulation system in accordance with Exception No. 1 of [22.4.3](#) is to be aged for the amount of time corresponding to an aging temperature that appears on the Class 105 (A) system response shown in [Figure 63.1](#). The motor insulation system is to cool to room temperature and the applicable dielectric voltage-withstand requirements specified in Section [48](#) are to be applied between live parts and noncurrent-carrying metal parts that are isolated from each other by the material under consideration. The material shall withstand the dielectric test potential without breakdown.

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Figure 63.1
Class 105(A) system response
(See [63.4.1](#))



64 Electrically Operated Valves (Class 2) for Use in Automatic Solar Panel Cleaning Systems

64.1 Torque test

64.1.1 The sample valve shall be rigidly anchored or otherwise supported by a tool which fits snugly about the body of the valve, or to a section of the shank shaped for a wrench, if such section is provided, adjacent to the end into which the pipe is to be connected. A section of unused Schedule 80 pipe (as specified in the Specifications for Welded and Seamless Steel Pipe, ANSI/ASTM A53) of sufficient length for wrench engagement is to be connected to the female pipe threaded section of the body, the male threads having first been lubricated with SAE No. 10 machine oil (as specified in the Engine Oil Viscosity Classification, ANSI/SAE J300). Each pipe section is then to be tightened to the applicable torque specified in [Table 64.1](#).

Table 64.1
Torque requirements for pipe connections

Pipe size	Torque	
	lb-in	(N·m)
Nominal inches		
1/8	170	(19.2)
1/4	220	(24.2)
3/8	280	(31.6)
1/2	375	(42.4)
3/4	560	(63.3)
1	750	(84.8)
1-1/4	875	(98.9)
1-1/2	940	(106)
2	1190	(134)
2-1/2	1310	(148)
3	1310	(148)

64.1.2 After the torque force has been applied to each connected pipe, the test sample shall be subjected to the Hydrostatic Strength Test, [64.2](#).

64.2 Hydrostatic strength test

64.2.1 All parts of a valve, except a diaphragm, that are subjected to pressure during intended operation shall be tested hydrostatically to determine that the strength of the parts is sufficient to withstand, without bursting or rupture, a pressure equivalent to two times the maximum rated pressure of the cleaning system, or two times the maximum rated pressure of the water pressure delivered by the system pump to the valve, whichever is greater.

64.2.2 Prior to the beginning of this test, a valve is to comply with the requirements for the Torque Test, [64.1](#).

64.2.3 The valve shall be tested by connecting the inlet to a hydraulic system. With the outlet of the valve sealed and the valve in the open position, the pressure shall be raised slowly to the required test pressure and held for a period of 1 min. In the case of a diaphragm valve, the test pressure shall be applied on both sides of the diaphragm slowly and without shock to avoid excessively stressing the diaphragm.

64.2.4 Leakage at a gasket is acceptable if there is no evidence of an increase in the risk of personal injury to persons.

64.3 Burnout test

64.3.1 There shall not be damage to the enclosure, or emission of flame or molten metal, when the valve mechanism has been blocked in the position assumed when the valve is de-energized and the valve then energized continuously at rated voltage and frequency with the valve grounded.

64.3.2 The circuit to which the valve is connected shall be protected by fuses rated at least ten times the current input rating of the valve. Opening of the fuses may occur and the valve need not be operative following the test.

64.3.3 If the valve body is nonmetallic, three samples shall be tested.

65 Interlock System Endurance Test – Recessed Ultrasonic Cleaners

65.1 The interlock system of a recessed ultrasonic cleaner shall be subjected to the endurance test described in [65.2](#) and [65.3](#). As a result of the test:

- a) There shall not be any electrical or mechanical malfunction of the interlock system, or undue pitting or burning of the switch contacts; and
- b) The fuse in the grounding connection shall not open.

65.2 To determine if an interlock system complies with the requirements in [65.1](#), the appliance is to be connected to a grounded power-supply circuit of rated frequency and voltage. During the test, exposed dead metal parts of the appliance are to be connected to ground through a 3-A non-time-delay plug fuse and the connection is to be such that any single-pole current interrupting device is in an ungrounded conductor of the supply circuit.

65.3 The interlock system is to be operated for 100,000 cycles at a maximum rate of 6 cycles per minute. Each cycle is to consist of lifting the interlocked safety door or guard from its closed position, to its maximum open position, and then back to its closed position. The interlock switch shall be operated at a cycle rate of one-second "on" and nine-seconds "off". A faster or slower cycle rate may be used if acceptable to those involved.

66 Polymeric Enclosure Mechanical Resistance – Recessed Ultrasonic Cleaners

66.1 Crushing resistance test

66.1.1 A recessed ultrasonic cleaner provided with a polymeric safety door or guard that is part of an interlock system shall comply with the Crushing Resistance Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. After the testing there shall be no malfunction of the interlock system.

66.2 Resistance to impact test

66.2.1 A recessed ultrasonic cleaner provided with a polymeric safety door or guard that is part of an interlock system shall comply with the Resistance to Impact Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C (5 ft-lb ball impact). After the testing there shall be no malfunction of the interlock system.

66A Ultraviolet Irradiance Test

66A.1 Emissions of ultraviolet (UV) radiation from the Insect and rodent-control equipment shall be evaluated in accordance with the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values and Biological Indices. The test shall be conducted in accordance with [66A.2](#), and shall comply with the requirements in [41A.1](#).

66A.2 Testing shall be performed in the condition(s) most likely to result in the highest emission levels, including removal or adjustment of guards or operating settings. The test shall be performed using a new lamp, or integral radiation source, representative of the maximum emission capability, including user replacement parts. The measurement device shall be placed at the distance specified in [Table 66A.1](#) for the fixed or location dedicated or wall/ceiling- hung type specified or at a lesser distance if requested by the manufacturer. The measurement shall be made as close to the equipment for other portable types. The effective irradiance value shall comply with the requirements of [41A.1](#).

Exception: When provided with installation instructions in accordance with [75A.2](#), the measurement device may be placed at the maximum general use distance indicated in [Table 66A.1](#) for the type specified or at a lesser distance if requested by the manufacturer.

Table 66A.1
Equipment type and general use distance measurement

Equipment type	Type of exposure	Measurement instrument distance for equipment
Commercial Fixed Equipment with a total lamp wattage of ≤ 50 W	General	39 inches (0.99 m)
	Relamping/servicing	16.85 inches (0.43 m)
Commercial Fixed Equipment with a total lamp wattage of >50 W but less than 100 W	General	78 inches (1.98 m)
	Relamping/servicing	16.85 inches (0.43 m)
Commercial Fixed Equipment with a total lamp wattage of ≥ 100 W	General	117 inches (2.97 m)
	Relamping/servicing	16.85 inches (0.43 m)
Commercial Portable Equipment with a total lamp wattage of ≤ 50 W (a)	General	39 inches (0.99 m)
	Relamping/servicing	16.85 inches (0.43 m)
Commercial Portable with a total lamp wattage of >50 W (a)	General	78 inches (1.98 m)
	Relamping/servicing	16.85 inches (0.43 m)
Household Fixed	General	39 inches (0.99 m)
	Relamping/servicing	16.85 inches (0.43 m)
Household Portable/Outdoor Portable (a)	General	39 inches (0.99 m)
	Relamping/servicing	16.85 inches (0.43 m)
Outdoor Fixed Equipment with a total lamp wattage of ≤ 50 W	General	120 inches (3.048 m)
	Relamping/servicing	16.85 inches (0.43 m)
Outdoor Fixed Equipment with a total lamp wattage of >50 W	General	300 inches (7.62 m)
	Relamping/servicing	16.85 inches (0.43 m)
*Note – general exposure limits are based on an 8-hour day and relamping/servicing is based on an exposure time of maximum 16 minutes.		
(a) – Portable units are applied to hung unit and are provided with installation instructions on general use distance per 75A.2 .		

66A.3 For insect and rodent-control equipment that employ enclosures, guards and similar protective features to minimize the risk of overexposure to ultraviolet radiation, these parts shall be resistant to degradation from mechanical abuse. After subjecting the protective features to the Strain-Relief Test, Section [53](#), and if applicable, the Resistance to Impact, Section 22 and the Mold-Stress-Relief Distortion,

Section 29 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, the protective features shall be visually examined. If visual examination indicates that the protection afforded by the protective feature may be impaired, irradiance measurements shall be repeated. A different sample may be used for each mechanical abuse/irradiance test sequence.

66A.4 For insect and rodent-control equipment that may emit different levels of ultraviolet (UV) radiation under use and service conditions, both conditions shall be considered in the irradiance measurements.

66A.5 Instrumentation used for the radiation measurements shall be suitable for the measuring of emissions of the radiation source and frequencies. These measurements should only be performed by people trained to make proper optical radiation measurements and follow good laboratory practices which can be found in documents such as ANSI/IESNA RP-27.1 and IEC 62471:2006.

MANUFACTURING AND PRODUCTION TESTS

67 Dielectric Voltage-Withstand Test

67.1 Each appliance shall withstand without electrical breakdown, as a routine production-line test, the application of a 40 – 70 Hz potential between the primary wiring, including connected components:

- a) Accessible dead metal parts that are likely to become energized, and
- b) Accessible low-voltage metal parts, including terminals.

67.2 The production-line test shall be in accordance with either Condition A or Condition B of [Table 67.1](#).

Table 67.1
Production-line test conditions

Appliance rating or application	Condition A		Condition B	
	Potential, V	Time, s	Potential, V	Time, s
250 V or less with or without a motor rated 1/2 hp (373 W output) or less	1000	60	1200	1
Applied directly to persons	1000 + 2V ^a	60	1200 + 2.4V ^a	1
Rated more than 250 V with a motor rated more than 1/2 hp	1000 + 2V ^a	60	1200 + 2.4V ^a	1
Applied in a wet or moist condition directly to persons	2500	60	3000	1
^a Maximum rated voltage.				

67.3 The appliance may be in a heated or unheated condition for the test.

67.4 The test is to be conducted when the appliance is complete – fully assembled – and with the primary switch in the on position. It is not intended that the appliance be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction-fit knob that would interfere with the performance of the test need not be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed appliance.

Exception No. 3: The test may be conducted before a solid-state component that can be damaged by the dielectric potential is electrically connected. However, a random sampling of each day's production is to be tested at the potential specified in [67.2](#), and the circuitry may be rearranged for the test to minimize the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

67.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit.

67.6 If the output of the test equipment transformer is less than 500 VA, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

67.7 If the output of the test equipment transformer is 500 VA or more, the test potential may be indicated by:

- a) A voltmeter in the primary circuit or in a tertiary winding circuit,
- b) A selector switch marked to indicate the test potential, or
- c) A marking in a readily visible location to indicate the test potential of equipment having a single test potential output. If marking is used without an indicating voltmeter, the equipment shall include a positive means, such as a power-on lamp to indicate that the manually reset switch has been reset following a tripout.

67.8 Test equipment other than that described in [67.5](#) – [67.7](#) may be used if found to accomplish the intended factory control.

67.9 During the test, both sides of the primary circuit of the appliance are to be connected together to one terminal of the test equipment; the second test equipment terminal is to be connected to the accessible dead metal.

Exception No. 1: This requirement does not apply to a resistive-type appliance.

Exception No. 2: This requirement does not apply to an appliance utilizing a motor, relay, coil, or transformer having circuitry not subject to excessive secondary voltage buildup in case of electrical breakdown during the test.

68 Grounding Continuity Test

68.1 Each appliance that has a power-supply cord having a grounding conductor shall be tested, as a routine production-line test, to determine that grounding continuity exists between the grounding blade of the attachment plug and the accessible dead metal parts of the appliance that are likely to become energized.

68.2 Only a single test need be conducted if the accessible metal selected is conductively connected by design to all other accessible metal.

68.3 Any indicating device, such as an ohmmeter, a battery-and-buzzer combination, or the like, may be used to determine compliance with the grounding continuity requirement in [68.1](#).

RATING

69 Details

69.1 An appliance shall be rated in volts, in frequency – expressed in one of the following terms: hertz, Hz, cycles-per-second, cps, cycles/second, c/s, ac-dc, or ac only and, other than as noted in [69.2](#), in amperes. The frequency may be expressed as ____/dc – for example, 60/dc – if a universal motor nameplate serves as the appliance rating marking. If an appliance is intended for use on a polyphase circuit, the number of phases shall be included in the rating.

69.2 Instead of the ampere rating mentioned in [69.1](#), an appliance may be rated in watts if the full-load power factor is 0.80 or more or if the rating of a cord-connected appliance is 50 W or less.

69.3 If a permanently connected appliance is marked with a horsepower (hp) rating, the rating shall not be less than the marked horsepower rating of the motor. If the appliance employs multiple motors, or one or more motors and other loads, the marked horsepower rating of the appliance shall not be less than the equivalent horsepower of the combined loads. The total load shall be calculated in accordance with Section 422.62(A) of the National Electrical Code, ANSI/NFPA 70. See [22.3.3](#).

69.4 An automatic solar panel cleaning system shall be marked with the maximum rated inlet water pressure and temperature. The maximum pressure of the system shall be less than 100 psig. These ratings shall also be provided in the instruction manual.

MARKING

70 Details

70.1 General

70.1.1 An appliance shall be plainly and permanently marked where it will be readily visible – after installation, in the case of a permanently connected appliance – with:

- a) The manufacturer's name, trade name, or trademark, or other descriptive marking by which the organization responsible for the product may be identified,
- b) A distinctive catalog number or the equivalent,
- c) The electrical rating, and
- d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception No. 1: The manufacturer's identification may be in a traceable code if the product is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code does not:

- a) Repeat in less than 10 years for a household product and less than 20 years for a commercial product, and*
- b) Require reference to the production records of the manufacturer to determine when the product was manufactured.*

70.1.2 A cautionary marking intended to instruct the operator shall be legible and visible from the position normally assumed by the operator when starting the appliance or from the position normally

assumed for the specific operation involved. Other such markings for servicing or making settings and adjustments shall be legible and visible to the individual when such work is being accomplished.

70.1.3 A marking intended to inform the user of a risk of electric shock, fire, or injury to persons shall be prefixed by a signal word "CAUTION," "WARNING," or "DANGER." The marking shall be in letters not less than 3/32 in (2.4 mm) high. The signal word shall be more prominent than any other required marking on the appliance.

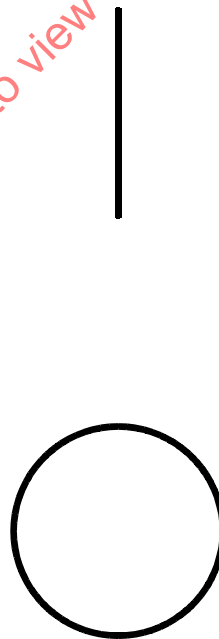
70.1.4 A cautionary marking shall be permanent and legible and shall be located on a permanent part of the appliance. See Section [59](#), Permanence of Marking Test.

70.1.5 An appliance or a separately packaged attachment having a hidden or unexpected risk of electric shock, fire or injury to persons shall be marked to inform the user of the risk.

70.1.6 If, when energized, an appliance has a moving part that may cause injury to persons, a motor control switch on the appliance shall have a plainly marked off position. The international symbols shown in [Figure 70.1](#) may be used if the significance of these symbols is explained in the instructions packaged with the product.

Exception: A momentary-contact switch need not comply with this requirement.

Figure 70.1
On and off symbols



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70.1.7 An appliance having a part of an enclosure as described in the Exception to [34.2](#) shall be marked with the word "CAUTION" and the following or equivalent: "To reduce the risk of injury from moving parts, unplug before servicing."

70.1.8 An appliance that employs a single motor as its only electrical-energy-consuming component need not show the electrical rating given on the motor nameplate elsewhere on the appliance if this nameplate is readily visible after the motor has been installed in the appliance.

70.1.9 If the motor nameplate of a dual-voltage motor is employed to give the electrical rating of the appliance as specified in [70.1.8](#), the appliance shall be additionally and permanently marked to indicate the particular voltage for which it is connected when shipped from the factory. See [73.8](#).

70.1.10 If a manufacturer produces or assembles motor-operated appliances at more than one factory, each finished appliance shall have a distinctive permanent marking by means of which it may be identified as the product of a particular factory.

70.1.11 An appliance having provisions for two or more separate connections to a branch circuit or other power-supply source shall be permanently marked with the word "CAUTION" and the following or the equivalent: "Risk of Electric Shock. This appliance has more than one connection to the source of supply. Disconnect all such connections before servicing." The marking shall be located at each point of connection, and shall be readily visible after installation of the appliance.

70.1.12 If the design of an appliance contemplates cleaning or servicing, such as the replacement of pilot lamps or fuses, by the user, and if such cleaning or servicing would involve the exposure of a normally enclosed or protected live part to unintentional contact, the appliance shall be plainly and permanently marked with the word "WARNING" and the following or equivalent: "To reduce the risk of electric shock, unplug before cleaning or servicing."

70.1.13 An appliance that will not start and attain normal running speed when connected to a circuit protected by an ordinary – not a time-delay – fuse as described in Exception (c) to [38.1](#) shall be plainly and permanently marked with the words: "If connected to a circuit protected by fuses, use time-delay fuses with this appliance," or with equivalent wording.

70.1.14 An appliance shall not be marked with a double insulation symbol – a square within a square – the words "Double Insulation," or the equivalent unless it complies with the requirements for double-insulated appliances.

70.1.15 An attachment that is packaged and marketed separately from the basic appliance and recommended by the manufacturer for use on the basic appliance shall be marked to identify the basic appliance with which it is intended to be used. The marking shall appear in at least one of the following locations:

- a) On the attachment,
- b) On the package housing the attachment,
- c) In the instruction manual for the basic appliance, or
- d) In the instruction manual furnished with the attachment.

70.1.16 Unless an appliance has been investigated and found to be acceptable for commercial use, the appliance shall be marked "For Household Use Only," "Household Type," or the equivalent. An appliance that has been investigated and found to be acceptable for commercial and household use shall be marked "For Household and Commercial Use," or equivalent.

70.1.17 An appliance that is intended for installation in a commercial garage and that incorporates arcing or sparking parts shall be permanently marked with the following statement: "WARNING – This equipment incorporates parts, such as snap switches, receptacles, and the like that tend to produce arcs