UL 1647

STANDARD FOR SAFETY

Motor-Operated Massage and Exercise Machines

UL Standard for Safety for Motor-Operated Massage and Exercise Machines, UL 1647

Sixth Edition, Dated August 3, 2015

Summary of Topics

This revision of ANSI/UL 1647 dated July 30, 2020 includes replacing references to the Standard for Power Conversion Equipment, UL 508C, with reference to the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1; 5.6.4.1 and 5.16.4.4.

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 May 29, 2020.

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Standard for Motor-Operated Massage and Exercise Machines

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The most recent designation of ANSI/UL 1647 as an American National Standard (ANSI) occurred on July 21, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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 massage and exercise machines, such as vibrators, exercise bicycles, vibrating and massaging chairs, and the like, are to be employed in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover massage and exercise machines such as vibrators in which motion of an operating part is produced by electrical means.

1.3 These requirements also cover portable motor-operated massage type footbaths that may employ a heating function.

1.4 These requirements do not cover appliances rated more than 250 V.

1.5 These requirements do not cover footbaths without a motor-operated massage type function.

1.6 These requirements also cover motorized and non-motorized inversion tables.

1.7 These requirements do not cover portable cord-connected hydromassage units that are intended for placement on the side of a bathtub. These type of appliances are covered by the Standard for Personal Hygiene and Health Care Appliances, UL 1431.

1.8 These requirements do not cover pedicure spas intended for use in salons and similar commercial establishments. These type of appliances are covered by the Standard for Electric Plumbing Accessories, UL 1951. A massage or exercise device that includes a pedicure spa as part of the overall product (ie; massage chair with pedicure spa at base) shall be evaluated using the requirements of UL 1951, plus the applicable requirements of UL 1647 as related to the portion(s) of the device that provide massage and/or exercise functions.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Undated References

3.1 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.

4 Glossary

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

4.2 AGILITY TRAINER – A non-motorized, electrical appliance intended for commercial indoor use and consisting of a control panel, footboard, and associated electrical components and wiring intended to develop and increase the user's agility.

4.3 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).

4.4 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.

4.5 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.

4.6 AUTOMATICALLY CONTROLLED APPLIANCE FUNCTION – An appliance function is considered to be automatically controlled if:

a) The repeated starting of the appliance or a portion 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 a 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 speed of a motor sufficiently to reestablish starting-winding connections to the supply circuit.

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

4.8 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 fire, electric shock, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

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

4.10 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 mitigate the risk of fire, electric shock, or injury to persons, is considered an operating control.

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

4.12 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 end product standard.

4.13 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 end product standard.

4.14 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.

4.15 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.

4.16 CORD, INTERCONNECTING – Flexible cord routed external to the product enclosure, provided as part of a complete product for purposes other than connection to the supply source.

4.17 FIXED APPLIANCE – An appliance that is intended to be permanently connected electrically to the wiring system.

4.18 FOOTBATH – A portable motor-operated appliance provided with an integral water vessel and massaging function, that also may be provided with a heating function. The massage function is produced mechanically by a motor or vibrating coil, or by a motor that pumps air (air-bubbler, bubble massage) or circulates water (hydro-massage). The heating function is typically provided by insulated resistance heating wire.

4.19 INVERSION TABLE – An appliance that is intended to invert the user by rotating a table through various inversion angles while the user's ankles are secured in a clamping device. When the table is in its full inverted position, the user is supported entirely by an ankle-clamping device. Motion of the table is either motorized (motor-operated) or non-motorized (body-weight operated).

4.20 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 250 V and having circuit characteristics in excess of those of a low-voltage circuit.

4.21 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.

4.22 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in millivolts RMS, in the measurement instrument in Figure 45.1, divided by 500 ohms. (The instrument indication is equal to the RMS value in milliamperes when the frequency is 60 Hz (sinusoidal current). The reading may not be a direct indication of the RMS or other common amplitude quantifier of leakage current when the leakage current is of complex waveform or frequency other than 50 or 60 Hz).

4.23 MOTION SIMULATION APPLIANCE – An upholstered furnishing intended for indoor, household use and provided with a motion simulating assembly that is comprised of a platform, electrical actuators, and a motion controller that synchronizes media action with the movement of the furnishing.

4.24 PORTABLE APPLIANCE – A cord connected appliance that is hand-held when used or easily conveyed by hand and weighs 40 lb (18.15 kg) or less.

4.25 REMOTELY CONTROLLED APPLIANCE FUNCTION – An appliance function that is initiated by an operator while out of sight of the appliance.

4.26 STATIONARY APPLIANCE – A cord connected appliance weighing more than 40 lb (18.15 kg).

4.27 TREADMILL BELT – The moving surface of the treadmill, on which the user walks, jogs, or runs.

CONSTRUCTION

5 Components

5.1 General

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

a) Comply with the requirements for that component as indicated in 5.2 – 5.26;

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.

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 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 5.2 – 5.26 is acceptable if:

a) The component also complies with the applicable component standard specified in 5.2 – 5.26; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, ANSI/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 is 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.

5.1.2 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.

5.1.3 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 component standard(s) need not be applied.

5.1.4 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in 5.2 – 5.26, and that involves a risk of fire, electric shock, or injury to persons, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 5.1.1(b) – (e).

5.1.5 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is suitable where that standard anticipates normal and abnormal use conditions consistent with the application of this end product standard.

5.2 Attachment plugs, receptacles, connectors, and terminals

5.2.1 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 5.2.9.

Exception No. 1 : Attachment plugs and appliance couplers integral to attached or detachable power supply cords that are investigated in accordance with the Standard for Cord Sets and Power Supply Cords, UL 817 are not required to comply with UL 498.

Exception No. 2 : A fabricated pin terminal assembly need not comply with UL 498 if it complies with Mechanical Assembly, Section 9, Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12, Current Carrying Parts, Section 14, Electrical Insulation, Section 15, and Spacings, Section 29, of this end product standard.

5.2.2 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 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 UL 310.

Exception No. 2: A connector that complies with UL 310 may be used with an appropriately sized tab that complies with the material, configuration, and dimensional requirements for production tabs as specified in UL 310. 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.

5.2.3 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 5.2.9.

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

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

5.2.6 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 5.2.9.

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

5.2.8 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 UL 1059 if the part complies with the requirements of Wiring Terminals and Leads, Section 13.2.3, Electrical Insulation, Section 15, and Spacings, Section 29, of this end product standard. This exception does not apply to protective conductor terminal blocks.

5.2.9 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.

5.3 Batteries and battery chargers

5.3.1 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. A lithium ion multiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

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

5.3.3 Rechargeable nickel metal-hydride (Ni-MH) battery cells and packs shall comply with 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.

5.3.4 Primary batteries (non-rechargeable) that comply with the applicable UL standards and the requirements in General, Section 5.1 are considered to comply with the requirements of this end product standard.

5.3.5 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"; or

c) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, with an output marked ″Class 2″, or that complies with the limited power source (LPS) requirements and is marked ″LPS″.

5.3.6 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; or

c) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

5.4 Boxes and raceways

5.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3, Wiring Methods and Materials, of the National Electrical Code, ANSI/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, or the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D) and the requirements in General, Section 5.1 are considered to comply with the requirements in this end product standard.

5.5 Capacitors and filters

5.5.1 The component requirements for a capacitor are not specified. A capacitor that complies with the Standard For Safety For Capacitors, UL 810, is considered to comply with the requirements in Grounding-General, Section 19.1.

5.5.2 Electromagnetic interference filters with integral enclosures that comply with the Standard for Electromagnetic Interference Filters, UL 1283 are considered to comply with the requirements in Grounding-General, Section 19.1.

5.6 Controls

5.6.1 General

5.6.1.1 Auxiliary controls shall be evaluated in accordance with the applicable requirements of this end product standard and the parameters in Controls – End Product Test Parameters, Section 27 unless otherwise specified in this end product standard; see 5.6.1.7.

5.6.1.2 Operating (regulating) controls shall be evaluated in accordance with the applicable component standard requirements specified in 5.6.2 – 5.6.7, if applicable, and the parameters in Controls – End Product Test Parameters, Section 27, unless otherwise specified in this end product standard; see 5.6.1.7.

5.6.1.3 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of fire, electric shock, or injury to persons, such as a speed control unexpectedly changing its output, shall comply with one of the following:

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.

5.6.1.4 Protective (limiting) controls shall be evaluated in accordance with the applicable component standard requirements specified in 5.6.2 – 5.6.7 and if applicable, the parameters in Controls – End Product Test Parameters, Section 27, unless otherwise specified in this end product standard.

5.6.1.5 Solid-state protective controls that do not rely upon software as a protective component shall comply with one of the following:

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 the Controls Using Software requirements, Clause H 11.12.

5.6.1.6 Solid-state protective controls that rely upon software as a protective component shall comply with one of the following:

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.

5.6.1.7 An electronic, auxiliary or operating control (e.g. a non-protective control), the failure of which would not increase the risk of fire, electric shock, or injury to persons, need only be subjected to the applicable requirements of this end product standard.

5.6.2 Electromechanical and electronic controls

5.6.2.1 A control, other than as specified in 5.6.3 – 5.6.7, shall comply with one of the following:

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

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

c) The Standard for Automatic Electrical Controls – General Requirements, UL 60730-1.

5.6.3 Liquid level controls

5.6.3.1 A liquid level control shall comply with one of the following:

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; or

d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and;

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

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

5.6.4 Motor and speed controls

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

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;

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

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

Exception: A control that controls the speed and acceleration of the treadmill belt shall comply with Switches and Controls, Section 40.1.

5.6.5 Pressure controls

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

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

b) The Standard for Industrial Control Equipment, UL 508; or

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 Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

5.6.6 Temperature controls

5.6.6.1 A temperature control shall comply with one of the following:

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; or

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.

Exception: A thermostat used in a heating pad assembly that complies with the requirements in Thermostat Test, Section 59 of this end product standard is considered to comply with the intent of this requirement.

5.6.6.2 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 the Standard for Thermistor-Type Devices, UL 1434.

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

5.6.7 Timer controls

5.6.7.1 A timer control shall comply with one of the following:

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

5.7 Cords, cables, and internal wiring

5.7.1 An attached or detachable power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

5.7.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to comply with this requirement when pre-assembled in an attached or detachable power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

5.7.3 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 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, ANSI/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, electric shock or injury to persons need not comply with UL 758.

5.8 Cord reels

5.8.1 A cord reel shall comply with special use cord reel requirements in the Standard for Cord Reels, UL 355.

5.9 Film-coated wire(magnet wire)

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

5.9.2 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.

5.10 Gaskets and seals

5.10.1 Gaskets and seals that comply with the Standard for Gaskets and Seals, UL 157, are considered to comply with the requirements of 11.2 and 44.2.

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

5.11.1 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."

5.11.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B.

5.11.3 With respect to 5.11.2, an ALCI is not considered an acceptable substitute for a GFCI when the National Electrical Code, ANSI/NFPA 70 requires a GFCI.

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

5.11.5 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Arc-Fault and Leakage Current Detectors/Interrupters, Section 24.

5.11.6 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Arc-Fault and Leakage Current Detectors/Interrupters, Section 24.

5.12 Heaters, heating elements and pads

5.12.1 Electric resistance heating elements shall comply with the construction requirements in the:

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 comply with this requirement.

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

5.12.3 A heating pad assembly shall comply with the applicable requirements in the Standard for Electric Heating Pads, UL 130.

Exception: A heating pad assembly that is not accessible as determined by the requirements in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12 of this end product standard, and that complies with the requirements of this end product standard, need not comply with UL 130. See the Resistance to Moisture Test, Section 53, Thermostat Test, Section 59, and Flexing and Twisting Test, Section 62.

5.13 Insulation systems

5.13.1 Materials used in a Class 105 (A) insulation system shall comply with 23.3.

5.13.2 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.

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

5.14 Light sources and associated components

5.14.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

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

5.14.2 Lighting ballasts shall comply with one of the following:

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 an 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).

5.14.3 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 an 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 UL 8750, but shall comply with the applicable requirements of this end product standard.

5.15 Marking and labeling systems

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

Exception: A marking or labeling system that complies with the requirements in the Permanence of Marking Test, Section 65 of this end product standard is considered to comply with the requirement.

5.16 Motors, generators and motor overload protection

5.16.1 General

5.16.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in General-Purpose Type Motors, Section 5.16.2. 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).

5.16.1.2 Motors not enclosed, or partially enclosed, by the end product enclosure shall comply with the requirements specified in General-Purpose Type Motors, Section 5.16.2.

5.16.1.3 Component type motors completely enclosed within the end product enclosure and generators shall comply with the requirements specified in General-Purpose Type Motors and Generators, Section 5.16.2 or Component Type Motors and Generators, Section 5.16.3.

5.16.1.4 Motors and generators located in a low-voltage circuit are evaluated for the risk of fire, electric shock, or injury to persons in accordance with the applicable requirements of this end product standard.

5.16.1.5 Low voltage component fans that comply with the Standard for Electric Fans, UL 507, are considered to comply with the requirements for Motors, Section 22 of this end product standard.

5.16.2 General-purpose type motors and generators

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

5.16.3 Component type motors and generators

5.16.3.1 Component type motors and generators shall comply with either 5.16.3.2 or 5.16.3.3.

5.16.3.2 The motor or generator shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 except as noted in Table 5.1.

Table 5.1
Superseded requirements

UL 1004-1 Exempted Requirement	Superseded by UL 1647 Requirements
Current and Horsepower Relation	Paragraph 22.2.4
Cord-Connected Motors	Section 13.1
Factory Wiring Terminals and Leads	Section 16
Electrical Insulation	Section 15
Non-Metallic Functional Parts, Section 28	Sections 7, 15, and 22
Solid-State Controls, 7.2	Paragraph 2.6
Non-metallic enclosure thermal aging, 9.1.4	Paragraph 7.2.2
Motor enclosure, 9.2 – 9.4	Section 7
Grounding	Section 19
Ventilation Openings, only applicable where the openings are on surfaces considered to be the appliance enclosure	Section 7.2.2
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts	Section 12
Protection Against Corrosion	Section 11
Available fault current ratings for motor start and running capacitors, Paragraph 26.6: not applicable for cord and plug connected appliances.	Section 19
Switch is not applicable to centrifugal starting switches	Section 26
With the exception of Resilient Elastomer Mounting and Electrolytic Capacitor Tests, the performance tests in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 are not applicable	All applicable performance tests
Only the following marking requirements in UL 1004-1 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	Paragraph 81.1

5.16.3.3 The motor or generator shall comply with the applicable component requirements for Components, Section 5, 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 11;

b) Terminal Compartment, Section 13 (13.2.2.3);

c) Electrical Insulation, Section 15;

d) Internal Wiring, Section 16;

e) Capacitors, Section 18;

f) Grounding, Section 19;

g) Motors, Section 22; and

h) Spacings, Section 29.

5.16.4 Motor overload protection

5.16.4.1 Thermal protection devices integral with the motor shall comply with one of the following:

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

b) The Standard for Thermally Protected Motors, UL 1004-3; or

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).

5.16.4.2 Impedance protection shall comply with the Standard for Impedance Protected Motors, UL 1004-2.

5.16.4.3 Electronic protection integral to the motor shall comply with the Standard for Electronically Protected Motors, UL 1004-7.

5.16.4.4 Except as indicated in 5.16.4.3, electronically protected motor circuits shall comply with one of the following. See Motor and Speed Controls, Section 5.6.4 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 Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1;

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 Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1.

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.

5.17 Overcurrent protection

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

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

5.17.3 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 UL 489.

5.17.4 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.

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

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

5.18 Polymeric materials and enclosures

5.18.1 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.

5.18.2 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.

5.19 Power supplies

5.19.1 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"; or

c) The Standard for Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements, UL 62368-1, with an output marked ″Class 2″, or that complies with the limited power source (LPS) requirements and is marked ″LPS″.

5.19.2 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; or

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

c) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

5.20 Printed wiring boards

5.20.1 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 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.

5.20.2 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 Electrical Insulation, Section 15 of this end product standard.

5.20.3 Unless otherwise specified, the flammability class and temperature rating shall be that as specified in Electrical Insulation, Section 15 of this end product standard.

5.21 Semiconductors and small electronic components

5.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Safety for Optical Isolators, UL 1577. The Dielectric Voltage Withstand Tests required by UL 1577 shall be conducted applying the requirements of the Dielectric Voltage Withstand Test, Section 52, of this end product standard.

5.21.2 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. The Dielectric Voltage Withstand Tests required by UL 1577 shall be conducted applying the requirements in Dielectric Voltage Withstand Test, Section 52 of this end product standard.

5.21.3 Except as specified in 5.21.4, 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.

5.21.4 Where an electronic component is determined to be a critical component during the Abnormal Operation Test, Section 64, one of the following standards shall be applied. See 27.4 of this end product standard for the test requirements to be used:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, including its Follow-Up Program; 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.

5.21.5 A critical component, as specified in 5.21.4, 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.

5.21.6 A critical component as specified in 5.21.4, may also be identified using a failure-mode and effect analysis (FMEA) in accordance with the Failure-Mode and Effect Analysis (FMEA) requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

5.21.7 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.

5.22 Supplemental insulation, insulating bushings, and assembly aids

5.22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to comply with 16.2.6 or a performance requirement of this end product standard. In such cases, the insulation shall comply with the following applicable standards:

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; or

c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

5.22.2 Wire positioning devices shall comply with the requirements in Insulating Material, Sections 15, 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.

5.22.3 Insulating bushings that comply with the requirements in General, Section 5.1, of this end product standard, and the Standard for Insulating Bushings, UL 635 are considered to comply with the requirements of this end product standard. Tests specified in this end product standard (e.g. Strain Relief Test, Section 60) may still need to be performed to confirm the combination of the insulating bushing and the supporting part comply with the intent of the requirements.

5.23 Switches

5.23.1 Switches shall comply with one of the following:

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; or

d) The Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A.

Exception: Switching devices that comply with the applicable UL standards 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 with this requirement.

5.23.2 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.

5.23.3 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 6000 cycles of operation, or as a manual control for 5000 cycles of operation, in accordance with one of the following:

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

5.23.4 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 5.6.1.3.

5.24 Transformers

5.24.1 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 complies with the applicable construction and performance requirements of this end product standard when tested in conjunction with the end product, complies with the intent of this requirement.

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 complies with the intent of this requirement.

5.24.2 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, and that do not involve a risk of fire, electric shock or injury to persons need not comply with this requirement.

5.25 Valves (electrically operated) and solenoids

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

a) The Standard for Electrically Operated Valves, UL 429; 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 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.

5.25.2 Solenoids shall comply with the applicable construction and performance requirements of this end-product standard.

5.26 Video and audio components

5.26.1 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 massage or exercise machine shall comply with one of 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; or

c) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

5.26.2 The location, orientation, and intended use of a video or audio component shall be evaluated with the massage or exercise machine to ensure that the component (s) does not increase the risk of fire, electric shock, or injury to persons. 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 machine.

6 General

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

6.2 An appliance employing a heating element is judged on the basis of its compliance with the requirements in this end product standard.

6.3 Foam padding provided with an appliance having a heating pad shall comply with the requirements for HBF or better material.

6.4 Thermoplastic material used for a part of an appliance having any dimension (length, width, or height) greater than 12 in (305 mm) shall be classified HB.

6.5 Fabric, batting, padding, foam, and synthetic or natural leather shall not be relied upon to serve as an electrical enclosure (or barrier) for insulated live parts, including internal wiring, and uninsulated live parts. Nor shall it be used to support a live part, be in direct contact with a live part, or be within 1/32 inch (0.8 mm) of a live part.

7 Frame and Enclosure

7.1 General

7.1.1 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 resulting in a 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.

7.1.2 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.

7.1.3 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. 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) shall not be used, except for relatively small areas or for surfaces that are curved or otherwise reinforced.

7.1.4 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.

7.1.5 Among the factors that shall be evaluated when determining the acceptability of magnesium or a nonmetallic material, other than a polymeric material, are resistance to:

a) Mechanical damage;

b) Impact;

c) Moisture absorption;

d) Combustion; and

e) Distortion at temperatures to which the material is subjected under conditions of normal or abnormal use.

7.1.5.1 With respect to resistance to combustion, wood or wood composite materials used to form outer enclosures shall be separated from ignition sources. In addition, the construction shall comply with the following:

a) The enclosure shall comply with the Impact Test of 66.2 without exposure of live parts, including insulated wiring, or moving parts capable of causing injury; and

b) Temperatures on the enclosure material during normal operation shall not exceeding the limit specified in Table 49.1 for wood or other combustible material.

7.1.5.2 Ignitions sources within line-voltage circuits of the appliance are considered to be:

a) Uninsulated electrical connections, such as splicing wire connectors, quick-connect terminals, terminal connectors and other forms of wire connectors,

b) Printed circuit board traces,

c) Open coils and windings,

d) Open contacts, and

e) Wiring not employing VW-1 insulation.

Exception No. 1: Type S, SE, SO, SOO, ST, STO, STOO, SJ, SJE, SJO, SJOO, SJT, SJTO, AND SJTOO power cords are not considered to be ignition sources.

Exception No. 2: Impedance protected motors employing open-coil or exposed winding constructions are not considered to be ignition sources if they comply with 7.1.7(a)(2) without emission of flames or molten metal from the motor housing.

Exception No. 3: Thermally protected motors having openings in their enclosures are not considered to be ignition sources if they comply with the requirements in 7.1.7(a)(3) or 7.1.7(a)(4).

Exception No. 4: Transformers complying with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, are not considered to be ignition sources.

7.1.5.3 Separation of ignition sources from wood or wood composite materials shall consist of barriers and spacing as illustrated in Figure 7.0 as follows:

a) A part located vertically below the ignition source and within Space A of Figure 7.0 shall be isolated by means of a barrier located and sized so that the barrier covers 5 degrees beyond each side of the ignition source as illustrated in Figure 7.0.

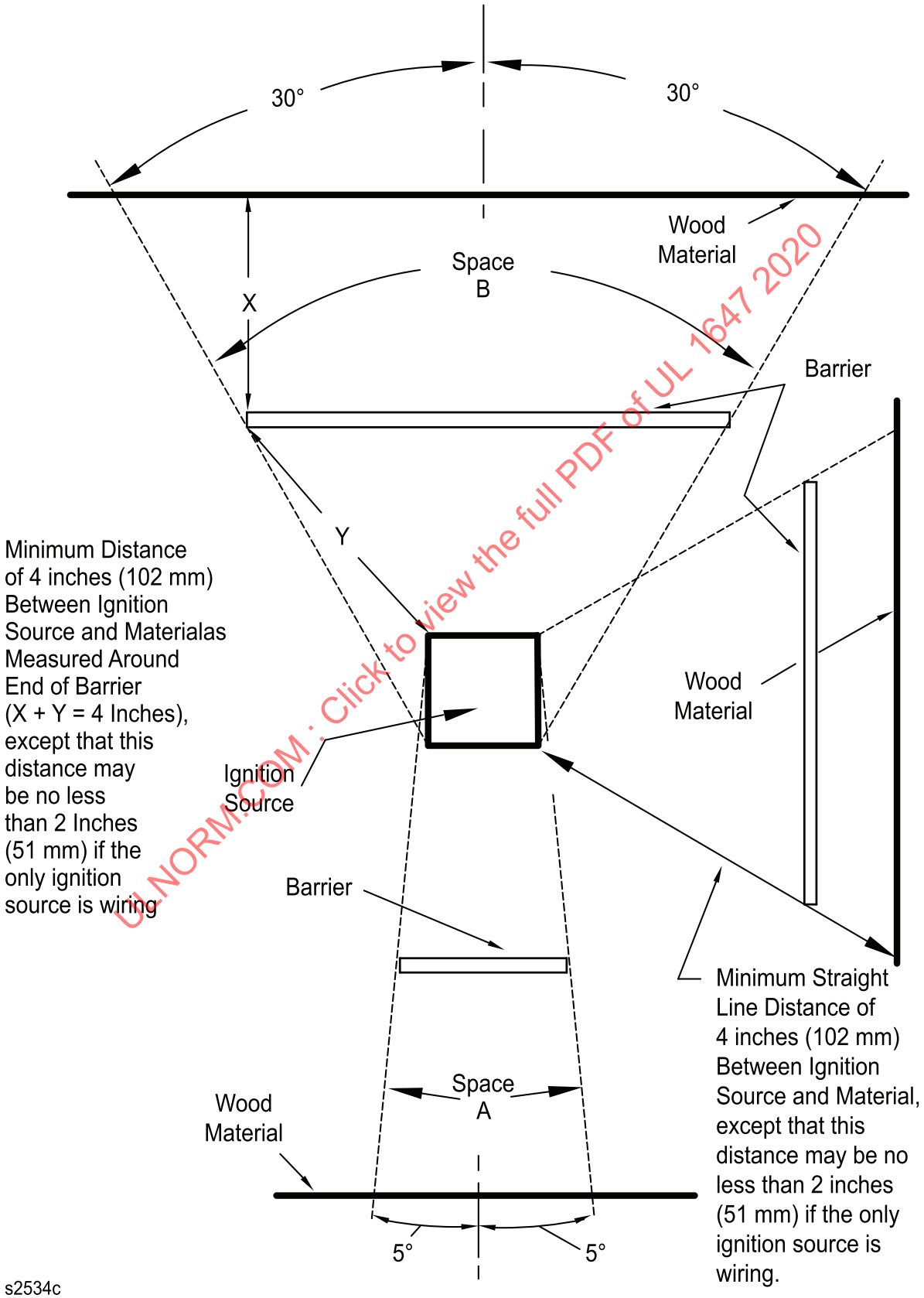
b) A part located vertically above the ignition source and within Space B of Figure 7.0 shall be isolated by means of a barrier located and sized so that the barrier covers 30 degrees beyond each side of the ignition source as illustrated in Figure 7.0 and so that the minimum distance between the nonmetallic material and ignition source is no less than 4 inches (102 mm).

c) A part located horizontally from the ignition source shall be isolated by means of a barrier located and sized so that the minimum straight line distance between the nonmetallic material and the ignition source is no less than 4 inches (102 mm).

Exception: When the only ignition source is wiring not employing VW-1 insulation the minimum distance between the nonmetallic material and the ignition source may be 2 inches (51 mm).

Figure 7.0

Separation of ignition sources from wood or wood composite materials



7.1.5.4 The barrier specified in 7.1.5.3 shall be of metal or a nonmetallic material having a flammability class as specified in 7.2.1.

7.1.6 The enclosure of components energized as a result of a remotely or automatically controlled appliance function shall prevent molten metal, burning insulation, flaming particles, or the like, from falling on combustible materials, including the surface upon which the appliance is supported.

7.1.7 The requirement in 7.1.6 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 prevent 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

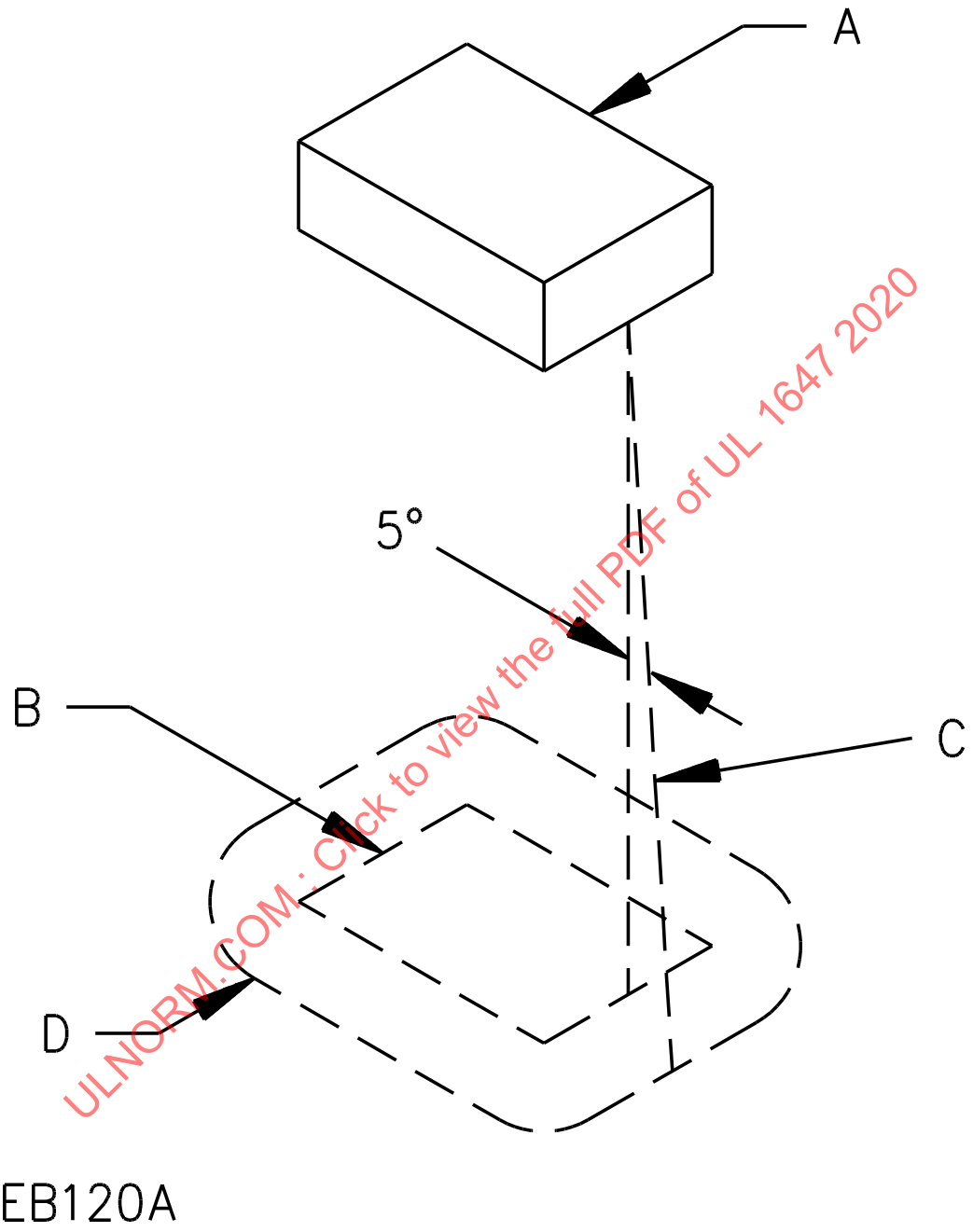
4) The motor complies with the requirements in the Standard for Overheating Protection for Motors, UL 2111, and the temperature of the motor winding will not exceed 150°C during the first 72 hours of operation with the rotor of the motor locked.

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

7.1.8 The barrier mentioned in 7.1.7 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



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 tangent to the component, 5 degrees from the vertical, and 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.

7.1.9 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.

7.1.10 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.

7.1.11 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.

7.1.12 To determine whether a product complies with the requirement in 7.1.11, 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.

7.1.13 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 metal part;

b) Magnet wire;

c) Internal wiring;

d) Moving parts; or

e) Any other part likely to create a risk of fire or electric shock.

7.2 Polymeric material enclosure

7.2.1 A polymeric material used to enclose uninsulated live parts, or enclose live parts having insulation less than 0.028 in (0.71 mm) thick or equivalent, shall comply with the Polymeric Enclosure Tests, Section 66, and shall have a flammability class determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, as follows:

a) Class 5VA for a fixed or stationary appliance or for an appliance that is permanently installed;

Exception No. 1: A polymeric material classed HB minimum is capable of being used for a stationary appliance intended for household use, and that is cord connected, attended, and intermittent duty when it complies with all the following:

1) All motors shall be provided with motor-overload protection complying with 22.2.2;

2) Transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411; or Class 2 Power Units, UL 1310; and

3) The appliance shall be provided with wheels or casters to facilitate movement from one location to another.

Exception No. 2: A polymeric material classed V-2 minimum is capable of being used for a stationary appliance intended for commercial use and that is cord connected, attended, and intermittent duty when it complies with all of the following:

a) All motors shall be provided with motor-overload protection complying with 22.2.2;

b) Transformers shall comply with the UL 5085-1 and the UL 5085-3; UL 1411; or UL 1310; and

c) The appliance shall be provided with wheels or casters to facilitate movement from one location to another.

Exception No. 3: In lieu of the required 5VA flame rating, the polymeric material may be subjected to the Flammability – 127 mm (5 inch) Flame Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) Class HB minimum for a portable, attended, intermittent duty, household appliance; or

Exception No. 1: Class V-2 minimum for a polymeric material used to enclose heating elements, including heating wire. For a massage type footbath in which the heating function can be operated only when the massage function is operating, Class HB minimum is applicable.

Exception No. 2: In lieu of the required HB flame rating, the polymeric material may be subjected to the Flammability – 12 mm Flame Test or the Flammability – 20 mm (3/4 Inch) Flame Test in accordance with the UL 746C.

c) Class V-2 minimum for an appliance other than mentioned in (a) and (b).

Exception No. 1: In lieu of the required V2 flame rating, the polymeric material may be subjected to the Flammability – 12 mm Flame Test 12 mm or the Flammability – 20 mm (3/4 Inch) Flame Test in accordance with UL 746C.

Exception No. 2: For portable, unattended, household use equipment, in lieu of the required V2 flame rating, the polymeric material may be subjected to the Portable Unattended Household Equipment - Alternate Path in accordance with UL 746C.

7.2.2 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.

7.2.3 A polymeric material used to enclose insulated live parts having insulation 0.028 in (0.71 mm) thick minimum or equivalent, internal wiring, or moving parts shall have a flammability class of HB minimum, and shall comply with Mold Stress-Relief Distortion, Section 66.1, and Impact, Section 66.2.

Exception: In lieu of the required V2 flame rating, the polymeric material may be subjected to the Flammability – 12 mm Flame Test or the Flammability – 20 mm (3/4 Inch) Flame Test in accordance with UL 746C.

7.2.4 The volume resistivity of a polymeric material used in an enclosure as specified in 7.2.1, determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, shall not be less than:

a) 50 MΩ-cm after conditioning for 40 h at 23 ±2°C (73 ±4°F) and 50 ±5 percent relative humidity; and

b) 10 MΩ-cm after exposure for 96 hours to moist air having a relative humidity of 90 ±5 percent at a temperature of 35 ±2°C (95 ±4°F).

Exception No. 1: A polymeric material having a volume resistivity lower than specified in (a) and (b) is capable of being used when the enclosure is determined to be a noncurrent-carrying metal part, and the product complies with Spacings, Section 29, and Spacings to Polymeric Enclosures, Section 29.2.

Exception No. 2: In lieu of volume resistivity, compliance with the Leakage-Current Test, Section 45 is acceptable. Leakage current measurement shall be taken from accessible surfaces of the polymeric material in question.

7.2.5 For a portable appliance, a polymeric material used to enclose uninsulated or insulated live parts shall have a hot wire ignition (HWI) performance level category (PLC) not greater than 4 – see Table 15.1 – as a result of the HWI test described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception No. 1: The material is not required to have a hot wire ignition rating when the live parts, including all internal wiring, are spaced 1/2 in (12.7 mm) or more from the material.

Exception No. 2: Materials that do not comply with the minimum HWI requirements specified in Table 15.1 shall comply with the:

a) Abnormal Overload Test, Section 69;

b) Glow-Wire End-Product Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

c) The Glow-Wire Ignitability Test in the UL 746A as follows:

i) The material shall have a glow-wire flammability index (GWFI) rating of at least the required glow-wire temperature specified in the table for Glow-Wire Temperature Requirements Based Upon a Products Functional End-Use Application of UL 746C; or the material shall have a glow-wire ignition temperature (GWIT) rating of at least 25°C higher than the required glow-wire temperature specified in the table for Glow-Wire Temperature Requirements Based Upon a Products Functional End-Use Application in UL 746C; and

ii) The GWFI or GWIT rating shall be in a thickness that is within ± 0.1 mm of the relevant end-product part, or if the rating is for a range of thicknesses, the relevant end-product part shall have a thickness within that range.

7.2.6 For a stationary or fixed appliance, a polymeric material used to enclose uninsulated or insulated live parts shall have a hot wire ignition (HWI) performance level category (PLC) not greater than 3 – see Table 15.1 – as a result of the HWI test, described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception No. 1: The material is not required to have a hot wire ignition rating when the live parts, including all internal wiring, are spaced 1/2 in (12.7 mm) or more from the material.

Exception No. 2: Materials that do not comply with the minimum HWI requirements specified in Table 15.1 shall comply with the:

a) Abnormal Overload Test, Section 69;

b) Glow-Wire End-Product Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

c) The Glow-Wire Ignitability Test in UL 746A as follows:

i) The material shall have a glow-wire flammability index (GWFI) rating of at least the required glow-wire temperature specified in the table for Glow-Wire Temperature Requirements Based Upon a Products Functional End-Use Application of UL 746C; or the material shall have a glow-wire ignition temperature (GWIT) rating of at least 25 C higher

than the required glow-wire temperature specified in the table for Glow-Wire Temperature Requirements Based Upon a Products Functional End-Use Application in UL 746C; and

ii) The GWFI or GWIT rating shall be in a thickness that is within ± 0.1 mm of the relevant end-product part, or if the rating is for a range of thicknesses, the relevant end-product part shall have a thickness within that range.

7.3 Motion simulation appliances

7.3.1 A motion simulation appliance as specified in 4.23 shall comply with the State of California Department of Consumer Affairs Bureau of Home Furnishings and Thermal Insulation, Technical Bulletin 117, Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture (March 2000) or Technical Bulletin 133, Flammability Test Procedure for Seating Furniture for use in Public Occupancies (January 1991). The furnishing shall be marked in accordance with 81.11.1.

8 Adhesives Used to Secure Parts

8.1 An adhesive that is relied upon to reduce a risk of electric shock, fire, 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.

9 Mechanical Assembly

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

9.2 A switch other than a through-cord switch, a lampholder, a plug adapter, a motor-attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 9.4.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

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

d) The intended 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 Mechanical Securement of Fluid-Handling Tubing

10.1 For a massage type footbath, fluid-handling tubing shall be mechanically secured at connections if there is a risk of fire or electric shock should the tubing become disconnected. This mechanical securement shall not rely upon friction between surfaces alone. See the Fluid-Handling Tubing Tests, Section 56.

11 Protection Against Corrosion

11.1 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.

11.2 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.

12 Accessibility of Uninsulated Live Parts and Film-Coated Wire

12.1 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 (a) or (b):

a) For an opening that has a minor dimension (see 9.3) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 12.1.

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 12.5 and Figure 12.2.

12.2 The probe mentioned in 12.1 and illustrated in Figure 12.1 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 shall be applied in any possible configuration, and, if necessary, the configuration shall be changed after insertion through the opening.

12.3 With reference to the requirements in 12.1, 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.

12.4 During the examination of an appliance to determine whether it complies with the requirements in 12.1, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

12.5 An opening as specified in 12.1 (b) and illustrated in Figure 12.2 is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire:

a) Less than X distance from the perimeter of the opening, as well as;

b) Within the volume generated by five times the diameter of the largest round rod that can be inserted through the opening, but not less than 4 in (102 mm).

In evaluating an opening, any barrier located within the volume usually is ignored unless it intersects the boundaries of the volume in a continuous, closed line.

12.6 During the examination of an appliance to determine whether it complies with the requirements in 12.1, the materials mentioned in 6.5 shall be removed.

Figure 12.1

Articulate probe with web stop

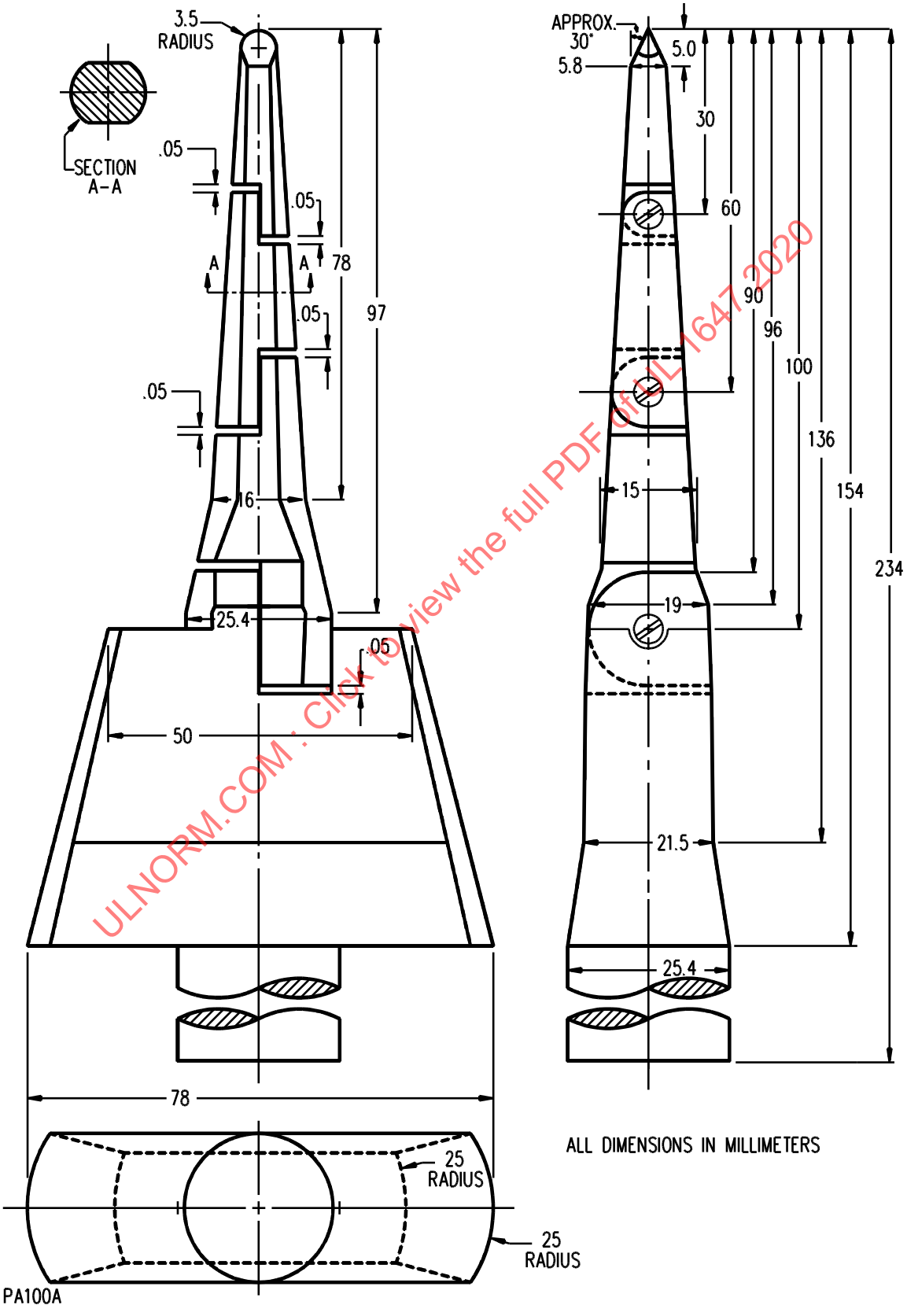
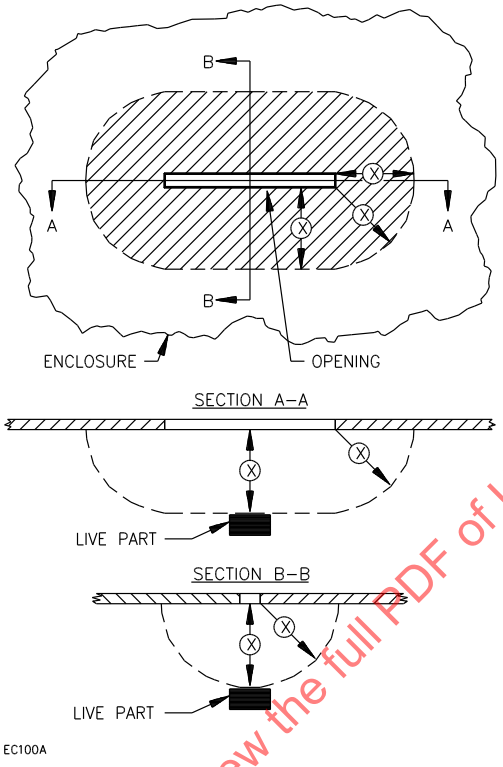


Figure 12.2

Opening in enclosure



13 Supply Connections

13.1 Cord-connected appliances

13.1.1 Cords and plugs

13.1.1.1 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. The flexible cord may be attached permanently to an appliance or may be in the form of a detachable power-supply cord with appropriate means for connection to the appliance.

13.1.1.2 The attachment plug of an appliance intended to be connected to a nominal 130 V circuit, and employing devices required to be connected to a specific supply conductor as specified in 21.1, 25.2, and 26.6 shall be a polarized type. The connections to the attachment plug shall be in accordance with Figure 13.1. The polarity identification of the supply cord shall be in accordance with Table 13.1. See 84.3.

Table 13.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Conductors intended to be grounded[a,b]	**All other conductors[a]**
Color of braid 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[d]	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[f]	

[a] An insulating 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 13.1.

[b] The grounded (identified) conductor is the neutral supply conductor.

[c] Only for cords – other than Types SP-1, SP-2, SPE-1, SPE-2, SPT-1, and SPT-2, – having no braid on any individual conductor.

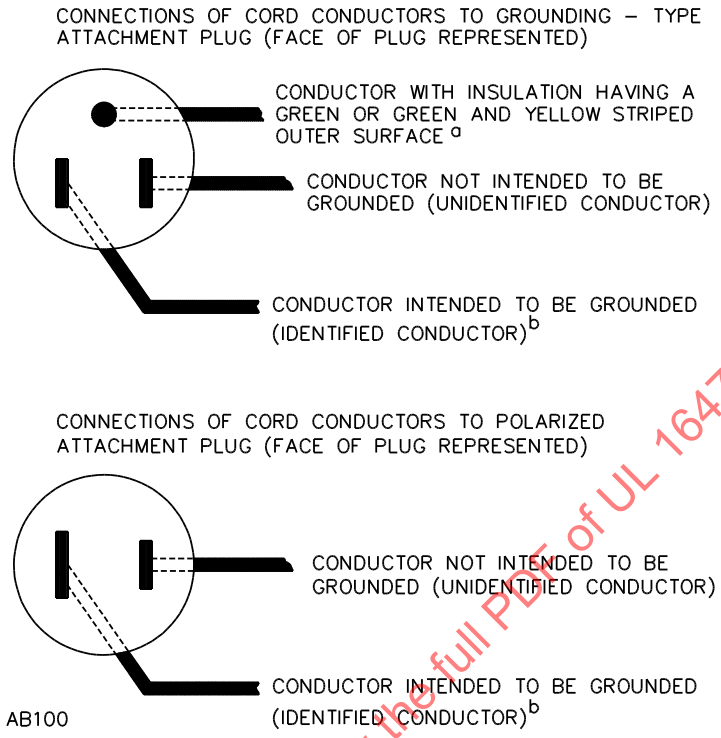
[d] For jacketed cords.

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

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

Figure 13.1

Connections to attachment plugs



[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 13.1. The grounded (identified) conductor is the neutral supply conductor.

13.1.1.3 An appliance that is required to employ a polarized attachment plug as specified in 13.1.1.2, and that is provided with a detachable power supply cord shall also employ an appliance connector of the polarized type.

13.1.1.4 The ampacity of the cord and the current rating of the attachment plug shall not be less than the maximum normal load current of the appliance. The voltage rating of the cord shall not be less than that of the appliance. The voltage rating of the attachment plug shall be equal to that of the appliance.

13.1.1.5 The flexible cord shall be as specified in Table 13.2, or shall be of a type at least equally serviceable for the application.

13.1.1.6 The flexible cord shall not be less than 6 ft. (1.83 m) long.

Table 13.2
Cords for appliances

Appliance type	Cord type
Household use other than noted below	SP-2, SPE-2, or SPT-2
Commercial use other than noted below	SJ, SJE, or SJT
Hand held weighing 1 lb (454 g) or less	TP, TPT
Hand held, household use, weighing more than 1 lb (454 g)	SP-1, SPE-1, or SPT-1
Hand held, commercial use, weighing more than 1 lb (454 g)	SP-2, SPE-2, or SPT-2
Chair, tables, and the like	SJ, SJE, or SJT
Commercial use, footstool or cushion type	SV, SVE, SVO, SVOO, SVT, SVTO, or SVTOO

13.1.1.7 The length of an attached flexible cord includes the attachment plug. The length of a detachable power supply cord includes the fittings.

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

13.1.1.9 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 81.1.3.

13.1.1.10 A massage type footbath shall employ a flexible cord that is attached to the appliance.

13.1.2 Strain relief

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

13.1.2.2 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.

13.1.2.3 A clamp of any material – metal or otherwise – shall not be used on Type SPT-1, SVT, SVTO, SVTOO, SPT-2, TP, or TPT cord or on cords of similar or lighter construction.

Exception No. 1: A clamp is capable of being used on Type SPT-1, SVT, SVTO, SVTOO, SPT-2, TP, or TPT (or similar) cord protected by varnished cloth tubing, phenolic, vulcanized rubber, or the equivalent under the cord grip, when the construction complies with Strain-Relief Clamp Test, Section 61. Thermoplastic tubing shall not be used over thermoplastic cords.

Exception No. 2: This requirement does not apply to a clamp that is rated for strain relief for the cord type used in the application.

13.1.2.4 For types of thermoplastic-insulated cord, heavier than Type SPT-1, 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.

13.1.2.5 Means shall be provided to prevent 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.

13.1.2.6 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.

13.1.3 Bushings

13.1.3.1 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.

13.1.3.2 An insulating bushing shall be provided if:

a) Type SP-1, SPE-1, SPT-1, 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.

13.1.3.3 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.

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

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

13.1.3.6 A vulcanized fiber bushing shall not be less than 3/16 in (4.8 mm) thick and shall be formed and secured in place so that it will not be adversely affected by conditions of ordinary moisture.

13.1.3.7 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:

a) The bushing is not less than 3/64 in (1.2 mm) thick; and

b) The bushing is 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 in 13.1.3.7 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 of these materials is used anywhere in the appliance, the edges of the hole in which the bushing is mounted are to be smooth and free from burrs, fins, and the like.

13.1.3.8 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-1 or heavier 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.

13.2 Permanently connected appliances

13.2.1 General

13.2.1.1 Except as noted in 13.2.1.2, an appliance intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems that would be acceptable for the appliance.

13.2.1.2 A stationary appliance may be acceptable if provided with not more than 8 ft (2.44 m) of Type S, SE, SO, SOO, ST, STO, or STOO cord and an attachment plug for supply connection. The investigation of such a feature will include consideration of the utility of the appliance and the necessity of having it readily detachable from its source of supply by means of a plug.

13.2.2 Terminal compartment

13.2.2.1 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.

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

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

13.2.3 Wiring terminals and leads

13.2.3.1 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.

13.2.3.2 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, and the like – factory-assembled to the wire, are provided as a part of the appliance.

13.2.3.3 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 wire binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

13.2.3.4 A wiring terminal shall be prevented from turning.

13.2.3.5 The free length of a lead inside an outlet box or wiring compartment shall be 6 in (152 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 may result in a risk of fire or electric shock.

13.2.3.6 A wire-binding screw at a wiring terminal shall not be smaller than No. 10.

Exception No. 1: A No. 8 screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.8 mm^2) conductor. See 13.2.3.7.

13.2.3.7 According to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) 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.

13.2.3.8 A wire-binding screw shall thread into metal.

13.2.3.9 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.

13.2.3.10 A terminal plate formed from stock having the thickness specified in 13.2.3.9 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

13.2.3.11 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in 13.2.3.1 under the head of the screw or washer.

13.2.4 Identified terminals and leads

13.2.4.1 A permanently connected appliance rated 135 or 135/250 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.

13.2.4.2 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.

13.2.4.3 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.

14 Current-Carrying Parts

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

14.2 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 the requirements in General, Section 5.1, or within a motor or associated governor.

15 Electrical Insulation

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

15.2 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.

15.3 A polymeric material used to support a live part, in direct contact with a live part or within 1/32 in (0.8 mm) of a live part shall be rated for use at the operating temperature involved and shall have the following material properties, determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A:

a) Volume resistivity not less than 50 MΩ-cm,

Exception: In lieu of volume resistivity, compliance with the Leakage-Current Test, Section 45 is acceptable. Leakage current measurement shall be taken from accessible surfaces of the polymeric material in question. If the polymeric part in question is not accessible, the leakage current shall be measured in accordance with 45.3 and 45.4.

b) Comparative tracking index (CTI) performance level category (PLC) not greater than 4, and

c) A PLC for high-current arc ignition (HAI) and hot wire ignition (HWI) not greater than specified in Table 15.1.

Exception No. 1: A material with a PLC for HAI greater than specified in Table 15.1 is capable of being used when the spacing over the surface of the material is not less than 1/2 in (12.7 mm):

1) Between live parts of opposite polarity,

2) Between live parts and grounded noncurrent-carrying metal; and

3) Between live parts and exposed noncurrent-carrying metal.

Exception No. 2: A material with a PLC for HAI greater than specified in Table 15.1 is capable of being used when the material complies with End-Product Arc Resistance, Section 68.

Exception No. 3: Materials that do not comply with the minimum HWI requirements specified in Table 15.1 shall comply with the:

a) Abnormal Overload Test, Section 69;

b) Glow-Wire End-Product Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

c) Glow-Wire Ignitability Test in UL 746A as follows:

i) The material shall have a glow-wire flammability index (GWFI) rating of at least the required glow-wire temperature specified in the table for Glow-Wire Temperature Requirements Based Upon a Products Functional End-Use Application in UL 746C; or the material shall have a glow-wire ignition temperature (GWIT) rating of at least 25 C higher than the required glow-wire temperature specified in the table for Glow-

Wire Temperature Requirements Based Upon a Products Functional End-Use Application in UL 746C; and

ii) The GWFI or GWIT rating shall be in a thickness that is within ± 0.1 mm of the relevant end-product part, or if the rating is for a range of thicknesses, the relevant end-product part shall have a thickness within that range.

Table 15.1
Material property

Material property (units)	Flame class of material			
	V-0	V-1	V-2	HB
HAI (PLC)	3	2	2	1
HWI (PLC)	4	3	2	2

15.4 A thermoplastic material used to support a live part shall be subjected to the conditioning described in 66.1.2. As a result of the conditioning, the spacings specified in Spacings, Section 29, and Spacings to Polymeric Enclosures, Section 29.2, shall be maintained and live parts shall remain reliably secured in place.

15.5 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 7.2.2.

16 Internal Wiring

16.1 Mechanical protection

16.1.1 Wiring and connection between parts of an appliance shall be protected or enclosed.

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

16.1.2 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.

16.1.3 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.

16.1.4 A flexible interconnecting cord as mentioned in the exception to 16.1.1 shall be provided with strain relief and bushings in accordance with the requirements in 13.1.2.1 – 13.1.3.8.

16.1.5 The strain relief means provided on an interconnected cord or cable shall be tested in accordance with Strain Relief Test, Section 60, except shall withstand for 1 minute a pull of 20 pounds (89 N) applied to the cord.

Exception No. 1: This test is to be waived if the cord is routed, protected, or secured such that it cannot be easily grasped or subject to other means of mechanical strain or motion.

Exception No. 2: Interconnecting cords or cables in low-voltage secondary circuits need not comply with this requirement unless stress on the cord or cable could cause the internal wiring of the secondary circuits to contact live parts of other circuits that can result in a risk of electric shock.

16.1.6 If either end of an external interconnecting cable terminates in a connector having one or more exposed contacts, risks of electric shock shall not exist between any contacts, or between earth ground and any contact that is exposed on either the connector or its receptacle while the connector is out of its receptacle. Inclusion of an interlock circuit in the cable to de-energize the exposed contacts whenever an end of the cable is disconnected constitutes compliance with the requirement.

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

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

16.1.9 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.

16.1.10 With reference to exposure of insulated wiring through an opening in the enclosure of an appliance, the protection of such wiring required by 16.1.1 is considered to exist if, when judged as though it were film-coated wire, the wiring would be acceptable according to 12.1. 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.

16.1.11 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.

16.2 Splices and connections

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

16.2.2 For an appliance in which vibration is likely to occur – such as a vibrator – the requirement in 16.2.1 will necessitate the use of lock washers or other equivalent means to prevent wire-binding screws and nuts from becoming loosened.

16.2.3 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.

16.2.4 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.

16.2.5 With reference to the requirements in 16.2.4, 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.

16.2.6 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. 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- and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

16.2.7 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.

17 Separation of Circuits

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

17.2 An insulated conductor shall be retained so that it is not capable of contact with an uninsulated live part of a circuit operating at a different potential.

18 Capacitors

18.1 A capacitor provided as a part of a 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 prevent the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall comply with the requirements in 7.1.2 and 7.1.3.

Exception: The individual container of a capacitor may be of sheet metal less than specified in 7.1.3 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 prevent 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 mF. See 45.2.

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 fire or electric shock 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 19.1.3;

c) An appliance intended for permanent connection to the electrical supply;

d) An appliance intended for outdoor use;

e) An appliance intended for use with water or other liquid; and

f) treadmills.

Exception: A cord-connected appliance other than a treadmill may be provided with an acceptable means of double insulation in accordance with the applicable requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, in lieu of grounding. See 20.3.

19.1.2 A product marked as being provided with double insulation shall not be provided with a means for grounding. See 81.1.7.

19.1.3 With reference to 19.1.1(b), a two-wire appliance intended to operate at a nominal potential of 240 V and any other potential greater than 150 V, is to 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.

19.1.4 If a grounding means is provided, whether required or not, it shall be in accordance with 19.1.5. If the appliance is cord connected, the grounding means shall also comply with the requirements in 19.1.8. 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 19.1.11.

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 as mentioned in this paragraph includes repair of the appliance by a qualified service person.

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 -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 grounding.

19.1.10 A terminal intended 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.

19.2 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 ," or " Grounding," or by a marking on a wiring diagram provided on the appliance.

20 Heating Elements and Heating Wire

20.1 The voltage rating of a heating element, including an insulated resistance heating wire, employed in an appliance shall not be less than that specified in Table 20.1.

Table 20.1
Voltage rating of heating element

Nominal voltage of circuit	Minimum rating of heating element, V
120	110
208	208
240	220

20.2 An insulated resistance heating wire shall be suitable for the application and shall also comply with the requirements for Internal Wiring, Section 16. See 16.1.9 for factors to consider in determining the heater wire's suitability for the application.

20.3 In a double insulated appliance using insulated resistance heating wire, reinforced insulation is acceptable in place of double insulation for the heating wire's insulation anywhere in the appliance, if the reinforced insulation consists of one or more layers with a total thickness of not less than 3/16 inch (5 mm); this total thickness shall not include the thickness of the heating wire insulation. In a multilayer assembly, contact between adjacent layers is acceptable.

21 Lampholders

21.1 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.

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 Maximum Normal Load, Section 49.2 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 prevent 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.

22.1.5 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 are retained to the degree necessary to keep:

a) Accessible dead metal parts from becoming energized; and

b) Live parts from becoming accessible.

22.2 Overload protection

22.2.1 An appliance employing a motor shall incorporate thermal or overload protection in accordance with 22.2.2 when it is remotely or automatically controlled, or when the appliance is permanently connected, continuous-duty, manually started, and the motor is rated 1 hp (746 W) output or less.

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

a) Thermal protection complying with the requirements specified in 5.16.4.1;

Exception No. 1: For an appliance that includes a control that positively and reliably limits the length of the time the appliance can operate, the duration of the temperature test and the endurance test, both under locked-rotor conditions, may be less than that specified but shall not be less than the time the appliance can operate.

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 5.16.4.2 when the motor is tested as used in the appliance under stalled-rotor conditions; or

c) Electronic protection complying with the requirements specified in 5.16.4.3 or 5.16.4.4.

22.2.3 For a multispeed motor, the requirement in 22.2.1 applies to all speeds at which the motor is intended to operate.

22.2.4 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.

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

22.3 Insulation systems

22.3.1 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 specified in Table 22.1 at the thicknesses specified are permitted to be used without further evaluation.

22.3.2 For Class A insulation systems employing other materials or thinner materials than those indicated in Table 22.1 or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements in 22.3.3.

22.3.3 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 minimum. Leads shall be rated 90°C minimum. Motors employing thermoplastic materials shall be subjected to the tests in Thermoplastic Motor Insulation Systems, Section 76.

Exception: Other polymeric materials used in a Class 105 (A) insulation system shall comply with the requirements in Thermal Aging Test, Section 76.4.

22.3.4 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.

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

Table 22.1
Primary Class A insulating materials and minimum thicknesses

Material	Minimum thickness	
	mm	(inches)
Vulcanized fiber	0.71	(0.028)
Polyethylene terephthalate film	0.18	(0.007)
Cambric	0.71	(0.028)
Treated cloth	0.71	(0.028)
Electrical grade paper	0.71	(0.028)
Mica	0.15	(0.006)
Aramid paper	0.25	(0.010)

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 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.

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

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

23.4 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.

23.5 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 Ground-Fault, Arc-Fault, And Leakage Current Detectors/Interrupters, Section 5.11 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 102 mm (4 inches) 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 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.

25.5 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 a permanently connected appliance rated 125 or 125/250 V (3-wire) or less, no switch or 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 the grounded 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).

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 manually operated, line-connected, switch for appliance on/off operation shall be connected to switch, at minimum the ungrounded conductor of the supply cord.

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 Controls, Section 5.6.

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 risk of fire, electric shock, or injury to persons.

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 Controls, Section 5.6 is considered to comply with 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 in accordance with 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 end product standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions. See 40.1.5;

c) Installation class 2 in accordance with 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; and

f) For the applicable Pollution Degree, see Table 27.3.

27.3.2 The following test requirements shall be among the items considered when judging the acceptability of an operating control investigated in accordance with 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. See 40.1.5;

c) For the applicable Overvoltage Category, see Table 27.1;

d) For the applicable Material Group, see Table 27.2; and

e) For the applicable Pollution Degree, see Table 27.3.

Table 27.1
Overvoltage categories

Appliance	Overvoltage Category
Control located in low-voltage circuit	I
Portable and stationary cord-connected	II
Intended for fixed wiring connection	III
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 ≥ 600 (PLC = 0)	I
400 ≤ CTI < 600 (PLC = 1)	II
175 ≤ CTI < 400 (PLC = 2 or 3)	IIIa
100 ≤ 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 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

27.4 Protective controls (limiting controls)

27.4.1 An electronic control that performs a protective function shall comply with the requirements in Controls, Section 5.6 while tested in accordance with 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 fire, electric shock, or injury to persons.

27.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated in accordance with 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 and the maximum ambient temperature determined by conducting the Temperature Test, Section 49;

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; and

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 in UL 60730-1 shall be conducted at ambient temperatures of 10.0+2°C and the maximum ambient temperature determined by conducting the Temperature Test, Section 49. 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, Section 49.

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 specified in 27.4.1 shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, in accordance with 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 complies with the requirements for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication.

b) A field strength of 3 V per meter 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 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C 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 end product 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. See 40.2.3, Overload, Section 59.3, and Endurance, Section 59.4.

27.5 Controls using a temperature sensing device

27.5.1 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control, shall 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 an operating device – 6000 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 Attachments

28.1 Functional attachments that are made available or recommended by the manufacturer for use with the basic appliance shall be included in the evaluation of the appliance. Unless recommended by the manufacturer, not more than one attachment shall be evaluated at a time with the appliance.

28.2 The literature accompanying a package containing a basic appliance and attachments intended to be marketed as a complete unit shall indicate what attachments are intended for use with the basic appliance.

28.3 If an attachment is packaged and marketed separately from the basic appliance and recommended for use with it by the manufacturer of the basic appliance, it shall have an assigned catalog number (or equivalent). Also, information packaged with the basic appliance shall identify by catalog number, the attachments which are intended for use with the basic appliance or the catalog number of the basic appliance with which the attachment is intended to be used shall appear in at least one of the following locations:

a) On the attachment;

b) On the package housing the attachment; or

c) In information furnished with the attachment.

29 Spacings

29.1 General

29.1.1 Other than at field-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 29.1.

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

Exception No. 2: An isolated dead metal part may be spaced as provided in 29.1.5.

Table 29.1
Spacings at other than wiring terminals

Potential involved, V	Rating of motor employed	Minimum spacings, Inch (mm)			
		Motor diameter 7 in (178 mm) or less[a]			
		Over surface		Through air	
		Inch	(mm)	Inch	(mm)
0 – 125	1/3 hp (250 W output) or less	1/16	(1.6)	1/16	(1.6)
	More than 1/3 hp	3/32	(2.4)	3/32	(2.4)
130 – 250	All motors	3/32	(2.4)	3/32	(2.4)

[a] See 16.1.4.

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

29.1.3 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.

29.1.4 In an appliance incorporating two or more motors of different horsepower rating, the spacings in the appliance are to be judged on the basis of the rating of the largest motor in the appliance.

29.1.5 If an isolated dead metal part is interposed between or is in close proximity:

a) To live parts of opposite polarity;

b) To a live part and an exposed dead metal part; or

c) 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 29.1.

29.1.6 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, except that 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 percent of the spacing required for air alone.

Exception: Thinner insulating material may be used, if upon investigation, it is found to be acceptable for the application.

29.1.7 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 29.1.1 and 29.1.9 and shall be judged on the basis of the highest voltage involved.

29.1.8 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal parts that are exposed to contact by persons or are intended to be grounded in service is not specified for parts of low-voltage circuits.

29.1.9 The spacing between wiring terminals of opposite polarity, and the spacing 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 29.2. See 13.2.3.2.

29.1.10 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 13.2.3.2, spacings shall not be less than those specified in Table 29.1 when such connectors, eyelets, and the like, are in such position that minimum spacings – opposite polarity and to dead metal – exist.

Table 29.2
Spacings at wiring terminals

Potential involved, V	Minimum spacings, Inch (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	
			Inch	(mm)	Inch	(mm)
250 or less	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)

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

29.2 Spacings to polymeric enclosures

29.2.1 The spacing between a polymeric enclosure and a nonarcing uninsulated live part (a bus bar, a connecting strap, a terminal, or similar part) shall not be less than 1/32 in (0.8 mm).

Exception: A spacing less than 1/32 in is capable of being used when the enclosure material complies with the requirements for support of a live part described in 15.3.

29.2.2 The spacing between a polymeric enclosure and an arching part (at a commutator, unenclosed switch contacts, or similar part) shall not be less than 1/2 in (12.7 mm).

Exception No. 1: A spacing less than 1/2 in (12.7 mm) but not less than 1/32 in (0.8 mm) is acceptable when the material has a PLC for high-current arc ignition (HAI) not greater than specified in Table 15.1.

Exception No. 2: A spacing is not required when the material complies with the requirements for support of a live part prescribed in 15.3.

29.2.3 With reference to 29.2.2, the spacing is to be measured from the source of the arc – that is, from the interface of the brush and the commutator, from the interface of the switch contacts, or similar parts.

29.3 Spacings on printed wiring boards

29.3.1 As an alternative to the spacing requirements of Table 29.1, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be applied. The spacing requirements in UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

29.3.2 The following end use factors from this end product standard shall be applied in the evaluation of alternative spacings:

a) For the applicable Overvoltage Category, see Table 27.1;

b) For the applicable Material Group, see Table 27.2; and

c) For the applicable Pollution Degree, see Table 27.3.

29.3.4 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.

29.3.5 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.

29.4 Spacings in Class 2 circuits

29.4.1 *Deleted*

30 Class 2 Power Units or Power Supplies

30.1 *Deleted*

31 Primary Lithium Batteries

31.1 *Deleted*

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, means shall be provided to reduce the risk.

32.2 When judging 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 evaluation 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 evaluated with the appliance.

32.4 The adequacy of a guard, a release, an interlock, or the like, and whether such a device is required are to 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 is to 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 is to 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 herein 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.

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 therewith, and such a part shall not be contacted by the probe illustrated in Figure 12.1.

Exception: 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 it is marked in accordance with 39.6.

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 could be endangered by the moving part or that clothing could 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 of the self-restoring type. Other features of guards that are to be considered include:

a) Removability without the use of tools;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness;

e) Creation of additional risk of injury to persons, such as pinch points, 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 The rotating massage heads of a shiatsu-type massager shall be such that the distance between the heads is 2 in (50.8 mm) or more at any position of rotation.

Exception No. 1: A distance between the heads less than 2 in (50.8 mm) complies with the requirement when a guard is provided that does not allow body parts to contact the massage heads when the massage heads are less than 2 in apart. The guard shall extend above the plane of the point where the heads come closest together.

Exception No. 2: A distance between the heads less than 2 in (50.8 mm) complies with the requirement when the massager complies with Shiatsu-Type Massager Entrapment Test, Section 70.

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 might 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, could 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 might create a risk of injury to persons, shall be constructed so as 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 is to be tested as described in 36.4. Parts that can become a risk of injury to persons shall not work loose as a result of the test.

36.4 For the test discussed in 36.3, an appliance employing a series motor is to be operated for 1 minute 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 Switches, Controls, and Interlocks

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

37.2 Each function of a multiple-function appliance is to be taken into consideration in determining whether the appliance complies with the requirement in 37.1.

37.3 If, when energized, an appliance has a moving part that may cause injury to persons, a motor control switch, other than a momentary-contact switch, on the appliance shall have a plainly identified "OFF" position, or "ON" and "OFF" positions, and be marked in accordance with 37.4 or 37.5, as applicable. If the international symbols "I" and "O" are used, the significance of these symbols shall be explained in the instruction manual provided with the product (see 82.8).

37.4 With reference to the requirement in 37.3, the "OFF" position of the switch shall be marked with either one or both of the following:

a) The word "OFF," or its equivalent (for example, "STOP"); or

b) The international symbol "O".

37.5 With reference to the requirement in 37.3, the "ON" position of the switch, when identified, shall be marked with one or both of the following, as determined by the marking of the "OFF" position of the switch:

a) The word "ON," or its equivalent (for example, "START") when the "OFF" position of the switch is marked with the word "OFF," or its equivalent (for example, "STOP") or “OFF/RESET”; or

b) The international symbol "I," when the "OFF" position of the switch is marked with the international symbol "O".

37.6 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.

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

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

37.9 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.

37.10 The requirement in 37.9 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.

37.11 The actuator of an interlock switch shall be located so that unintentional operation is unlikely. See 37.7.

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

37.13 An interlock shall not be capable of being defeated by materials that could accumulate in intended use.

37.14 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.

37.15 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirement in 37.11.

38 Stability Test

38.1 If a portable appliance overturns when tested as described in 38.2 and 38.4, a risk of injury to persons shall not result.

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

38.2 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) The 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 by 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. See 38.3.

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

a) Placed on a plane inclined at an angle of 10 degrees from the horizontal; or

b) Tipped through an angle of 10 degrees from an at rest position on a horizontal plane.

38.4 With reference to the requirement in 38.3(b), for an appliance that is constructed so that while being tipped through an angle of 10 degrees 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 degrees, 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 degrees from the horizontal supporting surface.

38.5 With reference to the requirement in 38.2(c), a massage type footbath shall be tested with water at the maximum fill line, and with the water vessel empty.

38.6 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.

39 Markings

39.1 An appliance having a hidden or unexpected risk of injury to persons shall be marked to inform the user of the risk.

39.2 A cautionary marking shall be permanent and legible and shall be located on a permanent part of the appliance.

39.3 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.

39.4 A marking intended to inform the user of a risk of 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.

39.5 If, when energized, an appliance has a moving part that may cause injury to persons, a switch that controls the motor that drives the part shall have a plainly marked off position.

39.6 A part of an enclosure as described in the exception to 34.2 and 42.1.9 shall be marked to indicate that such servicing is to be done with the appliance disconnected from the supply circuit.

40 Treadmills

40.1 Switches and controls

40.1.1 In addition to the manually operated motor control switch required by 26.4, a deliberate user action, such as a push button switch on the control panel, shall be required to initiate movement of the treadmill belt such that there is no unexpected operation. The user interface shall also give an indication that the treadmill is about to start and starting speed and acceleration shall be in accordance with 40.3.2. The motor control switch specified in 26.4 is not required to be on the control panel.

40.1.2 The control panel for the operation of the treadmill shall be readily accessible to the user. The control panel shall be provided with an obvious and readily accessible switch that is used to stop the treadmill belt.

40.1.3 If the treadmill is provided with a motor-operated incline system, the motor control switch required by 26.4 shall also stop the motion of the incline system.

40.1.4. The switch described in 40.1.2 shall be plainly marked "OFF," STOP," or with international symbols "O" and "I," in accordance with 37.4 or 37.5, as applicable If the international symbols "O" and "I" are used, the significance of these symbols O and I shall be explained in the instruction manual provided with the product (see 82.8).

40.1.5 The switch described in 40.1.2 that controls the "OFF," STOP," PAUSE," or "END" functions of the treadmill belt shall be suitably rated with respect to voltage (ac or dc), current, and the load being switched (such as a motor load, a relay coil load, low voltage inductive, or low voltage resistive load). The switch shall also be suitable for 6000 cycles of operation for household-use treadmills, and 50,000 cycles of operation for commercial-use treadmills, or be tested in accordance with 70.1.

40.1.6 If more than one switch or switching device is used to control the "OFF," "STOP," "PAUSE," or "END," functions then each switch or device shall comply with 40.1.2 – 40.1.5.

40.1.7 The motor or speed control that controls the speed and acceleration of the treadmill belt shall be suitably rated for the application, and shall comply with one of the following:

a) A control that automatically controls the speed of the treadmill belt (such as during a pre-set program in which the speed of the belt automatically increases or decreases), shall comply with the applicable requirements in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

b) A control that requires deliberate user action to change the speed of the treadmill belt (such as a push button on the control panel) shall comply with Abnormal Operation – Electronic Component Test, Section 40.4, or with the applicable requirements in the Standard for Solid-State Controls for Appliances, UL 244A.

Exception: A motor or speed control that is simple in design (for example, the control components consist of a triac and resistors, and does not include an integrated circuit) need only be subjected to the applicable requirements of this end-product standard; see Abnormal Operation – Electronic Component Test, Section 40.4 and Abnormal-Operations Test, Section 64.

40.2 Emergency stop switch

40.2.1 A treadmill shall be provided with an emergency stop switch. This switch may be either a push-button type or pull-cord type.

40.2.2 The actuator of a push-button type switch shall be either the palm or mushroom-head design, and shall be a color that contrasts with its background. The safety key, or the like of a pull-cord switch, shall be a color that contrasts with its background.

40.2.3 The switch shall be suitably rated with respect to voltage (ac or dc), current, and the load being switched (such as a motor load, a relay coil load, low voltage inductive, or low voltage resistive load), and shall be suitable for 6000 cycles of operation for household-use treadmills, or 50,000 cycles for commercial-use treadmills, or tested in accordance with the Emergency Stop Switch Endurance Test, Section 71.

40.2.4 For a pull-cord type switch, the entire pull-cord system shall be suitable for the number of cycles of operation as indicated in 40.2.3 when tested in accordance with the Emergency Stop Switch Endurance Test, Section 71. The pull-cord system may be comprised of a safety key, cord, strap, mechanical connections, and the like.

40.2.5 When the emergency stop switch is actuated, the power to the belt motor (and to the motor-operated incline system, if applicable) shall be directly disconnected without using the treadmill's software, and the treadmill belt shall be decelerated until it comes to a complete stop. Power to the user interface or display need not be disconnected when the emergency switch is actuated.

40.2.6 After actuation of the emergency stop switch, it shall not be possible to restart the treadmill until the user manually resets the emergency stop switch.

40.3 Treadmill belt speed and acceleration rates

40.3.1 The initial starting speed of the treadmill belt shall not exceed 1.5 mph (2.4 kph) when tested in accordance with Maximum Initial Starting Speed, Section 72.1.

40.3.2 The acceleration of the belt shall not exceed 2.0 mph/s (3.2 kph/s) with the treadmill operating at no-load, when tested in accordance with Maximum Acceleration, Section 72.2.

40.3.3 The treadmill design shall comply with the initial starting speed, and acceleration rates in the as-received condition, and after the Abnormal Operation – Electronic Components Test, Section 40.4).

40.4 Abnormal operation – electronic components test

40.4.1 A treadmill that uses electronic controls and circuit components in its design (such as a resistor, capacitor, solid state device, and the like), the failure of which may increase the likelihood of unexpected operation, or an unexpected increase in the speed of the treadmill belt at a rate exceeding the acceleration rate specified in 40.3.2, shall be subjected to the Abnormal Operation – Electronic Components Test specified in Electronic Components, Section 64.2.

40.4.2 A treadmill provided with an automatic speed control shall comply with 40.1.7(a).

40.4.3 Single-fault analysis of the motor speed control circuit and testing on each critical component located in the speed control circuit shall be conducted, as applicable.

40.4.4 As a result of the testing, the treadmill shall:

a) Not unexpectedly operate; and

b) Comply with the treadmill belt speed and acceleration rate requirements in Treadmill Belt Speed And Acceleration Rates, Section 40.3.

41 Inversion Tables

41.1 General

41.1.1 A non-motorized inversion table shall comply with the applicable requirements in Sections 1 – 11, 28, 32 – 40, and Sections 81 – 85, as applicable.

41.1.2 An inversion table shall be designed and rated for a maximum body weight (load) not to exceed 300 lbs (135 kg).

41.1.3 A motorized inversion table shall be provided with a means for the user to return to the full upright position (table in vertical position with foot support in the down-most position) in the event of a power loss.

41.1.4 When conducting the mechanical tests for inversion tables in accordance with Sections 41.2 – 41.6, consideration shall be given to the various adjustments, configurations, and settings that can be made and as referenced in the markings or instructions. If a table is rated and marked for different weight loads based on different settings or adjustments of the table, these tests shall be conducted at the various settings taking into consideration the rated loads, to evaluate the most unfavorable conditions.

41.2 Mechanical strength – static load

41.2.1 A sample shall be placed on a smooth level surface and subjected to a test load equal to four times the maximum rated body weight of the inversion table. The full test load shall remain on the sample for a period of 1 minute. The inversion table shall be in equilibrium within 1 minute after the application of the full test load. As a result of the testing, there shall be no mechanical or structural damage to parts of the inversion table that would increase the risk of personal injury. After the testing, the sample shall be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, permanent deformation, grinding of rotating parts, misalignment of the tables' rotation within the frame, outward spreading of the frame, tipping of the table, etc.).

41.2.2 The test described in 41.2.1 shall be conducted on a sample of the complete inversion table. The sample shall be positioned horizontally and, as applicable in the least favorable position in accordance with the use instructions, and then loaded with the test load. The test load shall be distributed evenly over the supporting surface, including any side rails. The test load shall be applied gradually to the table (or bench or mat) while it is in the horizontal position until the required test load is in place.

41.2.3 The test described in 41.2.1 shall be repeated on the ankle clamping system. Testing shall be conducted on a sample with the table in its full inverted position (table in vertical position with ankle clamps in the up most position). The test load shall be applied and evenly distributed along a 2-in by 3.5-in (5.1 cm by 8.9 cm) wide portion of the load bearing component(s) of the clamping system. The application and distribution of the test load shall simulate actual loading conditions. The test load shall be applied gradually on the outer-most lateral position of the load bearing component(s) until the required test load is in place.

41.2.4 The test described in 41.2.1 shall be repeated on the foot supports, except that the test load shall be equal to two times the maximum rated body weight of the inversion table. Testing of the foot supports shall be conducted on a sample with the table in its full upright position (table in vertical position with foot support in the down-most position). The test load shall be applied and evenly distributed along a 2-in by 3.5-in (5.1 cm by 8.9 cm) wide portion of the foot supports. The test load shall be applied gradually on the outer-most lateral position of the foot supports until the required test load is in place.

41.2.5 If the inversion table is provided with other means of supporting the user while inverted, such as inversion boots and inversion boot support bar, these components shall be subjected to the test described in 41.2.1. Testing shall be conducted on the sample with the table in its full inverted position (table in vertical position with inversion boots and support in the up most position). The test load shall be applied and evenly distributed along a 2-in by 3.5-in (5.1 cm by 8.9 cm) portion of the load bearing components of the supporting system. The test load shall be applied gradually on the outer-most lateral position of the load bearing component(s) until the required test load is in place.

41.3 Impact tests on end stops

41.3.1 A sample of the complete inversion table shall be placed on a smooth level surface and loaded to the maximum rated body weight (load). The test load shall be distributed over the supporting surface, including any side rails, and shall be secured to the table to balance the table in the horizontal position. The table shall then be biased to just achieve the fully vertical inverted position by adjusting the load on the table. The table is then manually rotated to horizontal position. The table is then released from the horizontal position and allowed to freely rotate towards the inverted position and impact the end-stop. If the table rotates but does not impact the end stops, the load shall be readjusted to increase the bias towards the inverted position. The test shall be repeated for a total of 50 impacts.

41.3.2 As a result of the testing, the end stop, crossbar, or mechanical stopping means, shall still be able to perform its function upon completion of the test, and there shall be no mechanical or structural damage to the end stop, crossbar, mechanical stopping means, or inversion table that would increase the risk of personal injury. After the testing, the sample shall be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, permanent deformation, grinding of rotating parts, misalignment of the table's rotation within the frame, outward spreading of the frame, tipping of the table, etc.).

41.4 Stability

41.4.1 An inversion table shall not overturn when subjected to conditions of maximum normal use, and when placed on a plane inclined at an angle of 10 degrees from the horizontal, or tipped through an angle of 10 degrees from an at-rest position on a horizontal plane.

41.4.2 The test shall be conducted under the conditions most likely to cause the inversion table to overturn. These conditions are considered to be:

a) The position of all movable or adjustable parts (for example, with the table set to the smallest and largest body heights);

b) Connection of, or omission of, any attachment made available by or recommended by the manufacturer;

c) Provision of or omission of any normal mechanical load; and

d) Direction in which the appliance is tipped or the supporting surface is inclined.

41.4.3 With respect to 41.4.2, the sample shall be placed on a smooth level surface and tested without a test load, and with a test load equivalent to the maximum rated body weight (load) in the following orientations. The test load shall be distributed evenly over the supporting surface, including any side rails, and shall be secured to the table.

a) The table's full upright position;

b) The table's full inverted position; and

c) With the table in the horizontal position.

41.4.4 With respect to 41.4.2, the sample shall be placed on a smooth level surface and tested with a test load equivalent to the maximum rated body weight (load). A sample of the table shall be placed in its full inverted position (table in vertical position with ankle clamp in the up most position). The test load shall be suspended from the foot supports so that the load is evenly distributed on both supports as follows:

a) With the test load suspended from the foot supports at a distance equal to the maximum rated body height (to simulate a person hanging in the full inverted position); and

b) With the test load suspended from the foot supports at a distance equal to half of the maximum rated body height (to simulate an elevated center of mass; a person hanging in the full inverted, sit-up position).

41.5 Inversion table endurance

41.5.1 A sample of the inversion table shall be placed on a smooth level surface and subjected to 30,000 cycles of operation while supporting a test load equal to the maximum rated body weight (load) of the inversion table. As a result of the testing, there shall be no mechanical or structural damage to parts of the inversion table that would increase the risk of personal injury. After the testing, the sample shall operate as intended, and then be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, permanent deformation, grinding of rotating parts, misalignment of the table's rotation within the frame, outward spreading of the frame, tipping of the table, etc.).

41.5.2 A sample shall be tested with a test load equivalent to the maximum rated weight (load). The test load shall be distributed evenly over the supporting surface, including any side rails, foot supports, and ankle clamping systems, to simulate actual loading conditions.

41.5.3 The sample shall then be rotated using a rotating device from the full upright position to the full inverted position, and then back to the full upright position. This shall be considered one cycle of operation. Each cycle shall be completed within 10 seconds. A faster cycle time greater than 6 cycles per minute may be used if agreed upon by all involved.

41.5.4 During each cycle, the sample shall contact an end stop, cross bar, or other mechanical means that limits rotation in either position, but is not required during the endurance test to be subject to the impact force as required by Impact Test on End Stops, Section 41.3.

41.5.5 Motorized inversion tables shall be tested without the motor in the test set-up, by using a separate rotating device.

41.6 Ankle clamping system endurance

41.6.1 Moving parts of the ankle clamping system that are used to secure the user's ankles to the inversion table's frame shall be subjected to 30,000 cycles of clamping operation. As a result of the testing, there shall be no mechanical or structural damage to parts of the ankle clamping system that would increase the risk of personal injury. After the testing, the sample shall be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, etc.).

41.6.2 Two samples of the ankle clamps shall be subjected to this testing. The testing shall begin with the moving parts of the ankle clamping system at the full open position. The parts shall then be rotated, moved, or the like, to the fully closed position (e.g. the ankle clamping or holding position) and then back to the fully open position (e.g. the ankle releasing position). This is considered to be one cycle of clamping operation. Each cycle shall be completed within 10 seconds. A faster cycle time greater than 6 cycles per minute may be used if agreed upon by all involved.

41.6.3 After the 30,000 cycles of clamping, the same samples shall be subjected to the mechanical strength testing in 41.2.3 except that the test load shall be equal to the maximum rated weight (load) of the inversion table. The same samples shall then be subjected to the endurance testing in Inversion Table Endurance, Section 41.5 except that the total number of test cycles shall consist of 100 cycles of operation. As a result of this testing, there shall be no mechanical or structural damage to parts of the ankle clamping system that would increase the risk of personal injury. After the testing, the sample shall be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, etc.).

41.6.4 Inversion boots provided with an ankle clamping system shall be subjected to the testing in 41.6.1 and 41.6.2. Two samples of the ankle clamping system shall be subjected to this testing. If the inversion boot has only one ankle clamp, then two boot samples are to be tested. If the inversion boot has more than one ankle clamp, two ankle clamps from one boot sample may be tested.

41.6.5 After the 30,000 cycles of clamping, the samples shall then be subjected to the mechanical strength testing in 41.2.5 except the test load shall be equal to the maximum rated weight (load) of the inversion table. The same sample shall then be subjected to the endurance testing in Inversion Table Endurance, Section 41.5 except that the total number of test cycles shall consist of 100 cycles of operation. As a result of this testing, there shall be no mechanical or structural damage to parts of the ankle clamping system that would increase the risk of personal injury. After the testing, the sample shall be visually examined for any mechanical or structural damage (such as cracks on supporting members, loosening of parts, etc.).

42 Dog Treadmills

42.1 Switches and controls

42.1.1 In addition to the manually operated motor control switch required by 26.4, a deliberate user action, such as a push button switch on the control panel, shall be required to initiate movement of the treadmill belt such that there is no unexpected operation. The motor control switch specified in 26.4 is not required to be on the control panel.

42.1.2 The control panel for the operation of the treadmill shall be readily accessible to the user. The control panel shall be provided with an obvious and readily accessible switch that is used to stop the treadmill belt.

42.1.3 If the treadmill is provided with a motor-operated incline system, the motor control switch required by 26.4 shall also stop the motion of the incline system.

42.1.4 The switch described in 42.1.2 shall be plainly marked "OFF", "STOP", or with international symbols " O" and "I", in accordance with 37.4 or 37.5, as applicable. If the international symbols "O" and "I" are used, the significance of these symbols, "O" and "I" shall be explained in the instruction manual provided with the product (see 82.9).

42.1.5 The switch described in 42.1.2 that controls the OFF, STOP, PAUSE, or END functions of the treadmill belt shall be suitably rated with respect to voltage (ac or dc), current, and the load being switched (such as a motor load, a relay coil load, low voltage inductive, or low voltage resistive load). The switch shall also be suitable for 6000 cycles of operation for household-use treadmills and 50,000 cycles of operation for commercial-use treadmills, or be tested in accordance with Push-Button Type Switch, Section 71.1.

42.1.6 If more than one switch or switching device is used to control the OFF, STOP, PAUSE, or END, functions then each switch or device shall comply with 42.1.2 – 42.1.5.

42.1.7 The motor or speed control that controls the speed and acceleration of the treadmill belt shall be suitably rated for the application, and shall comply with one of the following:

a) A control that automatically controls the speed of the treadmill belt (such as during a pre-set program in which the speed of the belt automatically increases or decreases), shall comply with the applicable requirements in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

b) A control that requires deliberate user action to change the speed of the treadmill belt (such as a push button on the control panel) shall comply with Electronic Components, Section 42.3, or with the applicable requirements in the Standard for Solid-State Controls for Appliances, UL 244A.

Exception: A motor or speed control that is simple in design (for example, the control components consist of a triac and resistors, and does not include an integrated circuit) need only be subjected to the applicable requirements of this end-product standard; see Electronic Components, Section 42.3 and Abnormal Operation Test, Section 64.

42.1.8 To reduce the risk of injury to dogs using the treadmill, if the treadmill is provided with a safety speed control that requires the user to remove and replace a safety key (or the like) between treadmill uses so that the speed of the treadmill belt is reset to its slowest starting speed, it shall be tested in accordance with Dog Treadmill – Safety Key Control Test, Section 73. The speed control shall reset the speed of the treadmill to the slowest starting speed when:

a) The user removes and replaces the safety key;

b) The user stops the treadmill using the “STOP” button on the control panel;

c) The user turns off the treadmill using the power “OFF” switch; and

d) The user unplugs the treadmill.

42.1.9 If a treadmill requires the user to assemble and electrically attach the control panel to the overall unit, the treadmill shall comply with the following:

a) The treadmill shall not operate until the unit is properly assembled and the user turns the unit on and starts it as intended using the proper switches and controls, as determined in accordance with the Operational Test, Section 63.

b) Any accessible live parts, wire connectors, and wiring shall be located in a low voltage, Class 2 circuit.

c) Any interconnecting cords and wires that are used in the connection of the control panel shall be subjected to the Strain Relief Test, Section 60, using the 20 lb pull force specified in the Exception 2 of 60.1.

42.2 Emergency stop switch

42.2.1 A treadmill shall be provided with an emergency stop switch. This switch may be either a push-button type or pull-cord type.

42.2.2 The actuator of a push-button type switch shall be either the palm or mushroom-head design, and shall be a color that contrasts with its background. The safety key, or the like, of a pull-cord switch, shall be a color that contrasts with its background.

42.2.3 The switch shall be suitably rated with respect to voltage (ac or dc), current, and the load being switched (such as a motor load, a relay coil load, low voltage inductive, or low voltage resistive load), and shall be suitable for 6,000 cycles of operation for household-use treadmills, or 50,000 cycles for commercial-use treadmills, or tested in accordance with the Emergency Stop Switch Endurance Test, Section 71.

42.2.4 For a pull-cord type switch, the entire pull-cord system shall be suitable for the number of cycles of operation as indicated in 42.2.3 when tested in accordance with the Emergency Stop Switch Endurance Test, Section 71. The pull-cord system may be comprised of a safety key, cord, strap, mechanical connections, and the like.

42.2.5 When the emergency stop switch is actuated, the power to the belt motor (and to the motor-operated incline system, if applicable) shall be directly disconnected without using the treadmill's software (if applicable), and the treadmill belt shall be decelerated until it comes to a complete stop. Power to the user interface or display need not be disconnected when the emergency switch is actuated.

42.2.6 After actuation of the emergency stop switch, it shall not be possible to restart the treadmill until the user manually resets the emergency stop switch.

42.3 Electronic components

42.3.1 A treadmill that uses electronic controls and circuit components in its design (such as a resistor, capacitor, solid state device, and the like), the failure of which may increase the likelihood of unexpected operation, or an unexpected increase in the speed of the treadmill belt, shall be subjected to the Abnormal Operation – Electronic Components Test, Section 64.2.

42.3.2 A treadmill provided with an automatic speed control shall comply with 42.1.7(a).

42.3.3 Single-fault analysis of the motor speed control circuit and testing on each critical component located in the speed control circuit shall be conducted, as applicable.

42.3.4 As a result of the testing in 42.3.3, the treadmill shall:

a) Not unexpectedly operate; and

b) Not exhibit an increase in the speed of the treadmill belt.

42.4 Dog treadmill storage

42.4.1 If a treadmill can be folded-up for the purpose of storage, the upright, folded-up, storage position of the treadmill shall have a positive means of locking the treadmill in place. See 81.8.2.

42.4.2 The treadmill shall comply with the Stability Test, Section 38. The test shall be conducted with the treadmill in its upright, folded storage position.

43 Motion Simulation Appliances

43.1 Enclosures and guards

43.1.1 When the operation and maintenance of a motion simulation appliance by the user or bystanders involves the risk of injury to persons, protection shall be provided to reduce the risk.

43.1.2 When investigating an appliance with respect to the requirement in 43.1.1, conditions of foreseeable misuse shall be evaluated.

43.1.3 A functional attachment that is made available or specified by the manufacturer for use with a motion-simulation appliance shall be included in the investigation of the appliance. Unless the manufacturer specifies the use of two or more attachments at the same time, only one attachment at a time is to be investigated with the appliance.

43.1.4 Whether a guard, a release, an interlock, or similar device is required and whether such a device is adequate shall be determined from an investigation of the complete appliance (consisting of a motion simulation assembly and the upholstered furnishing), its operating characteristics, and the potential risk of injury to persons. The investigation shall include evaluation of the results of breakdown or malfunction of any one component, and not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a particular component results in a risk of injury to persons, that component shall be investigated for reliability.

43.1.5 A moving part, lifting or reclining mechanism, or other part that constitutes a risk of injury shall be enclosed or provided with means to reduce the risk of injury. Such a part shall not be able to be contacted by the probe illustrated in Figure 12.1 unless the appliance is provided with a safety circuit and complies with 43.1.6.

43.1.6 Appliances that present a risk of injury as described in 43.1.5 shall be provided with either an active safety circuit or passive guard to prevent injury.

43.1.7 Safety systems that are electrical in nature shall be designed such that any failure of the system will result in the appliance not producing a risk of injury due to the safety system failure. The active safety control and circuit shall comply with Controls and Safety Circuits, Section 43.2.

43.1.8 A mechanical safety system, such as a guard, shall comply with 43.1.11.

43.1.9 During the investigation of an appliance to determine compliance with 43.1.5, a part of the enclosure that is removable without the use of a tool (such as an accessory, the cover over an opening for an operating adjustment, or similar components) is to be opened or removed.

Exception: A part that is removable without the use of a tool is not required to be opened or removed when the appliance is marked in accordance with 39.6.

43.1.10 Among the factors to be evaluated with respect to both intended operation of the appliance and any foreseeable misuse in investigating an exposed moving part are:

a) The degree of exposure required to perform the intended function;

b) The sharpness of the moving part;

c) The risk of unintentional contact;

d) The speed of the moving part; and

e) The risk that a part of the body is endangered or that clothing is able to be entangled by the moving part, resulting in a risk of injury to persons.

43.1.11 Guards shall:

a) Require the use of tools for their removal;

b) Be removable for servicing;

c) Have sufficient strength and rigidity;

d) Be complete;

e) Not present a risk of injury to persons such as a pinch point, during additional handling because of required service, such as cleaning, unjamming, or similar service; and

f) Be self-restoring.

43.1.12 An enclosure or guard over a rotating part shall retain a part that, because of breakage or other reasons, becomes loose or separates from a rotating part, and shall retain a foreign object that is able to be struck and propelled by the rotating part.

43.1.13 When breakage or deterioration of material adjacent to a moving part results in an increased risk of injury, the material shall have such properties as to withstand the loads it is subjected to during use of the appliance.

43.2 Controls and safety circuits

43.2.1 An individual component or an electronic circuit used to perform safety functions shall indicate that the reliability of the components and circuit are suitable for the application. Components that have been determined to be reliable through previous investigation are not subject to further evaluation unless by review of the use or specific use within a circuit requires additional evaluation to determine the device or circuit will perform reliably. An electro-mechanical device intended to control the safety functionality of the appliance, such as but not limited to a relay, contactor, position switch, reed switch and similar devices shall be capable of functioning properly through 100,000 cycles of operation at rated load.

43.2.2 A component investigation in accordance with the Abnormal-Operation Test, Section 64 shall be required when evaluating:

a) Controls that perform safety functions;

b) Circuits that perform safety functions; and

c) Normal operation control whose failure to function as intended would result in a risk of fire, electric shock, or injury to persons.

43.2.3 The failure of a component in a control circuit shall not result in a risk of fire, electric shock, or injury to persons.

43.2.4 When the investigation in accordance with the Abnormal-Operation Test, Section 64 determines that a component or circuit fault results in a risk of fire, electric shock, or injury to persons, then the component(s) or circuit(s) in question shall be investigated to determine that they possess the necessary reliability for the anticipated product service life. The circuit(s) shall comply with the requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

43.2.5 When the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 is used to determine compliance with 43.2.4, only the following criteria from UL 991 shall be applied:

a) Supervised safety circuits as defined by UL 991 may not rely on a trouble signal or indicator to prevent the risk of injury.

b) The Composite Operational and Thermal Cycling Tests in accordance with UL 991 is not required on indoor appliances.

c) The Humidity Tests on safety control circuits shall be conducted as defined under Humidity Classes for the products intended use.

d) A product relying on a safety circuit shall be supplied, for the investigation of the product, with a failure-mode and effect analysis in accordance with Failure Mode and Effect Analysis (FMEA).

e) With regard to electrical supervision of critical components, a motor operated system being inoperative with respect to movement of the device complies with the criteria for trouble indication.

f) A field strength of 3 V per meter is to be used for the Radiated EMI Test.

g) A vibration level of 5 g is to be used for the Vibration Test.

h) When a Computational Investigation is conducted, λ_p shall not be greater than 6 failures / 10^6 hours for the entire system. For external secondary entrapment protection devices that are sold separately, λ_p shall not be greater than 0 failures / 10^6 hours. For internal secondary entrapment protection devices whether or not they are sold separately, λ_p shall not be greater than 0 failures / 10^6 hours. The Operational Test is to be conducted for 14 days.

i) 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 (160°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 the full range of motion of the mounting system.

j) For the Electrical Fast Transient Burst Test, test level 3 is to be used for systems.

43.3 Stability test

43.3.1 A motion simulation appliance shall be subjected to the stability requirements in 43.3.4 and 43.3.6, as applicable. As a result of the tests, there shall be no introduction of a risk of fire, electric shock, or injury to persons. The stability tests shall be conducted prior to the Mechanical Strength (Proof Load) Tests, Section 43.4.

a) A risk of injury to persons is determined to exist when the appliance or part of the appliance fails to remain upright, is displaced from its support system, or when the appliance or support system is damaged to the extent that there are sharp edges or corners exposed. Whenever referee measurements are necessary to determine that a part is not sufficiently sharp to constitute a risk of injury to persons, the method described in the requirements for determination of sharpness of

edges on equipment in the Standard for Test for Sharpness of Edges on Equipment, UL 1439 shall be used.

b) A risk of fire or electric shock is determined to exist if the appliance does not comply with the requirements in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12, and Dielectric Voltage-Withstand Test, Section 52, after the stability test.

43.3.2 An appliance is to be tested on a smooth hard surface such as concrete or smooth wood. The appliance shall be assembled or set up in accordance with the instruction manual provided with the appliance.

43.3.3 An appliance shall be subjected to the stability tests while at rest, and while operating in any or all of the following conditions considered to be most severe:

a) Unloaded condition;

b) Partially loaded condition; and

c) Fully loaded condition.

43.3.4 An appliance that is intended to support a person while seated shall be subjected to the stability test described in 43.3.5. As a result of the test, there shall be no damage that introduces a risk of fire, electric shock, or injury to persons.

43.3.5 The appliance as described in 43.3.4 shall be configured as described in 43.3.2. A sample of each type of a fully assembled appliance is to be subjected to a 300-lb (136-kg) load applied through a 16 inch (406 mm) diameter rigid disk. The load is to be moved or repositioned slowly over the entire surface intended for seating. The edge of the disk shall be allowed to overhang the edge of the appliance a maximum of four inches along unobstructed edges. An obstructed edge is considered to be one which has a raised projection such as the back of a chair, or the arms of a chair. The appliance shall not tip more than ten degrees from its at rest position.

43.3.6 An appliance provided with a foot rest or foot support, or a surface that is likely to be used as a foot rest and/or leg rest and not likely to be used as a step, shall be subjected to the stability test described in 43.3.7. The appliance shall not tip more than 10 degrees from its at rest position. As a result of the test, no permanent damage or deflection shall occur to the appliance and there shall be no damage that introduces a risk of fire, electric shock, or injury to persons.

43.3.7 An appliance as described in 43.3.6 shall be configured as described in 43.3.2. A sample of each type of a fully assembled appliance is to be subjected to a 50 lb (222.4 N) load applied straight down through a flat rigid structure 4 by 4 inches (102 by 102 mm) in any position along the appliance structure element under investigation. The load is to be applied for 1 minute. The appliance shall not tip more than 10 degrees from its at rest position.

43.4 Mechanical strength (proof load) tests

43.4.1 General

43.4.1.1 A motion simulation appliance shall be subjected to the tests described in Load-Bearing Surface (Couch, Or Chair) Weight And Weight Drop Tests, Section 43.4.2. This test shall be conducted with the appliance unenergized, and then energized under the condition considered worse case. As a result of the tests, the appliance shall not collapse or deform to a degree that introduces a risk of fire, electric shock, or injury to persons.

43.4.1.2 With reference to 43.4.1.1:

a) A risk of injury to persons is determined to exist when the appliance or part of a appliance is displaced from its support system or when the appliance or support system is damaged to the extent that there are sharp edges or corners exposed. Whenever referee measurements are necessary to determine that a part is not sufficiently sharp to constitute a risk of injury to persons, the method described in the requirements for determination of sharpness of edges on equipment in the Standard for Test for Sharpness of Edges on Equipment, UL 1439 shall be used.

b) A risk of fire or electric shock is determined to exist if the appliance does not comply with the requirements in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12, and Dielectric Voltage-Withstand Test, Section 52.

43.4.2 Load-bearing surface (couch, or chair) weight and weight drop tests

43.4.2.1 For the weight test, a test weight of 450 lbs (204 kg) for each intended person is to be applied to the appliance. For example, a chair is intended for 1 person and a couch is intended for 2 or 3 people. The weight shall be evenly distributed over the surface. The weight shall be applied for 3 hours.

43.4.2.2 For the weight drop test, a test weight of 300 lbs (136 kg) in a canvass bag 16 inches (41 cm) in diameter filled with sand, ball bearings, lead shot, or steel shot is to be applied the appliance. The weight shall be dropped 6 inches (21.24 cm) above the surface. Any sitting position not under test shall have a weight of 225 lbs (102 kg). Any laying position not under test shall have a weight of 250 lbs (113 kg). Each sitting or laying position shall be tested.

PERFORMANCE

44 General

44.1 Unless otherwise noted, all tests are to be conducted with the appliance connected to a supply circuit as specified in 44.2. The voltage of the supply circuit shall be as specified in Table 44.1.

Table 44.1
Test voltages

Maximum marked rating range	Test voltage
110 – 120 V, ac	120 V, ac
220 – 240 V, ac	240 V, ac
110 – 120 V, dc	115 V, dc
220 – 240 V, dc	230 V, dc
Other	Highest value of marked range

44.2 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 or 50 – 60 Hz is to be tested on 60-Hz alternating current.

45 Leakage-Current Test

45.1 The leakage current of a single-phase cord-connected appliance when tested in accordance with 45.3 – 45.7 shall not be more than:

a) 0.5 MIU for an ungrounded 2-wire appliance;

b) 0.5 MIU for a grounded 3-wire portable appliance; and

c) 0.75 MIU 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.

Exception: Those conductive parts of a stationary treadmill which contains an EMC suppression filter shall have a leakage current from simultaneously accessible parts to the grounded supply conductor of no greater than 3.5 MIU.

45.2 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.

45.3 All exposed conductive surfaces are to be tested for leakage currents. Leakage currents from these surfaces are to be measured to the grounded-supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. A part is considered to be exposed unless it is guarded by an enclosure that is acceptable for protection against the risk of electric shock as defined in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12. Surfaces are considered to be simultaneously accessible if 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 are not considered to involve a risk of electric shock. If all accessible surfaces are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current can be measured between the grounding conductor and the grounded supply conductor.

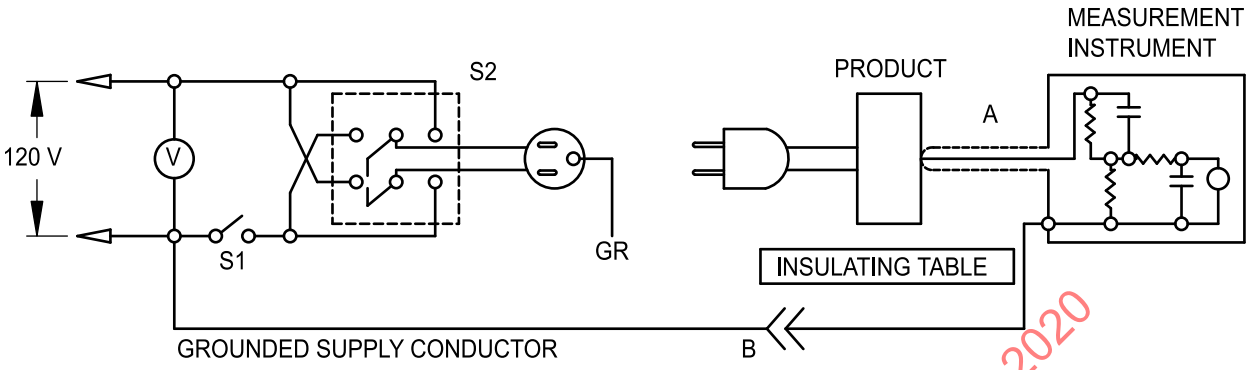
45.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having an area of 10 by 20 cm in contact with the surface. If the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface.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

45.5 The measurement instrument shall be as described in the Standard for Leakage Current for Appliances, UL 101. The measurement circuit for leakage current is to be as illustrated in Figure 45.1.

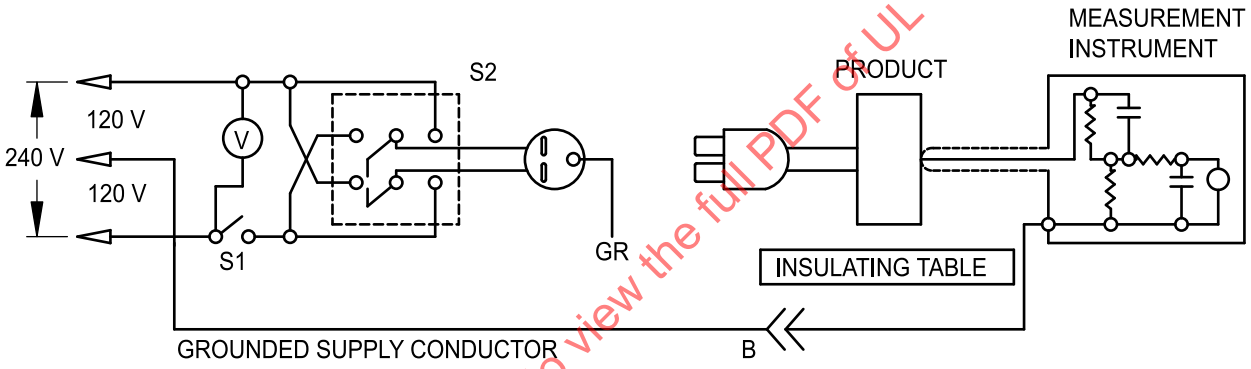
45.6 Unless the meter is being used to measure leakage from one part of an appliance to another, it is to be connected between accessible parts and the grounded-supply conductor.

Figure 45.1

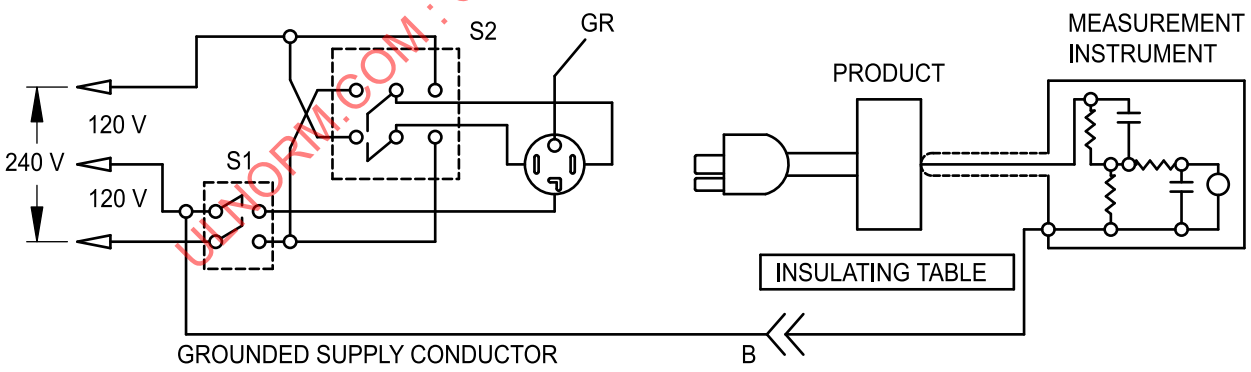
Leakage current measurement circuits



Product intended for connection to a 120-volt power supply, as illustrated above.



Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.



Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

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A – Probe with shielded lead.

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

45.7 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 is without prior energization except as may occur as part of the production-line testing. The test sequence, with reference to the measuring circuit – Figure 45.1 – 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 seconds, the leakage current is to be measured using both positions of switch S2, and with the appliance switching devices in all their normal operating positions; and

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 temperature test.

45.8 Normally, the complete leakage current test program as covered by 45.7 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.

46 Leakage Current Following Humidity Conditioning

46.1 An appliance as described in 45.1 shall comply with the requirements for leakage current in 45.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

46.2 To determine whether an appliance complies with the requirement in 46.1, 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 is to remain for 48 hours under the conditions specified in 46.1. Following the conditioning and while still in the test chamber, the sample is to be tested unenergized as described in 45.7(a). Either while the sample is still in the chamber or immediately after it has been removed, the sample is to be energized and tested as described in 45.7 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

47 Starting-Current Test

47.1 An appliance shall start and operate as intended 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 No. 1: 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 as intended on a circuit protected by a time-delay fuse; and

c) The appliance is marked in accordance with 81.1.6.

Exception No. 2: The requirement concerning an ordinary fuse does not apply to a household appliance that would normally be used on a 15- or 20-A branch circuit, provided that the appliance starts and

operates as intended 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.

47.2 In a test to determine whether an appliance complies with the requirement in 47.1, the appliance is to be started three times under the condition of maximum normal load as described in Maximum Normal Load, Section 49.2, with the appliance at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of intended operation – the beginning of the intended operating cycle, in the case of an automatic appliance – and the motor is to be allowed to come to rest between successive starts.

48 Input Test

48.1 The current or wattage input to an appliance shall not be more than 110 percent of the rated value when the appliance is operated under the condition of maximum normal load as described in Maximum Normal Load, Section 49.2.

48.2 The marked output rating in amperes or volt-amperes of a power unit or power supply shall not be exceeded during the Maximum Normal Load, Section 49.2.

Exception: A power unit or power supply with a measured output that exceeds its marked rating need not comply with this requirement as long as it complies with the temperature test specified in Temperature Test, Section 49.

49 Temperature Test

49.1 General

49.1.1 An appliance shall be tested as described in Maximum Normal Load, Section 49.2, 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 49.1.

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

49.1.3 All values of temperature rise in Table 49.1 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 – 49°C (49 – 104°F).

49.1.4 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 – subitems 1 and 3 of item A in Table 49.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

Table 49.1
Temperature rises

Materials and components	°C	°F
A. MOTORS		
1. Class A insulation systems on coil windings of an a-c motor having a frame diameter of 7 in (178 mm) or less, not including a universal motor and on a vibrator coil[a,b]		
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
2. Class A insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in (178 mm), of a d-c motor and of a universal motor[a,b]		
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
3. Class B insulation systems on coil windings of an a-c motor having a frame diameter of 7 in (178 mm) or less, not including a universal motor[a,b]		
a. In an open motor:		
Thermocouple or resistance method	95	171
b. In a totally enclosed motor:		
Thermocouple or resistance method	100	180
4. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in (178 mm), of a d-c motor, and of a universal motor[a,b]		
a. In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
b. In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
5. Class F (155°C) insulation systems on coil windings of 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
6. Class F (155°C) insulation systems on coil windings of 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 method:		

Table 49.1 Continued on Next Page

Table 49.1 Continued

Materials and components	°C	°F
Thermocouple or resistance method	120	216
b. In a totally enclosed motor:		
Thermocouple or resistance method	125	225
B. COMPONENTS		
1. Capacitors:		
a. Electrolytic[c]	49	72
b. Other types[d]	65	117
2. Fuses[e]	65	117
3. Relay, solenoid, and coils (except motor coil windings and transformers) with:		
a. Class 105 insulated systems		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulation systems		
Thermocouple method	85	153
Resistance method	105	189
4. Vibrator coils with Class 130 insulation systems:		
Thermocouple or resistance method	95	171
5. Sealing Compound	49	104
	less than melting point	
6. Transformers with Class 105 insulation systems:		
Thermocouple method	65	117
Resistance method	75	135
C.CONDUCTORS		
1. Copper conductors:		
a. Tinned or bare strands having:		
(1) A diameter less than 0.015 in (0.38 mm)	125	225
(2) A diameter of 0.015 in or more	175	315
b. Plated with nickel, gold, silver, or a combination of these	225	495
2. Rubber- or thermoplastic-insulated wire and cord[e, f, g]	35	63
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	65	117
2. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[e]	125	225
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. A surface upon which a product may be placed or mounted in service, and a surface that may be adjacent to the product when it is so placed or mounted	65	117
2. Any point within a terminal box or wiring compartment of a permanently connected product in which power-supply conductors are to be connected, including such conductors themselves, unless the product is marked in accordance with 81.2.1.	35	63
3. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the product	65	117

Table 49.1 Continued on Next Page

Table 49.1 Continued

Materials and components	°C	°F
[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple may be more than the maximum acceptable temperature specified in this table provided the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple may be more than the specified value by: 1. 5°C (9°F) for Class A insulation systems on coil windings of alternating-current motors having a diameter of 7 in (178 mm) or less, open type, 2. 10°C (18°F) for Class B insulation systems on coil windings of alternating-current motors having a diameter of 7 in or less, open type, 3. 15°C (27°F) for Class A insulation systems on coil windings of alternating-current motors having a diameter of more than 7 in, open type, 4. 20°C (36°F) for Class B insulation systems on coil windings of alternating-current motors having a diameter of more than 7 in, open type, 5. 15°C (27°F) for Class 105 insulation systems on windings of a relay, a solenoid, and the like. 6. 15°C (27°F) for Class 130 insulation systems on windings of a relay, a solenoid, and the like. [b] See 22.1.4. [c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum acceptable temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F). [d] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature. [e] These limitations do not apply to compounds and components that have been found acceptable for use at higher temperatures. [f] A rubber-insulated conductor within a Class-A-insulated motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor may be subjected to a higher temperature if the conductor is provided with sleeving or a braid that has been investigated and found acceptable for use at the higher temperature. 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 (149°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of the necessary dielectric strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration.		

49.1.5 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). 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 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.

49.1.6 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.

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

49.1.8 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 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

49.2 Maximum normal load

49.2.1 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 intended 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. However, appliances having features not

contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

49.2.2 The operation of a hand-held appliance need not approximate those conditions of actual service. An appliance that is intended for household use is to be operated for 20 minutes. An appliance that is intended for commercial use is to be operated through repeated cycles of 5 minutes on and 5 minutes off until constant temperatures have been reached.

49.2.3 A hand-held massager or vibration device is to be operated in accordance with 49.2.2 with the appliance held in its most unfavorable normal position of use and no load applied to the massage or vibration head.

49.2.4 A hand-supported appliance that includes a heater that can be energized independently of the vibrator or motor is also to be tested with only the heater energized until temperatures become constant.

49.2.5 A massage machine that is not intended to be hand-supported is to be operated continuously until temperatures become constant.

49.2.6 With reference to 49.2.1, a massage type footbath is to be operated continuously with water, and with the water vessel empty, until temperatures become constant. When operated with water, testing shall begin with the water at 49° C (104° F) and with water at the maximum fill line. Additional water at that temperature is to be added as necessary to keep the water at that maximum level.

49.2.7 A machine provided with a receptacle (see Receptacles, Section 25) shall be tested with the receptacle loaded to its rated current, or with the receptacle loaded with the intended ampere load that is marked adjacent to the receptacle. See 80.5.

49.2.8 An agility trainer shall be operated continuously at its maximum setting until temperatures become constant.

49.2.9 A motion simulation appliance shall be loaded with a test load equivalent to 300 lbs (136 kg) for each intended person, with the test load applied uniformly across the intended human contact area. The appliance shall be operated continuously until thermal equilibrium.

49.2.10 The maximum normal load conditions for a treadmill shall be based on a 200 lbs (90.7 kg) user.

49.2.11 The load shall be achieved by either:

a) Having an actual person (s) weighing the specified amount run on the treadmill belt at the specified speed setting(s); or

b) A suitable load application device (such as an electric motor dynamometer, or a load cart on the belt) that provides a load to the motor and drive system equivalent to the load of the treadmill operating with an actual person may be used for the test.

49.2.12 If the method of loading does not represent a user load for purposes of operating the incline, when the incline is operated for the Input Test, Section 48 and the Temperature Test, Section 49, a separate load shall be placed on the treadmill. The load shall be 200 lbs (90.7 kg). The load shall be centered on the treadmill 1 ft. (0.30 m) from the most forward point of the visible belt.

49.2.13 During the Input Test, Section 48, a treadmill shall be operated at no load at maximum speed, and with a 200 lbs (90.7 kg) load at maximum speed, whichever results in higher input. A treadmill provided with a motor-operated incline system shall additionally have the incline system being raised or lowered during testing, whichever results in the higher input.

49.2.14 During the Temperature Test, Section 49, a treadmill shall be operated at the condition noted in the Input Test, see 48, which results in the highest input, without an incline system operating, if provided.

49.2.15 During the Temperature Test, Section 49, once constant temperatures have been reached in accordance with 49.2.14, a treadmill provided with a motor-operated incline system shall additionally have the incline system raised and lowered for 9 complete cycles with a 5 minute pause between each cycle, unless the instructions or operating modes a more severe rate of operation. One cycle consists of starting the incline from the lowest position, raising it as quickly as possible to the highest point, then immediately lowering the incline back to the starting position as quickly as possible.

50 Surface Temperatures

50.1 During the temperature test, the temperature of a surface that may be contacted by the user shall not be more than the value specified in 50.2 or Table 50.1, as applicable. 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 50.1
Maximum surface temperatures

Location	Composition of surface[a]			
	Metal		Nonmetallic	
	°C	(°F)	°C	(°F)
Handles or knobs that are grasped for lifting, carrying, or holding	50	(122)	60	(140)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding	60	(140)	85	(185)
Surfaces of a hand-held appliance that are known to be hot and are intended to be contacted by the user	60	(140)	85	(185)
Surfaces known to be hot, other than the area of a heating pad or of a hand-held appliance, and intended to be contacted by the user	45	(113)	50	(122)
Other surfaces subject to contact during operation or user maintenance	60	(140)	85	(185)

[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 judged as, a nonmetallic part.

50.2 The maximum acceptable temperature rise on external surfaces of an appliance employing a heating pad shall not exceed 55°C (99°F) in the area of the heating pad.

51 Surface-Temperature Test

51.1 A small, cord-connected appliance of the hand-supported type 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.

51.2 To determine whether an appliance complies with the requirement in 51.1, the appliance is to be operated until constant temperatures are attained. The appliance may be stationary during the test, and simulation of actual service conditions need not be attempted.

52 Dielectric Voltage-Withstand Test

52.1 An appliance shall withstand for 1 minute 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 intended 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 (c).

c) Twenty-five hundred volts for an appliance that is applied in a wet or moist condition directly to persons.

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

a) One-thousand volts if the secondary operates at 51 – 250 V; or

b) 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.

52.3 A capacitor used for radio-interference elimination or arc suppression shall withstand for 1 minute 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 intended use. The test potential shall be 1000 V for an appliance employing a motor rated 1/2 hp (373 W output) or less and 250 V or less.

52.4 To determine whether an appliance complies with the requirements in 52.1 – 52.3, 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 minute. 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.

52.5 For an appliance that employs a heating pad, the test potential is also to be applied between interconnected current-carrying parts of each sample appliance and sheets of metal foil on the sides or faces of the appliance. The appliance, with the foil on either side or face, is to be placed between felt mats as described in 52.6. A uniform pressure of 25 lb-f/ft^2 (1200 N/m^2) is to be applied to the felt mats so that the metal foil is in close proximity to the appliance.

52.6 The felt mats mentioned in 52.5 are to be 1 in (25 mm) thick and have an area sufficient to completely cover the area of the appliance containing the pad and to extend for not less than 2 in (51 mm) all the way around the pad area.

53 Resistance to Moisture Test

53.1 An appliance that employs a heating pad and a vinyl or treated fabric covering in the area of the heating pad shall be tested as described in 53.2 and 53.3. As a result of the test, the leakage current for an appliance shall not exceed 0.5 MIU at 120 V, and the covering shall neither lose its moisture-resistant properties nor develop hard spots.

53.2 To determine whether an appliance complies with the requirements in 53.1, a cushion-type appliance is to be placed on a 1-in (25-mm) thick felt mat, and an appliance of other construction, such as a chair, is to have a 1-in thick felt mat placed against that portion of the appliance containing the heating pad. The sample is then to be continuously operated at its maximum operating temperature. After operation for 300 hours, the surface of the covering is to be carefully examined to determine whether there are any hard spots in the material. It is then to be folded and manipulated back and forth several times as allowed by the construction of the appliance to flex the material throughout the entire surface. Following the manipulation, the appliance is to be tested for leakage current in accordance with the Leakage-Current Test, Section 45.

53.3 The sample or the area of the sample containing the heating pad is then to be placed in a horizontal plane, with the edges of the appliance turned up at right angles for approximately 1 in (25 mm) to form a shallow tray. If the edges of the appliance cannot be turned up, supplementary sides may be attached to or formed on the appliance to hold the solution. The side or face that was in contact with the felt mat during the 300-hour test is to be the upper or inside surface of the tray. A solution of approximately 8 g of NaCl per 1000 cm^3 of water is to be introduced into the tray to a minimum depth of 1/4 in (6 mm), and the leakage current between the electrolyte and the appliance is then to be measured. The solution is to be allowed to remain on the covering for 3 hours, and if there is no leakage current, the test may be discontinued, but, if any leakage current is measured, the test is to be continued until ultimate results are obtained, but not longer than 7 hours.

54 Resistance to Moisture Tests for Massage Type Footbaths

54.1 General

54.1.1 Massage type footbaths shall not cause a risk of fire or electric shock when tested under the conditions specified in Standing Overfill, Section 54.2, Tipover, Section 54.3, and Spill, Section 54.4. A risk of fire or electric shock is considered to exist if the test results in any of the following:

a) Obvious wetting of uninsulated live parts, film-coated wire, or insulation adversely affected by the fluids used with the appliance. 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;

b) The footbath;

1) If grounded;

i) During and after the tests, does not comply with the Leakage-Current Test, Section 45; and

ii) After the tests, does not comply with the Dielectric Voltage-Withstand Test, Section 52;

2) If double insulated;

i) During and after the tests, does not comply with the Leakage-Current Test in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097; and

ii) After the tests, does not comply with the Dielectric Voltage-Withstand Test in the UL 1097.

54.1.2 During and after the tests described in Standing Overfill, Section 54.2 and Spill, Section 54.4, the applicable leakage current test shall be conducted. After the test of Spill, Section 54.4, the applicable

leakage current test shall be conducted. Immediately following the leakage current test, the footbath is to be emptied, dried with a soft cloth to remove all exterior surface moisture, filled with hard water solution to the maximum fill line, and then subjected to the applicable dielectric voltage-withstand test.

54.1.3 For the tests described in Standing Overfill, Section 54.2 and Spill, Section 54.4, after the dielectric voltage-withstand test, the appliance shall be carefully emptied, the exterior shall be dried as previously indicated, and the appliance shall be opened and examined to ensure that there is no wetting of uninsulated live parts, film-coated wire, or insulation.

54.1.4 Components such as boots, diaphragms, seals, o-rings, and gaskets, shall be removed completely or in part (whichever is considered most unfavorable) for the testing described in Standing Overfill, Section 54.2 and Spill, Section 54.4, unless they have been tested in accordance with 55.3.

54.2 Standing overfill

54.2.1 To determine whether a massage type footbath complies with the requirements in Resistance to Moisture Tests for Massage Type Footbaths-General, Section 54.1, the appliance is to be supported on a level surface in the normal use position.

54.2.2 The footbath is then to be filled to maximum capacity using a hard water solution (1/2 gram of calcium sulfate, $CaSO_4$, per liter of distilled water). Then a further quantity equal to 50 percent of the footbath capacity, but no more than 1/2-liter, is to be steadily poured into the footbath over a period of 30 seconds. The solution is then to stand in the footbath for 1 hour during which the leakage current shall be monitored on all exposed conductive surfaces. Leakage currents from these surfaces are to be measured to the grounded-supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. 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.

54.2.3 For footbaths provided with an air bubbler, this test shall be conducted with the air bubbler de-energized.

54.3 Tipover

54.3.1 To determine whether a massage type footbath complies with the requirements in Resistance to Moisture Tests for Massage Type Footbaths-General, Section 54.1, the footbath is to be filled to maximum capacity with the hard water solution specified in 54.2.2, and then overturned in the direction most likely to result in a risk of fire or electric shock.

54.4 Spill

54.4.1 To determine whether a massage type footbath complies with the requirements in 54.1, 1/2-liter of hard water solution, as specified in 54.2.2, is to be evenly poured over any part of the appliance through a 3/8-inch (9.5-mm) diameter orifice while in its intended position during a 30 second period that may be subject to a spill or splash, and which is most likely to result in a risk of fire or electric shock.

54.4.2 For footbaths provided with an air bubbler, this test shall also be conducted with the air bubbler de-energized, and the solution additionally poured over the air vents.

55 Flooding of Live Parts Test

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

55.2 In a test to determine whether an appliance complies with the requirement in 55.1 with respect to deterioration or damage of a part, such as a boot, diaphragm, seal, or gasket, or an elastomeric part subject to hot soapy water, such a component shall be removed completely or in part, whichever is most unfavorable. In the case of a footbath, after the component is removed, the footbath shall then be filled to maximum capacity and operated as in normal operation.

Exception: A part not subject to flexing need not be removed if the part complies with 55.3.

55.3 In a test to determine compliance with the Exception in 55.2, a polymeric or elastomeric material used for a gasket, diaphragm, seal, gasket, or an elastomeric part subject to hot soapy water, shall be subjected to the tensile strength and elongation test in accordance with the Standard for Gaskets and Seals, UL 157. For each test, three samples shall be tested in the as-received condition and three samples shall be tested after oven conditioning. For oven conditioning, the samples shall be placed in a circulating-air oven at a temperature of 69 – 70° C (156 – 158°F) for 168 hours. As a result of the oven conditioning, the average of the samples shall retain 75 percent of its original tensile strength and 60 percent of its original elongation.

Exception No. 1: If a part is too small to determine the percent tensile strength and elongation, the part shall be subjected to a visual examination. The part shall not harden, deform, melt, or otherwise deteriorate to a degree that will adversely affect the sealing properties.

Exception No. 2: A noncomposite material that complies with the requirements in the UL 157, and that complies with the minimum intended elongation and tensile strength after aging, complies with these requirements.

56 Fluid-Handling Tubing Tests

56.1 A massage type footbath that employs fluid-handling tubing is to be tested as described in 56.2 to determine whether deterioration or breakage of the fluid-handling tubing can result in the risk of fire or electric shock. A risk of fire or electric shock is considered to exist if the test results in any of the following:

a) Wetting of uninsulated live parts, film-coated wire, or insulation;

b) The footbath;

1) If grounded;

i) During and after the tests, does not comply with the Leakage-Current Test, Section 45; and

ii) After the tests, does not comply with the Dielectric Voltage-Withstand Test, Section 52;

2) If double insulated;

i) During and after the tests, does not comply with the Leakage-Current Test in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097; and

ii) After the tests, does not comply with the Dielectric Voltage-Withstand Test in UL 1097.

Exception: Fluid-handling tubing need not comply with this requirement if it complies with the test in 56.3.

56.2 To determine whether a massage type footbath complies with 56.1, a 1/4-inch (6.4-mm) diameter hole shall be drilled into the fluid-handling tubing in any location that can result in the fluid reaching an uninsulated live part, a film-coated wire, or insulation. The hole shall then be plugged, and the footbath filled to maximum capacity with the hard water solution described in 54.2.2. The footbath shall be energized. The plug shall then be removed, so that all of the solution flows out. The component shall be in its intended position, and the appliance shall be in the position that, during intended use, allows maximum exposure to the solution. This test shall then be repeated with the footbath de-energized.

Exception: If the inside diameter of the tubing is less than 1/4 inch, the size of the hole drilled in the tubing shall be equal to the inside diameter of the tubing.

56.3 With reference to the Exception to 56.1, if deterioration or breakage of fluid-handling tubing can result in the risk of fire or electric shock, the tubing shall be subjected to the requirements in the Mold Stress-Relief Distortion Test, Section 66.1 while installed in the footbath. The footbath shall then be cooled to room temperature. After this conditioning, the footbath shall be filled to maximum capacity with water and operated as intended as described in the Operational Test, Section 63. As a result of the conditioning, there shall be no evidence of water leakage within the electrical enclosure of the footbath.

57 Backflow Prevention Test

57.1 A massage type footbath that employs air-handling tubing is to be tested as described in 57.2 to determine whether the footbath design is provided with a means to prevent the backflow of liquid into the footbath. As a result of the test(s), there shall be no risk of fire or electric shock as evidenced by water leakage within the electrical enclosure of the footbath.

57.2 To determine whether a massage type footbath complies with 57.1, a sample of the appliance is to be subjected to a Mold Stress-Relief Distortion Test, Section 66.1. If the backflow or check valve location can be exposed to impact in normal use, a sample shall also be subjected to the ball impact test as described in Ball Impact, Section 66.4.

57.3 Following the mold stress-relief distortion conditioning, the sample shall be cooled to room temperature and then subjected to the tests described in Standing Overfill, Section 54.2 and Spill, Section 54.4.

58 Switch and Control Test

58.1 A switch or other device that controls a motor of an appliance, or that controls 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 58.2 – 58.4, 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 placed in the circuit for this test shall not open.

Exception No. 1: A device known to be acceptable for the application need not be tested.

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

58.2 In a test to determine whether the switch or other control device complies with the requirement in 58.1, exposed dead metal parts of the appliance are to be connected to ground through a 3-A plug fuse.

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.

58.3 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 percent of the voltage specified in 44.1. The load on the device being tested is to be the same as that which it is intended to control in service.

58.4 When testing a switch or other control device that controls a motor, the rotor of the motor is to be locked in position. The supply-circuit 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.

59 Thermostat Test

59.1 General

59.1.1 A thermostat employed in a heating pad shall comply with 59.3.1 – 59.5.1.

59.2 Original calibration

59.2.1 The cutoff temperature of each of six thermostats that are identical to the thermostats employed in the heating pad is to be measured by any method whereby the temperature can be closely regulated and accurately measured.

59.3 Overload

59.3.1 When tested as described in 59.3.2, there shall be no electrical or mechanical breakdown or undue pitting or burning of the contacts in any of the six calibrated thermostats.

59.3.2 The thermostats are to be operated automatically on a 125-V supply circuit for 100 cycles at a rate of not more than 6 cycles per minute, making and breaking twice the maximum noninductive current that the thermostat normally carries in the pad. An alternating-current supply circuit is to be used if the pad is rated for use on only alternating current. A direct-current supply circuit is to be used if the pad is rated for use on only direct current or for use on both direct current and alternating current.

59.4 Endurance

59.4.1 There shall be no electrical or mechanical breakdown or undue pitting or burning of the contacts in any of the six thermostats that performed acceptably in the overload test described in 59.3.2 as the result of their additional automatic operation on a 125-V alternating current supply circuit for at least 100,000 cycles at a rate of not more than 30 cycles per minute making and breaking the maximum noninductive current that the thermostat normally carries in the pad. See 52.6.

59.4.2 This test is intended to represent at least 1000 hours of service under conditions that produce the fastest operation of a thermostat in the pad. The test is to be continued beyond 100,000 cycles if necessary to represent 1000 hours of service.

59.5 Recalibration

59.5.1 After the six thermostats that performed acceptably in the endurance test described in 59.4.1 and 59.4.2 have been kept at a temperature of 0°C (32°F) for 1 hour and then at a temperature of 125°F (257°F) for an additional hour, the cutoff temperature of each of the six thermostats will not be more than 5°C (9°F) higher than the original cutoff temperature determined in accordance with 59.2.1.

60 Strain-Relief Test

60.1 The strain-relief means provided on an attached flexible cord, when tested in accordance with 60.2, shall withstand for 1 minute without displacement a direct pull of 35 lb (156 N) applied to the cord, with the connections within the appliance disconnected.

Exception No. 1: The pull applied to a Type TP or TPT cord is to be 20 lb (89 N).

Exception No. 2: The pull applied to flexible cords or wires used in dog treadmills for the external interconnection of electrical components shall be 20 lb (89 N).

60.2 A 35 lb (15.9 kg) weight 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.

61 Strain-Relief Clamp Test

61.1 With reference to Exception No. 1 to 13.1.2.3, four samples of the clamp that have been applied to the cord in the intended manner are to be tested as specified in 61.2 and 61.3. As a result, the samples, installed in the equipment as intended, shall comply with Dielectric Voltage-Withstand Test, Section 52, and Strain-Relief Test, Section 60.

61.2 One sample is to be subjected to Strain-Relief Test, Section 60, and Dielectric Voltage-Withstand Test, Section 52, in the as-received condition.

61.3 The other three samples are to be conditioned in an air-circulating oven for 168 hours. The oven temperature is to be 10°C (18°F) higher than the maximum temperature measured on the cord at the strain-relief device during the test described in Temperature Test, Section 49, and not less than 70°C (158°F). After cooling to room temperature, the conditioned samples are to be subjected to Strain-Relief Test, Section 60, and Dielectric Voltage-Withstand Test, Section 52.

61.4 The potential in Dielectric Voltage-Withstand Test, Section 52, is to be applied between the conductors and, for a clamp of metal, the potential is also to be applied between the conductors and the clamp.

62 Flexing and Twisting Test

62.1 Flexing

62.1.1 An appliance employing a heating pad that may be subjected to flexing or twisting, or both, shall be tested as described in 62.1.3 – 62.2.4. Following the test:

a) The appliance shall comply with the requirements in the:

1) Leakage-Current Test, Section 45;

2) Strain-Relief Test, Section 60;

3) Dielectric Voltage-Withstand Test, Section 52;

4) Resistance to Moisture Test, Section 53; and

b) There shall be no:

1) Loosening of the cord from the appliance;

2) Breakage of the covering material or the seams of the covering;

3) Breakage or loosening of any wiring connection;

4) Appreciable shifting of the position of the heating pad within the appliance; or

5) Breakage of a conductor of the heating element or other interruption of the electrical circuit through the appliance.

62.1.2 The minor flexing of small amplitude due to the compression of padding material during intended use of an appliance otherwise employing a rigid frame is not considered to be flexing as mentioned in 62.1.1.

62.1.3 Each of three complete samples of the appliance is to be flexed 8000 cycles under the conditions described in 62.1.4 – 62.2.4.

62.1.4 The apparatus for conducting the flexing test is to consist of a power-driven testing machine, a pair of wide clamps for gripping the edges of each sample, and a number of weights, each large enough to exert 1 lb of force (4.45 N) when suspended from a clamp.

62.1.5 The machine is to draw each sample back and forth by means of a clamp over the 1/2-in (13-mm) radius edge of a smooth horizontal metal bed at a rate of approximately 15 cycles per minute. The stroke of the machine is to be adjustable to accommodate appliances of various dimensions, so that the greatest possible area of the heating pad is subjected to the flexing.

62.1.6 The clamps are to be in pairs that are long enough to accommodate edges of different dimensions, and may be of any construction that securely grips the edges of the appliance. One clamp is to be provided with hooks for the suspension of the weights. The clamps are to be applied to opposite edges of each sample, which is then to be adjusted in the machine with the weighted clamp hanging over the rounded edge of the bed. A weight exerting a force of 1 lb (4.45 N) is to be used for each 6 in (152 mm) or fraction thereof of the edge of the appliance in the clamp.

62.1.7 Each sample is to be connected by means of its flexible cord and plug to a supply circuit. After 2000 cycles of continuous operation the machine is to be stopped, the pad turned 90 degrees so that the bending is at right angles to that previously made, and operation resumed. After the second 2000 cycles of operation the machine is to be stopped, the pad turned over, and operation resumed. After the third 2000 cycles of operation the machine is to be stopped, the pad turned again through 90 degrees, and the operation continued for a fourth 2000-cycle period.

62.2 Twisting

62.2.1 Each of three complete samples of an appliance shall be subjected to a 6000-cycle twisting test as described in 62.2.2 – 62.2.4 while connected to a supply circuit, with the heating pad switch in the high position. At the completion of the test, the appliance shall comply with the requirements in 62.1.1.

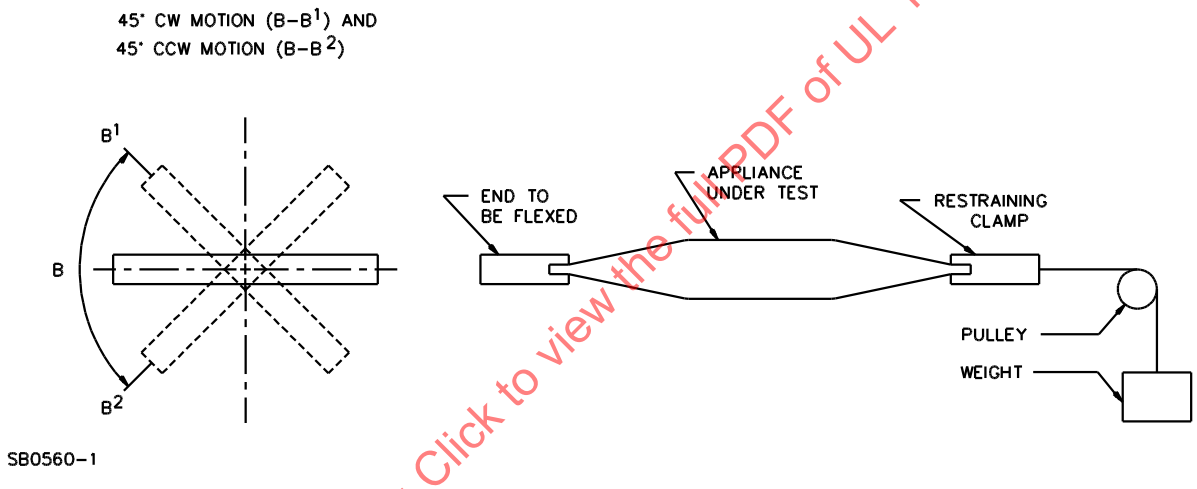
62.2.2 The apparatus for conducting the twisting test is to consist of a power-driven twisting machine and a pair of wide clamps for gripping the edges of each sample.

62.2.3 One end of the sample is to be rigidly clamped in a horizontal plane along its width. This end is to be prevented from twisting. The appliance is to be kept in tension by a pull of 5 lb (22 N) that is placed on this end. The other end of the appliance is to be clamped in the twisting machine along its width.

62.2.4 The machine, with the sample clamped in place, is to twist back and forth through a 90 degree arc. The test is to be conducted at approximately 15 cycles per minute, a cycle being considered as the movement from the horizontal clockwise through 45 degrees of arc, counterclockwise through 90 degrees of arc to a position 45 degrees below the horizontal, and back to the horizontal. A faster twisting rate may be used with the concurrence of those concerned. See Figure 62.1.

Figure 62.1

Twisting-test apparatus



63 Operational Test

63.1 Operation of an appliance as described in 63.2 shall not result in a risk of fire, electric shock, or injury to persons.

63.2 With reference to 63.1, 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. All accessories recommended by the manufacturer for use with the appliance are to be tested. 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.

63.3 With reference to 63.2, a massage type footbath shall also be filled with water as intended and then emptied under any foreseeable manner either rapidly or slowly, whichever is the most unfavorable condition.

64 Abnormal-Operation Test

64.1 General

64.1.1 Equipment shall not cause a risk of fire or electric shock or increased risk of personal injury when operating under the abnormal conditions specified in Electronic Components, Section 64.2.

64.1.2 Operation under the abnormal conditions specified in 64.1.1 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 64.1.4 opens;

c) Any opening is developed in the overall enclosure that is larger than those permitted by requirements as specified in Accessibility of Uninsulated Live Parts and Film Coated Wire, Section 12;

d) The appliance does not comply with the Dielectric Voltage-Withstand Test, Section 52 (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) For treadmills and similar exercise machines, an increased risk of personal injury exists if there is an unexpected increase in the speed of the moving part capable of causing injury (such as a treadmill belt). Treadmills that comply with Abnormal Operation – Electronic Components Test, Section 40.4 are considered to comply with this requirement.

64.1.3 Following the abnormal condition specified in 64.1.1, the sample shall be subjected to the applicable Dielectric Voltage-Withstand Test, Section 52.

64.1.4 For the abnormal operation tests specified in 64.2.1, the appliance is to be connected to a supply circuit protected by a 30 A time-delay fuse marked Type D. 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.

64.2 Electronic components

64.2.1 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.

64.2.2 The Dielectric Voltage-Withstand Test, Section 52 need be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

64.3 Agility trainers

64.3.1 An agility trainer provided with a lithium battery shall be subjected to the tests described in 64.3.2 and 64.3.3. As a result of the testing there shall be no:

a) Ignition of the polymeric enclosure material;

b) Charring or burning of the cheesecloth or tissue paper; or

c) Rupturing of the primary battery.

64.3.2 An agility trainer as described in 64.3.1 shall be subjected to the following abnormal conditions:

a) Shorted battery terminals; and

b) Shorted electronic components upstream of the battery.

64.3.3 The sample shall be mounted as intended on a softwood surface covered by a double layer of white tissue paper, and then covered by a single layer of cheesecloth. The sample shall then be energized and operation continued until ultimate results are obtained or for seven hours, whichever occurs first.

65 Permanence of Marking Test

65.1 After being subjected to the conditions described in 65.2 – 65.6, a pressure sensitive label or a label secured by cement or adhesive is considered to be of a permanent nature if immediately following removal from each test medium and after being exposed to room temperature for 24 hours following removal from each medium:

a) Each sample demonstrates good adhesion and the edges are not curled.

b) The label resists defacement or removal as demonstrated by scraping across the test panel with a flat steel blade, held at right angles to the test panel.

c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

65.2 OVEN-AGING TEST – Three samples of the label applied to test surfaces as in the intended application are to be conditioned for 24 hours in an oven maintained at the temperature specified in Table 65.1.

Table 65.1
Temperatures, oven-aging

Maximum temperature during temperature test of surface to which applied		Oven temperature	
°C	°F	°C	°F
60 or less	(140 or less)	87	(189)
80 or less	(176 or less)	105	(221)
100 or less	(212 or less)	121	(250)
125 or less	(257 or less)	150	(302)
150 or less	(302 or less)	180	(356)
Over 150	(Over 302)	a	

[a] A label that is applied to a surface attaining a temperature greater than 150°C (302°F), during the temperature test, is to be oven-aged at a temperature representative of the temperatures attained by the appliance during normal and abnormal operation.

65.3 IMMERSION TEST – Three samples of the label applied to test surfaces as in the intended application are to be conditioned for 24 hours in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a 50 ±5 percent relative humidity. The samples are then to be immersed for 48 hours in water at a temperature of 21 ±2°C (70 ±4°F).

Exception: In place of the immersion test, a label that is located within an enclosure and not subject to moisture during normal and abnormal operating conditions or routine cleaning may be conditioned for 72 hours in a controlled atmosphere maintained at 32 ±2° C (90 ±4° F) with a relative humidity of 85 ±5 percent.

65.4 STANDARD-ATMOSPHERE TEST – Three samples of the label applied to test surfaces as in the intended application are to be conditioned for 72 hours in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a 50 ±5 percent relative humidity.

65.5 UNUSUAL-CONDITION EXPOSURE – If the labels are exposed to unusual conditions in service, such as oil, grease, cleaning solutions, or the like, three samples of the label applied to test surfaces as in the intended application are to be conditioned for 24 hours in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a 50 ±5 percent relative humidity. The samples are then to be immersed for 48 hours in a solution representative of service use maintained at the temperature the solution would attain in service but not less than 23 ±2°C (73 ±4°F).

65.6 OUTDOOR EXPOSURE TEST – If a label is intended to be exposed to the weather, three samples of the label applied to test surfaces as in the intended application are to be subjected for 720 hours to ultraviolet rays and water spray. The test cycle is to consist of exposure to ultraviolet rays for 17 minutes followed by exposure to ultraviolet light and a fine spray of water for 3 minutes.

66 Polymeric Enclosure Tests

66.1 Mold stress-relief distortion

66.1.1 Conditioning of an appliance as described in 66.1.2 shall not result in softening of the material as determined by handling immediately after the conditioning, or shrinkage, warpage, or other distortion of the enclosure, determined after cooling to room temperature, that results in any of the following:

a) Reduction of spacings between:

1) Uninsulated live parts of opposite polarity;

2) Uninsulated live parts and accessible noncurrent-carrying or grounded metal; or

3) Uninsulated live parts and the enclosure less than the minimum values specified in Spacings, Section 29, and Spacings to Polymeric Enclosures, Section 29.2;

b) Making uninsulated live parts or internal wiring accessible to contact as determined in accordance with Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12;

c) Non-compliance with Strain-Relief Test, Section 60; or

d) Defeating the integrity of the enclosure so that mechanical protection in accordance with Frame and Enclosure, Section 7, and Enclosure and Guards, Section 34, is not afforded to internal parts of the appliance.

Exception: This test is not required for rigid thermosetting materials.

66.1.2 The appliance is to be placed in a full-draft circulating-air oven maintained at a uniform temperature not less than 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70°C (158°F). The appliance is to remain in the oven for 7 hours. After careful removal from the oven and return to room temperature, the sample is to be examined for compliance with 66.1.1.

66.2 Impact

66.2.1 An appliance enclosure shall withstand the impacts described in 66.3.1 or 66.4.1 as applicable, without resulting in any of the following:

a) Reduction of spacings below the minimum specified in Spacings, Section 29, and Spacings to Polymeric Enclosures, Section 29.2;

b) Accessibility of insulated or uninsulated live parts as determined in accordance with Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12;

c) An increase in the risk of injury to persons operating the appliance, see Enclosures and Guards, Section 34; or

d) A risk of electric shock.

66.2.2 With reference to 66.2.1(d), the appliance shall comply with the Dielectric Voltage-Withstand Test, Section 52, after being subjected to the impacts.

66.3 Drop impact

66.3.1 An appliance intended to be completely supported in the hand or by the body during use shall withstand being dropped three times on a hardwood floor from a height of 3 ft (914 mm). The appliance is to be dropped so it strikes the hardwood floor in a different position for each drop. The hardwood surface shall consist of a layer of nominal 2-in (50.8-mm) wide tongue-and-grove oak flooring mounted on two layers of nominal 3/4-in (19.1-mm) plywood. The oak flooring shall be 3/4 in thick (nominal). The assembly is to rest on a concrete or equivalent nonresilient floor during the test.

66.4 Ball impact

66.4.1 A stationary, fixed, or floor-supported appliance shall withstand an impact of 5 ft-lb (6.8 J) from a solid, smooth, steel sphere 2 in (50.8 mm) in diameter and weighing approximately 1.18 lb (0.5 kg) while the appliance is supported against, or on, a rigid surface that prevents the appliance from moving as a result of the impact. The impact is to be applied to any location considered exposed to a blow in normal use.

66.5 Strain-relief after mold stress-relief distortion

66.5.1 After the test sample has cooled to room temperature following the oven conditioning described in 66.1.2, the sample shall comply with Strain-Relief Test, Section 60.

66.6 Abnormal operation

66.6.1 As a result of the test described in 66.6.2, there shall not be ignition of polymeric enclosure parts or exposure of live parts. The material that the appliance is placed on, or draped with, shall not ignite as a result of emission of flame through other than existing openings.

66.6.2 The appliance is to be operated under the conditions of abnormal operation, such as stalled-rotor operation, that the appliance is capable of producing. During the tests, the appliance is to rest on white tissue paper on a softwood surface covered by a single layer of white tissue paper. A single layer of cheesecloth is to be draped over the entire appliance and the appliance is to be operated continuously until ultimate results have been attained. In most cases, continuous operation for 7 hours is required to attain the ultimate results. The simulated abnormal conditions are to be imposed one at a time.

66.6.3 With reference to 66.6.2, for a bubbler-type and hydromassage-type footbath, a condition of abnormal operation includes operating the appliance under a blocked air, and a blocked water inlet and outlet condition.

66.7 Crushing resistance

66.7.1 Stationary and fixed appliances shall withstand a 1-minute application of the crushing force described in 66.7.2 without resulting in any of the following:

a) Reduction of spacings below the minimum specified in Spacings, Section 29, and Spacings to Polymeric Enclosures, Section 29.2;

b) Accessibility of insulated or uninsulated live parts as determined in accordance with Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 12;

c) Breakage, cracking, rupture, or similar damage that adversely affects the insulation; or

d) A risk of electric shock, fire, or injury to persons operating the appliance.

66.7.2 Three samples of the appliance are to be backed on the mounting side by a fixed rigid supporting surface. A crushing force is to be applied to the side opposite the mounting surface. The force is to be applied through applicators having flat surfaces each 4 by 10 in (102 by 266 mm). Each force applicator is to exert 100 lb (45.4 kg) on the sample. As many applicators are to be applied as the sample can accommodate on the surface opposite the mounting surface, based on an arrangement of applicators as indicated in Figure 66.1.

66.8 Thermal aging

66.8.1 A polymeric enclosure material shall be resistant to thermal degradation at the maximum temperature to which it is exposed during normal use. The thermal-aging characteristics of the material shall comply with one of the following:

a) The material shall have a relative thermal index (RTI), based on historical data or a long-term thermal aging program, as described in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, that indicates that the material is rated for use at the temperature involved; or

b) The maximum temperature to which the material is exposed during normal use of the appliance shall not exceed:

1) 80°C (176°F) for a portable, attended, intermittent-duty household use appliance;

2) 65°C (149°F) for any other portable appliance; or

3) 50°C (122°F) for all other appliances.

Figure 66.1

Location of applicators for crush-resistance test