UL 1431

STANDARD FOR SAFETY

Personal Hygiene and Health Care Appliances

UL Standard for Safety for Personal Hygiene and Health Care Appliances, UL 1431

Third Edition, Dated March 23, 2011

Summary of Topics

This revision of UL 1431 dated May 14, 2024 includes the following changes in requirements:

– Update to Section 32A to reflect changes to UL 4200A

– Embedded Power Units; 3.19.3, Sections 87 – 103

Text that has been changed in any manner or impacted by ULSE'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 March 15, 2024.

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UL 1431

Standard for Personal Hygiene and Health Care Appliances

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This UL Standard for Safety consists of the Third Edition including revisions through May 14, 2024.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover household electric products having personal hygienics or health care applications, such as hydromassage units, contact lens disinfectors and cleaners, and toothbrushes, rated at 250 V or less, for use on premises wiring systems in accordance with the National Electrical Code.

1.2 These requirements do not cover professional medical and dental equipment, electrically heated pads, facial saunas, sun and heat lamps, permanently-installed whirlpool baths, spas and hot tubs, shavers, hair dryers, steam and dry heat cabinets or other equipment or products that are covered by separate, individual requirements separate from this Standard.

1.3 The requirements of this Standard do not consider the complete spectrum of physiological or therapeutic effects, beneficial or otherwise, except where generally recognized limits for conditions where a potential risk of injury to persons are defined.

2 Glossary

2.1 For the purpose of this Standard, the following definitions apply.

2.2 ACCESSIBLE PART – A part located so that it can be contacted by a person, either directly or by means of a probe or tool during user servicing, or that is not recessed the required distance behind an opening.

2.3 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).

2.4 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.

2.5 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.

2.6 BASIC INSULATION – The insulation applied to live parts to provide basic protection against electric shock. Basic insulation does not necessarily include insulation used exclusively for functional purposes.

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

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

2.9 CONTROL, AUTOMATIC ACTION – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

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

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

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

2.12 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 potential hazard, is considered an operating control. Operating controls are also referred to as “regulating controls”.

2.13 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the appliance. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as “limiting controls” and “safety controls”.

Note – During the evaluation of the protective control / circuit, the protective functions are verified under normal and single-fault conditions of the control.

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

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

2.16 DOUBLE INSULATION – An insulation system comprised of basic insulation and supplementary insulation, with the two insulations physically separated and so arranged that they are not simultaneously subjected to the same deteriorating influences (temperature, contaminants, and the like) to the same degree. See 2.6, 2.25, and 2.28.

2.17 ENCLOSURE – An external portion of a product that serves to house or support component parts or both.

2.18 ENERGIZED (LIVE) PART – A part energized with respect to some other part or with respect to earth.

2.19 FIELD-WIRING TERMINAL – Any terminal to which a supply or other wire is to be connected by an installer is a field-wiring terminal. If the wire, to be connected to the terminal, is provided as part of the unit and a pressure terminal, connector, soldering lug, soldered loop, crimped eyelet, or other means for making the connection is factory-assembled to the wire, it is not a field wiring terminal.

2.20 INTERLOCK – A device used to de-energize electrical components or stop moving parts that become exposed when an enclosure is opened or when a cover is removed.

2.21 ISOLATING TRANSFORMER – A transformer of which one or more output windings is electrically separated from the input winding and all other output windings.

2.22 LIMITED ENERGY PRIMARY CIRCUIT – A line voltage circuit that incorporates a limiting impedance in series with the supply circuit so that:

a) The circuit potential on the load side of the limiting impedance does not exceed 42.4 V peak (the peak voltage of a 30-V sine wave), under normal conditions, and

b) The maximum energy available at the load side of the limiting impedance circuit is 15 VA under any condition, including abnormal operation.

2.23 LOW VOLTAGE CIRCUIT – A circuit involving an open circuit potential of not more than 42.4 V peak (the peak voltage of a 30-V sine wave) supplied by a primary battery, by a standard Class 2 transformer, or by a combination of a transformer and fixed impedance that, as a unit, complies with all performance requirements for Class 2 transformers.

2.24 OPERATOR (USER) SERVICING – Any form of servicing that might be performed by personnel other than qualified service personnel. Some examples are:

a) The attachment of accessories by means of attachment plugs and receptacles or by means of other separable connectors not involving disassembly or use of tools.

b) Resetting of circuit breakers or replacement of fuses, and lamps that are accessible without the use of tools.

c) Routine operating adjustments necessary to adapt the product for its different intended functions.

d) Routine cleaning and changing of filters.

2.25 REINFORCED INSULATION – Improved basic insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as double insulation.

2.26 SAFETY CIRCUIT – Any circuit, either in the primary or secondary, that is relied upon to reduce the risk of fire, electric shock, or unintentional contact with moving parts, for example, an interlock circuit is considered to be a safety circuit.

2.27 SECONDARY CIRCUITS – Secondary circuits are those circuits supplied from transformer output windings that are electrically separated from the input windings.

2.28 SUPPLEMENTARY (PROTECTING) INSULATION – An independent insulation provided in addition to the basic insulation to protect against electrical shock in case of mechanical rupture or electrical breakdown of the basic insulation.

2.29 HYDROMASSAGE UNITS – For the purpose of this Standard, hydromassage units are considered to be two types:

Water Pump Type – A unit that agitates the bath water by having its moving parts in direct contact with the water, is considered to be of the water pump type.

Air Blower Type – A unit that agitates the bath water by means of air that is generated by the unit, and whose moving parts do not come in contact with the water, is considered to be of the air blower type.

3 Components

3.1 General

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

a) Comply with the requirements for that component as indicated in 3.2 – 3.26;

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, with the exception of fluorescent lamps.

Exception: As specified in 3.1.2 and 3.1.3.

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

3.1.2 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.

3.1.3 A component complying with a UL component standard other than those cited in 3.2 – 3.26 is acceptable if:

a) The component also complies with the applicable component standard of 3.2 – 3.26; or

b) The component standard:

3.1.4 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.

3.1.5 A component not anticipated by the requirements of this standard, not specifically covered by the component standards of 3.2 – 3.26, and that involves a potential risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 3.1.1 b) – d).

3.1.6 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of UL 1431.

3.2 Attachment Plugs, Receptacles, Connectors, and Terminals

3.2.1 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 3.2.9.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords are covered under the requirements of UL 817 and need not comply with UL 498.

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

Exception: 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.

3.2.3 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 3.2.9.

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

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

3.2.6 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 Multi-Pole Splicing Wire Connectors, UL 2459. See 3.2.9.

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

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

3.2.9 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.

3.3 Batteries and Battery Chargers

3.3.1 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 muiltiple 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.

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

3.3.3 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.

3.3.4 Primary batteries (non-rechargeable) that comply with the relevant UL standard and 3.1 are considered to fulfill the requirements of this Standard.

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

a) Standard for Class 2 Power Units, UL 1310; or

b) 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) 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".

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

a) Standard for Power Units Other Than Class 2, UL 1012; or

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

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

3.4 Boxes and Raceways

3.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of NFPA 70 and that comply with the relevant UL standard (such as UL 514A, UL 514C, UL 514D) and 3.1, General, are considered to fulfill the requirements of this standard.

3.5 Capacitors and Filters

3.5.1 The component requirements for a capacitor are not specified. A capacitor complying with the Standard for Capacitors, UL 810.

3.5.2 Electromagnetic interference filters with integral enclosures that comply with the Standard for Electromagnetic Interference Filters, UL 1283.

3.6 Controls

3.6.1 General

3.6.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and the parameters in Section 26.

3.6.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 3.6.2 – 3.6.7, and if applicable, the parameters in Section 26, unless otherwise specified in this end product standard.

3.6.1.3 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 hazard, such as a speed control unexpectedly changing its output, shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

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

3.6.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 3.6.2 – 3.6.7, and if applicable, the parameters in Section 26, unless otherwise specified in this end product standard.

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

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) Standard for Automatic Electrical Controls for Household and Similar Use, UL 60730-1, except Clause H 11.12 (Controls using software).

3.6.1.6 Protective controls that rely upon software as a protective component shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

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

3.6.1.7 An electronic, non-protective control that is simple in design need only be subjected to the applicable requirements of this end-product standard. A control that does not include an integrated circuit or microprocessor, but does consist of a discrete switching device, capacitors, transistors, and resistors, is considered simple in design. See Section 54.

3.6.2 Electromechanical and Electronic Controls

3.6.2.1 A control, other than as specified in 3.6.3 – 3.6.7, shall comply with the:

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

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

c) Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

3.6.3 Liquid Level Controls

3.6.3.1 A liquid level control shall comply with the:

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

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

c) Standard for Industrial Control Equipment, UL 508; or

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

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

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

3.6.4 Motor and Speed Controls

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

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

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

c) Standard for Industrial Control Equipment, UL 508;

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

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

3.6.5 Pressure Controls

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

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

b) Standard for Industrial Control Equipment, UL 508;

c) Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the 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, or

d) Standard for Limit Controls, UL 353.

3.6.6 Temperature Controls

3.6.6.1 A temperature control shall comply with the:

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

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

c) Standard for Industrial Control Equipment, UL 508; or

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

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

3.6.6.2 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with the Standard for Thermistor-Type Devices, UL 1434.

3.6.6.3 A thermal cutoff shall comply with the Standard for Thermal-Links (Thermal Cutoffs) for Use in Electrical Appliances and Components, UL 60691.

3.6.7 Timer Controls

3.6.7.1 A timer control shall comply with the:

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

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

3.7 Cords, Cables, and Internal Wiring

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

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

3.7.3 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) Standard for Thermoset-Insulated Wires and Cables, UL 44;

b) Standard for Thermoplastic-Insulated Wires and Cables, UL 83;

c) Standard for Fixture Wire, UL 66; or

d) The appropriate UL standard(s) for other insulated conductor types specified in Chapter 3 (Wiring Methods and Materials) of NFPA 70.

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

3.8 Cord Reels

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

3.9 Film-Coated Wire (Magnet Wire)

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

3.9.2 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.

3.10 Gaskets and Seals

3.10.1 Gaskets and seals shall comply with the Standard for Gaskets and Seals, UL 157 if they are used to prevent wetting of live parts as determined by the performance testing of this end product standard.

3.11 Ground-Fault, Arc-Fault, and Leakage Current Detectors / Interrupters

3.11.1 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."

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

Note – An ALCI is not considered an acceptable substitute for a GFCI when NFPA 70 requires a GFCI.

3.11.3 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.

3.11.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Section 23.

3.11.5 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 Section 23.

3.12 Heaters, Heating Elements and Pads

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

a) Standard for Electric Heating Appliances, UL 499; or

b) Standard for Sheathed Heating Elements, UL 1030.

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

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

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

3.13 Insulation Systems

3.13.1 Materials used in a Class 105 (A) insulation system shall comply with Section 28.3.

3.13.2 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.

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

3.14 Light Sources and Associated Components

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

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

3.14.2 Lighting ballasts shall comply with the:

a) Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) 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 fulfill this requirement.

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

3.14.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Light Sources 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 fulfill 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.

3.15 Marking and Labeling Systems

3.15.1 A marking and labeling system shall comply with UL 969 (Marking and Labeling Systems) under the specified environmental conditions.

3.16 Motors and Motor Overload Protection

3.16.1 General

3.16.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in 3.16.2. 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).

3.16.1.2 Motors not enclosed, or partially enclosed, by the end product enclosure shall comply with the requirements specified in 3.16.2.

3.16.1.3 Component type motors completely enclosed within the end product enclosure shall comply with the requirements specified in 3.16.2 or 3.16.3.

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

3.16.1.5 Low voltage component fans that comply with the Standard for Electric Fans, UL 507 used for air handling only are considered to meet the requirements of this end product standard.

3.16.2 General-purpose type motors

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

3.16.3 Component type motors

3.16.3.1 Component type motors shall comply with either 3.16.3.2 or 3.16.3.3.

3.16.3.2 The motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 except as noted in Table 3.1.

Table 3.1
Superseded requirements

UL 1004-1 Exempted Requirement	Superseded by UL 1431 Requirements
Cord-Connected Motors, Section 15	11.2
Factory Wiring Terminals and Leads, Section 17	Section 15
Electrical Insulation, Section 22	Section 19
Non-Metallic Functional Parts, Section 28	Sections 8, 19
Solid-State Controls, 7.2	3.6
Non-metallic enclosure thermal aging, 9.1.4	8.5
Motor enclosure, 9.2 – 9.4	Section 8
Grounding, Sections 10 and 11	Section 30
Ventilation Openings, Section 12: only applicable where the openings are on surfaces considered to be the appliance enclosure	8.5
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 13	8.7- 8.19
Protection Against Corrosion, Section 14	Section 10
Switch, Section 27 is not applicable to centrifugal starting switches	Section 25
With the exception of Sections 35 and 40 (Resilient Elastomer Mounting and Electrolytic Capacitor Tests, respectively), the performance tests of UL 1004-1 are not applicable	All applicable performance tests.
Only the following marking requirements specified in 43.1 of 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	68.1

3.16.3.3 The motor shall comply with the applicable component requirements in Section 3, the following construction requirements, and the applicable performance requirements (when tested in conjunction with the end product), of this end product standard:

a) Protection against corrosion, Section 10.
b) Terminal compartment, Section 11

c) Insulating Material, Section 19.

d) Internal wiring, Section 15.

e) Grounding, Section 30.

f) Spacings, Section 29.

3.16.4 Motor Overload Protection

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

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

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

c) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2 Particular Requirements for 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).

3.16.4.2 Impedance protection shall comply with the:

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

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

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

3.16.4.4 Except as indicated in 3.16.4.3, electronically protected motor circuits shall comply with one of the following. See 3.6.4 for basic control requirements.

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

b) Standard for Automatic Electrical Controls for Household and Similar Use, 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) 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 casualty hazard during abnormal testing with the motor electronic circuit rendered ineffective; compliance with the applicable requirements of this end product standard is then required.

3.17 Overcurrent Protection

3.17.1 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 appropriate UL standard for the fuse are considered to fulfill this requirement.

3.17.2 Fuseholders shall comply with the:

a) Standard for Fuseholders, UL 512; or

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

3.17.3 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.

3.17.4 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.

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

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

3.18 Polymeric Materials and Enclosures

3.18.1 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.

3.18.2 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.

3.19 Power Supplies

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

a) Standard for Class 2 Power Units, UL 1310; or

b) 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) 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".

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

a) Standard for Power Units Other Than Class 2, UL 1012; or

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

3.19.3 Embedded power units shall comply with the requirements of this Standard including those requirements found in Sections 87 – 103.

3.20 Printed Wiring Boards

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

Exception No. 1: 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.

Exception No. 2: Printed-wiring boards complying with Section 17 and the performance tests of Section 60 need not comply with UL 796.

3.21 Semiconductors and Small Electronic Components

3.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard of Safety for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Section 51 of this end product standard.

3.21.2 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 criteria of Section 51 of this end product standard.

3.21.3 Except as specified in 3.21.4, 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.

3.21.4 Where an electronic component is determined to be a critical component during the testing of UL 1431, Section 54 (Abnormal Operation Test), one of the following standards shall be applied. See 26.4 of this end product standard for the test parameters to be used.

a) 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) Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

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

3.21.6 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with Failure-Mode and Effect Analysis (FMEA), Section 7 of UL 991.

3.21.7 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1, Annex H.

3.22 Supplemental Insulation, Insulating Bushings, and Assembly Aids

3.22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 32.1 or a performance requirement of this standard. In such cases:

a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441;

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

3.22.2 Wire positioning devices shall comply with Sections 16 and 19. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to fulfill this requirement.

3.22.3 Insulating bushings that comply with Section 3.1 of this end product standard, and the Standard for Insulating Bushings, UL 635, are considered to fulfill the requirements of this Standard. Tests specified in this Standard (e.g. Strain Relief Test) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

3.23 Switches

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

a) Standard for Special-Use Switches, UL 1054;

b) Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;

c) Standard for General-Use Snap Switches, UL 20; or

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

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

3.23.2 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) Standard for Clock-Operated Switches, UL 917; or

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

3.23.3 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 the following:

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

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

3.23.4 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 3.6.1.3.

3.24 Transformers

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

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

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

3.24.2 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 or personal injury, need not comply with this requirement.

3.25 Valves (Electrically Operated) and Solenoids

3.25.1 Electrically operated valves shall comply with the:

a) Standard for Electrically Operated Valves, UL 429; or

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

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

3.26 Video and Audio Components

3.26.1 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 shall comply with the following:

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

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

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

3.26.2 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 shock, fire, or personal injury. Examples include, but are not limited to, the mechanical mounting of the component, and the effect of the audio and video component on the overall leakage current of the machine.

3.27 Induction Power Transmitters and Receivers for Use with Low Energy Products

3.27.1 Induction power transmitters and receivers typically used for charging batteries shall comply with the requirements of the Standard for Induction Power Transmitters and Receivers for use with Low Energy Products, UL 2738.

4 Units of Measurement

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

5 References

5.1 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.

6 General

6.1 Requirements in this Standard apply generally to all personal hygiene and health care products and are supplemented by requirements for specific products. Throughout these requirements, the term "product" is used broadly to refer to any personal hygiene and health care product and its associated control assembly.

CONSTRUCTION

7 General

7.1 A container for liquid intended for use with the product, and supplied as part of the product, shall comply with applicable construction requirements.

8 Frame and Enclosure

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

8.2 A risk of fire is considered to exist at a component part or assembly if an investigation shows that the supply for such part or assembly is capable of delivering a power of more than 15 W into an external resistor connected between the point in question and any return to the power supply.

8.3 A risk of electric shock is considered to exist at parts accessible only to the user or operator during intended use or user servicing if the voltage exceeds 42.4 V peak (the peak voltage of a 30-V sine wave) and the available current exceeds the leakage current levels specified in Leakage Current Test, Section 46.

8.4 Among the factors taken into consideration in determining the acceptability of an enclosure are its:

a) Physical strength,

b) Resistance to impact,

c) Moisture absorptive properties,

d) Combustibility,

e) Resistance to corrosion, and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

For a nonmetallic enclosure, all of these factors are considered with respect to thermal aging.

8.5 A polymeric enclosure shall comply with the applicable requirements in Section 4, Enclosures – General, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. A polymeric enclosure used in the construction of cord connected equipment that is fixed or permanently installed to the building structure, such as plumbing, shall have a flammability rating of 5VA in accordance with UL 746C.

Exception: A portable unattended household appliance employing an HB enclosure may be considered acceptable if the appliance complies with Section 5, Portable Unattended Household Equipment – Alternate Path, in UL 746C.

8.6 The minimum thickness of a metal enclosure shall be as indicated in Table 8.1.

Table 8.1
Minimum acceptable thicknesses of enclosure material

Metal	At small, flat, unreinforced surfaces and at surfaces that are reinforced by curving, ribbing and the like or are otherwise of a shape and/or size to provide physical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
Die-cast	3/64	1.2	–	–	5/64	2.0
Cast malleable iron	1/16	1.6	–	–	3/32	2.4
Other cast metal	3/32	2.4	–	–	1/8	3.2
Uncoated sheet steel	0.026[a]	0.66[a]	0.032	0.81	0.026	0.66

Table 8.1 Continued on Next Page

Table 8.1 Continued

Metal	At small, flat, unreinforced surfaces and at surfaces that are reinforced by curving, ribbing and the like or are otherwise of a shape and/or size to provide physical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
Galvanized sheet steel	0.029[a]	0.74[a]	0.034	0.86	0.029	0.74
Nonferrous sheet metal	0.036[a]	0.91[a]	0.045	1.14	0.036	0.91

[a] Thinner sheet metal may be employed if found to be acceptable when the enclosure is evaluated under considerations such as those mentioned in 8.4.

8.7 An electrical part of the product shall be so located or enclosed that protection against unintentional contact with any uninsulated live part and internal wiring will be provided.

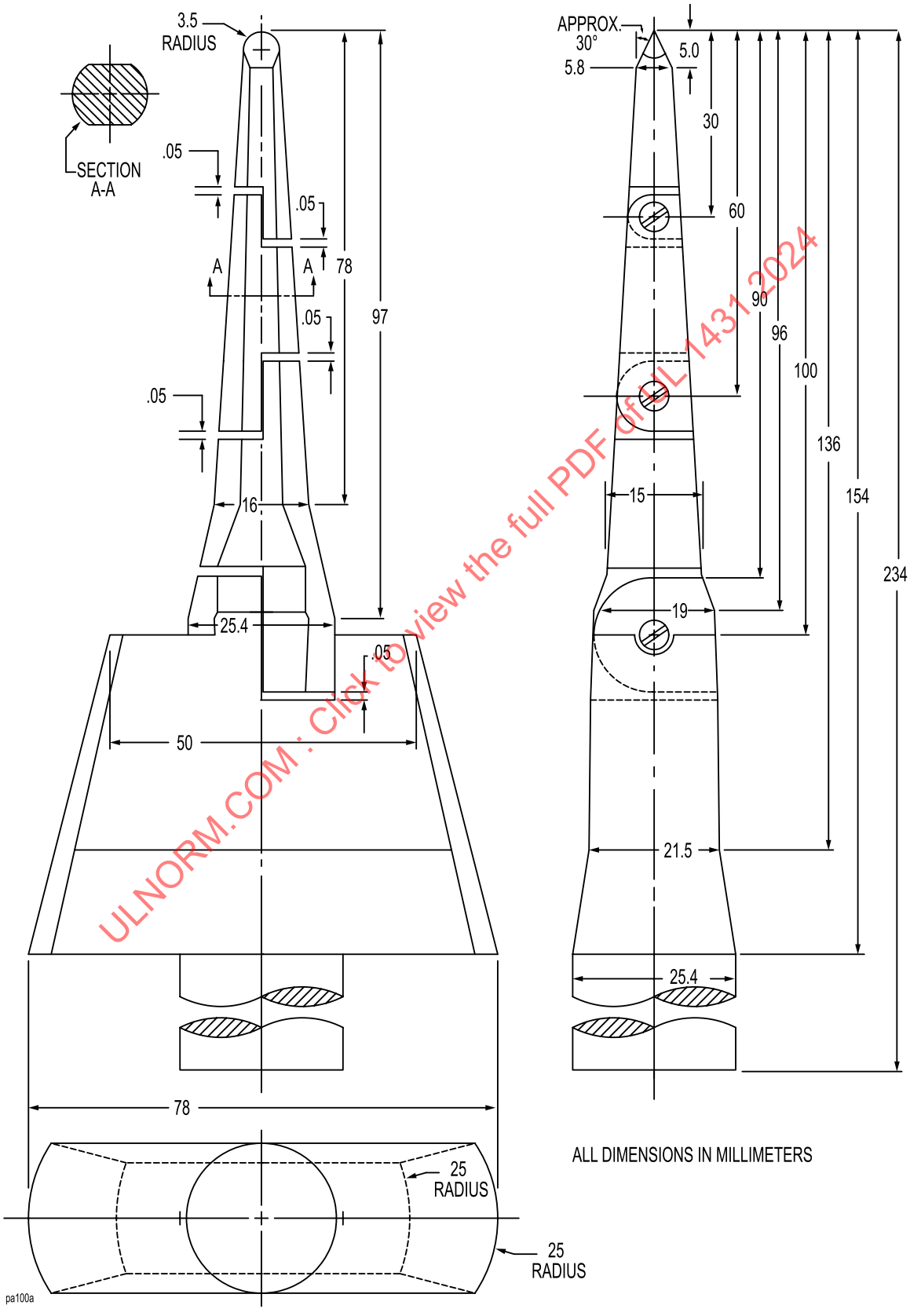
8.8 A live part of a limited energy primary circuit is considered to require the same degree of protection against unintentional contact as is required of a live part of a line voltage circuit.

8.9 In connection with the requirements in 8.7, a part of the outer enclosure that may be removed without the use of a tool – to provide for the attachment of accessories, to allow access to means for making operating adjustment, or for another reason – is to be disregarded. It will not be assumed that the part in question affords protection against risk of electric shock.

8.10 In the enclosure of a product, an opening that a 1 inch (25.4 mm) diameter rod will not enter is acceptable if a probe as illustrated in Figure 8.1 cannot be made to touch any part that involves a risk of electric shock to earth ground when inserted through the opening.

Figure 8.1

Accessibility probe



8.11 With respect to the application of the requirement of 8.10, the probe may be articulated into any configuration and may be rotated or angled to any position before, during, or after insertion into the opening, and the penetration may be to any depth allowed by the opening size, including minimal depth combined with maximal articulation.

8.12 An opening that has a minor dimension of 1 inch (25.4 mm) or more, in an enclosure, as illustrated in Figure 8.2, is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire, that involves a risk of electric shock, less than, R distance from the inside edge of the perimeter of the opening and X distance from the plane of the opening. T equals the enclosure thickness, R equals X minus T, and X equals five times the diameter of the largest round rod that can be inserted through the opening but not less than 6-1/16 inches (154 mm). In evaluating an opening, any barrier located within the volume is to be ignored unless it intersects the boundaries of the volume in a continuous, closed line.

8.13 Insulated brush caps do not require additional enclosure.

8.14 The enclosure of a remotely or automatically controlled product shall not permit molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the product is supported.

8.15 A product is automatically controlled under any one or more of the following conditions:

a) If the repeated starting of the product, 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.

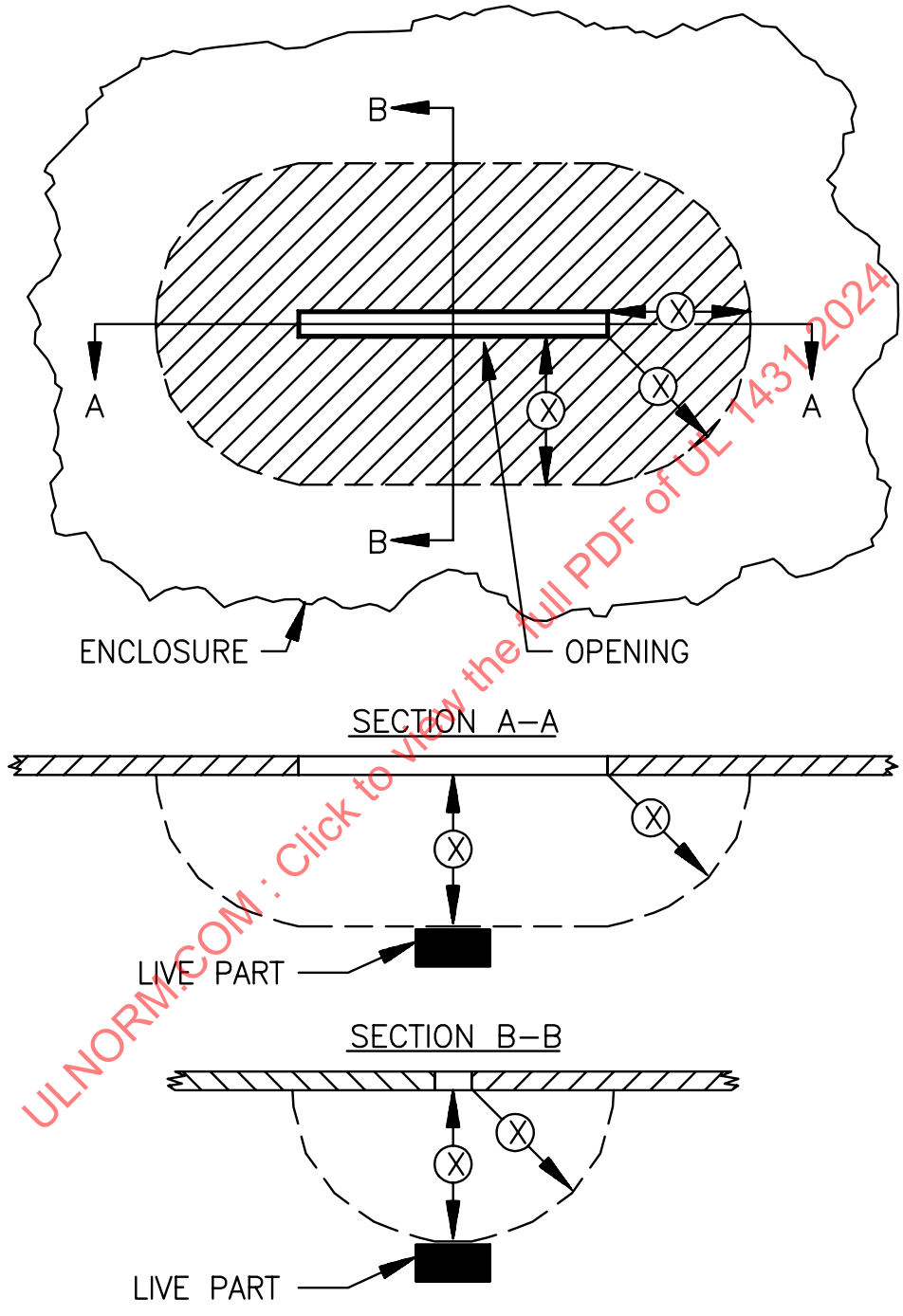
b) If, during any single predetermined cycle of operation, the motor is caused to stop and restart.

c) If, upon energizing the product, the initial starting of the motor may be intentionally delayed beyond conventional starting.

d) If, during any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

Figure 8.2

Opening in enclosure



EC100A

Proportions exaggerated for clarity

8.16 The requirement in 8.14 will necessitate the use of a barrier of material that is resistant to combustion:

a) Under a motor unless:

1) The structural parts of the motor or of the product 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 product when the motor is energized under each of the following fault conditions:

i) Main winding opened,

ii) Starting winding opened,

iii) Starting switch short circuited, and

iv) For a permanent split capacitor motor, the capacitor short circuited (the short circuit is to be applied before the motor is energized, and the rotor is to be locked) or

3) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will keep the temperature of the motor windings from becoming more than 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle, and from becoming more than 150°C (302°F) with the rotor of the motor locked.

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

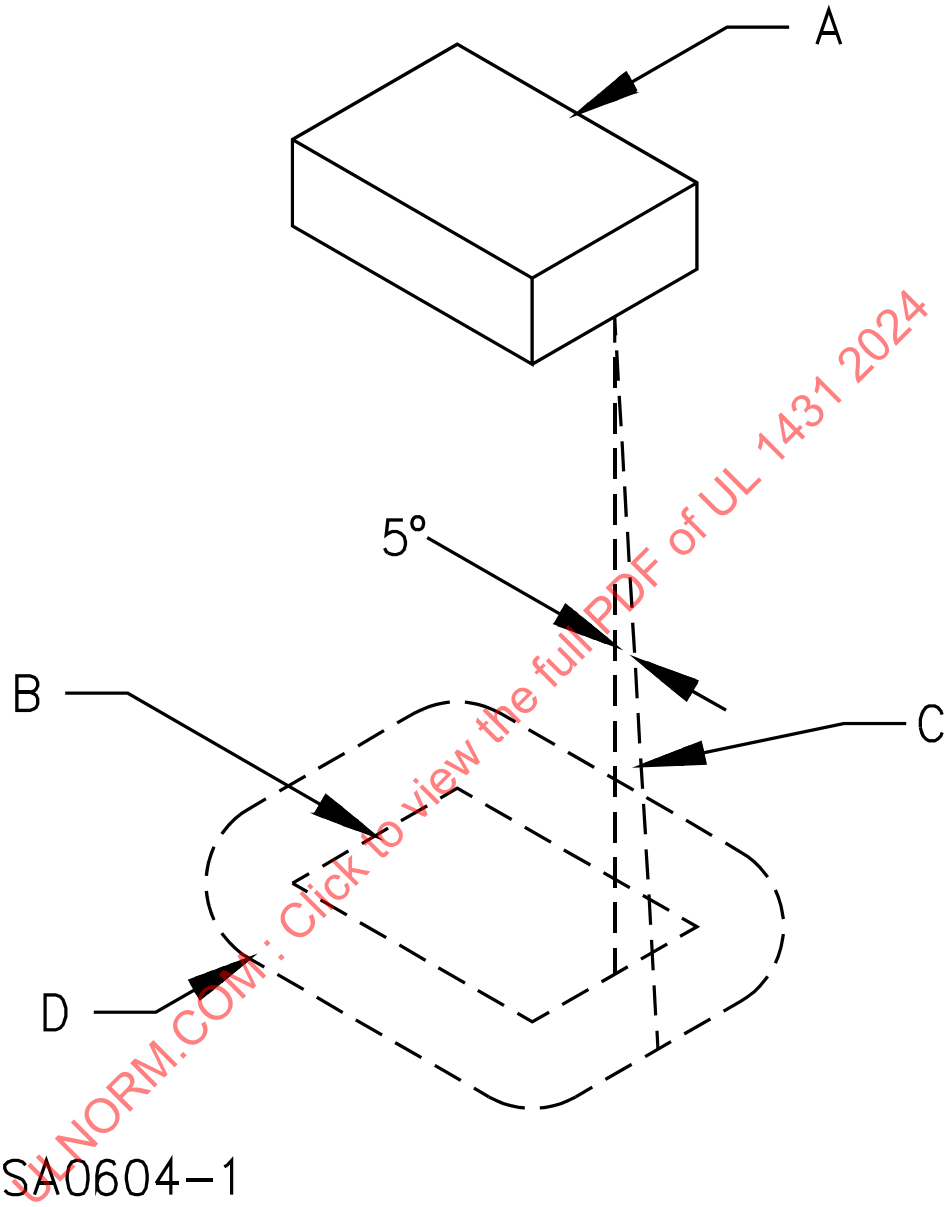
It will also necessitate that a switch, relay, solenoid, or the like be individually and completely enclosed unless there is no opening in the bottom of the product enclosure, or it can be shown that malfunction of the component would not result in a risk of fire.

Exception: Terminals of a switch, relay, solenoid or the like need not be individually and completely enclosed.

8.17 The barrier mentioned in 8.16 shall be horizontal, shall be located as indicated in Figure 8.3, and shall not have an area less than that described in that illustration. An opening for drainage, ventilation, and the like may be employed in the barrier, provided that such an opening would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 8.3

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:

1) Tangent to the component,

2) 5 degrees from the vertical, and

3) Oriented so that the area traced out on a horizontal plane is maximum.

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

8.18 The door or cover of an enclosure shall be provided with means for holding it in place in the closed position.

8.19 The door or cover of an enclosure shall be hinged or attached in an equivalent manner if it gives access to any overload protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device. Such a door or cover shall be provided with a latch or the equivalent, and shall be tight-fitting or shall overlap the surface of the enclosure around the opening.

9 Mechanical Assembly

9.1 The assembly of a product that involves a motor or other vibrating unit shall be such that the product will not be affected adversely by the vibration of intended operation. Brush caps shall be tightly threaded or otherwise so constructed as to keep them from loosening.

9.2 A switch, a lampholder, a receptacle, a motor-attachment plug, or similar component shall be mounted securely, and shall be kept from turning.

Exception No. 1: The requirement that a switch be kept from turning can be waived if all four of the following conditions are met:

a) The switch is of the 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 of mounting the switch is such that the operation of the switch is unlikely to result in the switch becoming loosened.

c) The spacings are not reduced below the minimum acceptable values if the switch does rotate.

d) 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 by a nonremovable jewel, need not be kept from turning if the rotation cannot reduce spacings below the minimum acceptable values.

9.3 The means to keep a device from turning mentioned in 9.2 is to include more than friction between surfaces. For example, a lockwasher, properly applied, is acceptable as a means to prevent turning of a device having a single-hole mounting means.

9.4 Positive means shall be provided to keep parts of a product from turning with respect to each other if such turning would result in reduction of spacings, twisting of wires, and the like.

10 Protection Against Corrosion

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

Exception No. 1: In certain instances in which the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet steel within an enclosure may not be required to be protected against corrosion. The requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

Exception No. 2: Cast-iron parts are not required to be protected against corrosion.

Exception No. 3: The sheath of a heating element operating in air and terminal parts attached directly to the heating element need not be protected against corrosion. The sheath of an immersion type heating element shall be of a metal resistant to corrosion resulting from the liquid in which the element is intended to be immersed.

10.2 A container for liquid shall be protected against the possible corrosive effect of the liquid intended to be used in the container.

11 Supply Connections

11.1 Permanently connected products

11.1.1 General

11.1.1.1 A permanently connected product – a product intended for permanent connection to the power supply – shall have provision for connection to the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA No. 70, would be acceptable for the product.

11.1.1.2 A product intended for permanent attachment to the building structure, water or steam supply, drains, and the like shall be provided with a means for permanent connection to the branch-circuit supply.

11.1.1.3 A product that is not actually moved or easily moved in intended use, but which is not obviously intended to be permanently connected, may be acceptable if provided with the shortest feasible length of Type SJE, SJT, SJO, or equivalent cord and an attachment plug for supply connection. The investigation of such feature will include consideration of the utility of the product and the necessity of having it readily detachable from its source of supply by means of the plug.

11.1.1.4 The location of a terminal or splice compartment in which power supply connections to a permanently connected product are to be made shall be such that these connections may be readily inspected after the product is installed as intended.

11.1.1.5 The compartment mentioned in 11.1.1.6 shall be so located that during conduit connections thereto, internal wiring and electrical components are not exposed to physical abuse or strain.

11.1.1.6 A terminal compartment intended for connection to a supply raceway shall be attached to the product so that it will not turn with respect thereto.

11.1.1.7 A compartment or part of an enclosure that contains field wiring splices other than low-voltage circuits (see 2.23) shall not be provided with ventilating openings.

11.1.2 Wiring terminals

11.1.2.1 A product intended for permanent electrical connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than 125 percent of the current rating of the product when the load is continuous (3 hours or more) and not less than the current rating of the product when the load will be intermittent.

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

Exception: A wire binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.26 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

11.1.2.3 A wiring terminal shall be kept from turning or shifting in position by means other than friction between surfaces. This is to be accomplished by two screws or rivets, by square shoulders or mortices, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by an equivalent method.

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

Exception: A No. 8 screw may be used at a terminal intended only for the connection of a 14, 16, or 18 AWG (2.08, 1.31, or 0.82 mm^2) conductor, and a No. 6 screw may be used for the connection of a 6 AWG or 18 AWG control-circuit conductor.

11.1.2.5 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

Exception: A plate less than 0.050 inch thick, but not less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have acceptable mechanical strength.

11.1.2.6 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 11.1.2.1, but not smaller than 14 AWG (2.08 mm^2), under the head of the screw or the washer.

11.1.2.7 A wire binding screw shall thread into metal.

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

11.1.2.9 A lead intended for the connection of a grounded circuit conductor shall be finished to show a white or gray color and shall be readily distinguishable from the other leads.

11.1.2.10 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152.4 mm) or more if the lead is intended for field connection to an external circuit.

Exception: A lead may be less than 6 inches in length if it is evident that the use of a longer lead might result in a risk of fire, electric shock or injury to persons.

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

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

11.1.2.13 A terminal solely for connection of an equipment grounding conductor shall be capable of securing a conductor of the correct size for that purpose. A quick-connect terminal or a solder lug shall not be used for the grounding terminal.

11.2 Cord- and plug-connected products

11.2.1 Cords and plugs

11.2.1.1 A product intended for cord connection shall be provided with 6 – 8 feet (1.83 – 2.44 m) of flexible cord and an attachment plug for connection to the supply circuit. The cord length is measured from the point of cord entry into the enclosure, or into the wiring device at the product end of the cord, to the face of the attachment-plug.

Exception: Cord length may vary for certain types of products, as specified in Table 11.1.

Table 11.1
Cord lengths for specific conditions

Type of product	Cord length feet (m)	
	Minimum	Maximum
Product supported by hand, table top, or counter top	4 (1.22)	8 (2.44)
Any product having a jacketed cord	a	not specified
Product secured in place such as toilet seat assemblies	2 (0.61)	4 (1.22)
[a] As specified elsewhere in this table or in 11.2.1.1.		

11.2.1.2 The flexible cord:

a) May be permanently attached to the product, or

b) For other than a hand supported product, may be in the form of a detachable power supply cord with means for connection to the product.

11.2.1.3 The ampacity of the cord, and of the plug, shall not be less than the current rating of the product. Such components shall be rated for use at a voltage equal to the rated voltage of the product.

11.2.1.4 The flexible cord shall be of a type indicated in Table 11.2 or shall have properties such that it will be at least equally as serviceable for the particular application.

Table 11.2
Acceptable types of cord and applicable limitations on their use

Product on which the cord in to be used	Cords acceptable where temperature higher than 121°C (250°F) are attained on any surface the cord can touch	Cords acceptable where 121°C (250°F) or lower temperatures are attained on any surface the cord can touch
Contact Lens Disinfector and similar table top (counter top) products	HPN, HSJ, HSJO	SP-2, SPE-2, SPT-2, SV, SVE, SVO, SVT, SVTO, SJ, SJE, SJO, SJT, SJTO, SP-1[a], SPE-1[a], SPT-1[a]
Charger Units >10 W for battery operated toothbrushes, and the like; Denture Cleaners and Oral Irrigation Products		SPE-1, SP-1, SPT-1
Toothbrushes ,Charger Units ≤10 W for battery operated toothbrushes.		TP or TPT (maximum 50 W), SP-1, SJE-1 or SPT-1, XT (parallel 2-conductor construction required)
Oxygen Enrichers and similar Floor Mounted Devices		SJ, SJE, SJO, SJT, SJTO
Toilet Seat Assemblies		SVE, SVO, SVT, SVTO, SJ, SJE, SJO, SJT, SJTO
[a] Acceptable on table-supported products weighing 1/2 lb (0.23 kg) or less.		

11.2.1.5 Type SPT-2, SVT, or other flexible cord at least as serviceable may be used for connecting a pendant-type on-off switch, a temperature control or both to a table- or floor-supported product.

11.2.1.6 The attachment plug of the power supply cord of an appliance provided with:

a) A manually operated, line-connected, single pole switch for appliance on-off operation or

b) An Edison-base lampholder,

shall be of the polarized or grounding type.

11.2.1.7 If a 3–wire grounding-type or a 2–wire polarized attachment plug is provided, the circuit conductors in the flexible cord shall be connected to the plug and to the wiring in the product so that any of the following devices used in the primary circuit shall be connected in an ungrounded side of the line: the center contact of the Edison-base lampholder, a single pole switch, an automatic control with a marked off position, a single fuseholder, and any other single-pole overcurrent protective device.

11.2.1.8 If a 3–wire grounding-type attachment plug or a 2–wire polarized attachment plug is provided, the attachment plug connection shall comply with Figure 11.1 and the polarity identification of the flexible cord shall comply with Table 11.3.

Table 11.3
Polarity identification of flexible cords

Method of identification	Acceptable combinations		
	Wire intended to be grounded[d]		All other wires[d]
Color of braids on individual conductors	A	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	B	Color other than white or gray, with tracer in bold	Solid color other than white or gray – without tracer

Table 11.3 Continued on Next Page

Table 11.3 Continued

Method of identification	Acceptable combinations		
	Wire intended to be grounded[d]		All other wires[d]
Color of insulation on individual conductors	C[a]	Solid white or gray	Solid color other than white or gray
	C1[e]	Light blue	Solid color other than light blue, white, or gray
Color of separators	D[b]	White or gray	Color other than white or gray
Other means	E[c]	Tin or other white metal on all strands of the conductor	No tin or other white metal on the strands of the conductor
	F[b]	A stripe, ridge, or groove on the exterior surface of the cord	

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

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

[c] Only for Type SPT-1 and SPT-2 cords.

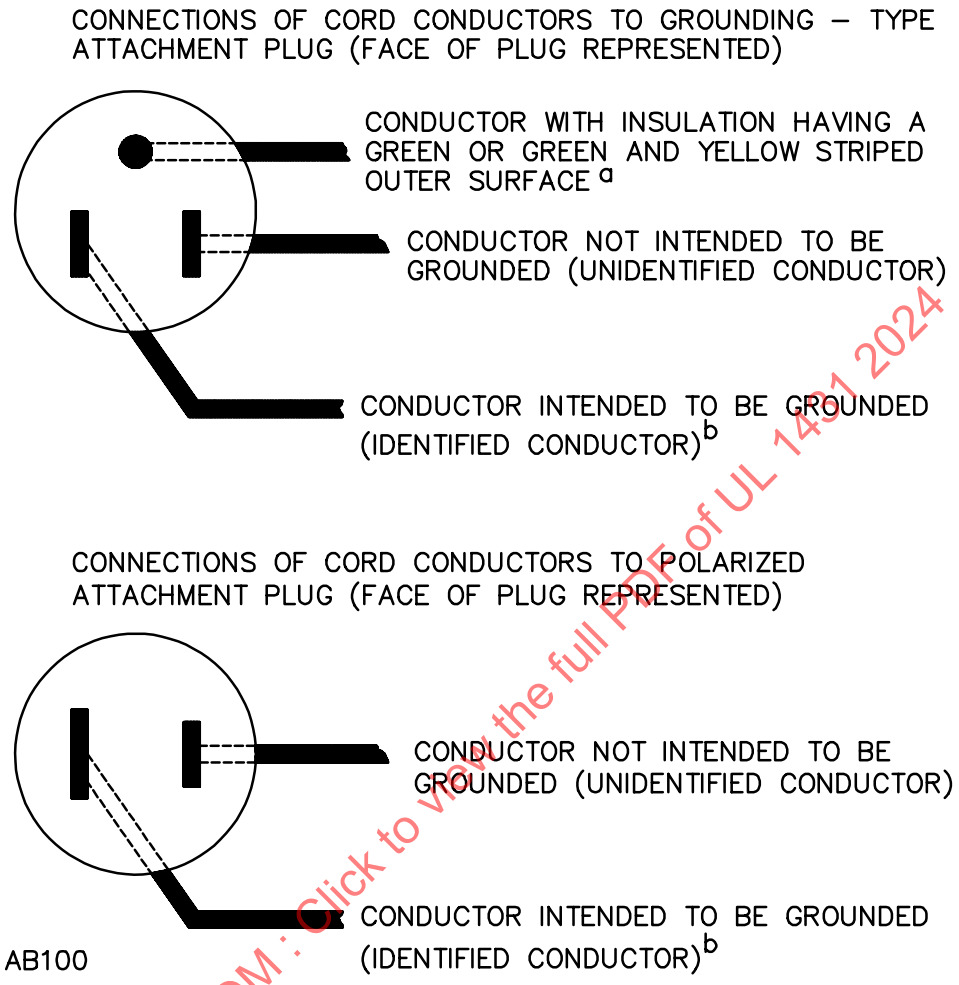
[d] A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment grounding conductor. See 30.5 and Figure 11.1.

[e] For jacketed cord.

11.2.1.9 If a fused polarized attachment plug is provided, the screw shell of the plug fuseholder and accessible contact of an extractor fuseholder shall be connected toward the load.

Figure 11.1

Connections to attachment plug



[a] In the above illustration, the blade to which the green conductor is connected may have a U-shaped or circular cross section.

[b] Signifies a conductor identified in accordance with Table 11.3.

11.2.2 Pin terminals

11.2.2.1 If a product is provided with pin terminals, the construction of the product shall be such:

a) That no live parts will be exposed to unintentional contact both during and after the placement of the plug on the pins, in the intended manner and

b) That the pins are not subjected to mechanical damage when the plug is not connected.

11.2.2.2 A pin guard is required, such that:

a) A straight edge placed in any position, across and in contact with edges of the plug opening without the plug in place, cannot be made to contact any current-carrying pin.

b) With the plug aligned with the pins and the face of the plug in a plane located perpendicular to the end or ends of the farthest projecting current-carrying pin, the probe illustrated in Figure 8.1 should not touch any current-carrying pin while the probe is inserted through any opening with the product in any position.

11.2.3 Strain relief

11.2.3.1 Strain relief shall be provided so that a stress on a flexible cord, such as a pull or twist, will not be transmitted to a terminal, splice, or internal wiring in the product.

11.2.3.2 If a knot in a flexible cord serves as strain relief, the surface against which the knot may bear or with which it may come in contact shall be free of any projection, sharp edge, burr, fin, and the like, that may cause abrasion of the insulation on the conductors.

11.2.3.3 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 is substantial, reliably secured in place, and that has a smooth, rounded surface against which the cord can bear. If Type SP-1, SPE-1, SPT-1, SP-2, SPE-2, SPT-2 or other cord lighter than Type SJ is employed, if the wall or barrier is of metal, and if the construction is such that the cord might be subjected to strain or motion, an insulating bushing shall be provided. The heat and moisture resistant properties of the bushing material shall be acceptable for the particular application.

11.2.3.4 If the cord hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smooth, rounded surface is considered to be equivalent to a bushing.

11.2.3.5 Ceramic materials and some molded compositions are acceptable generally for insulating bushings, but a separate bushing of wood or rubber material (other than in a motor) is not acceptable. Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick, and if it is so formed and secured in place that it will not be affected adversely by conditions of ordinary moisture.

11.2.3.6 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 physically attached to a motor, but not elsewhere in a product, provided that:

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

b) The bushing is so located that it will not be exposed to oil, grease, oily vapor, or other substance having a harmful effect on the compound employed.

Exception: A bushing of any of the materials mentioned may be employed at any point in a product if used in conjunction with a type of cord for which an insulating bushing is not required, and if the edges of the hole in which the bushing is mounted are smooth and free from any burr, fin, and the like.

11.2.3.7 An insulated metal grommet is acceptable in place of an insulating bushing if the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

12 Live Parts

12.1 A current carrying part shall be of silver, copper, a copper alloy, or equivalent material.

12.2 Plated iron or steel may be used for a current carrying part whose temperature during normal operation is more than 100°C (212°F), within a motor or associated governor, or if in accordance with 3.1; however, unplated iron or steel is not acceptable. Stainless steel and other corrosion resistant alloys may be used for current carrying parts regardless of temperature.

12.3 An uninsulated live part shall be so secured to the base or mounting surface that it will be kept from turning or shifting in position if such motion might result in a reduction of spacings below the minimum acceptable values.

12.4 Friction between surfaces is not acceptable as a means to prevent shifting or turning of an uninsulated live part, but a properly applied lockwasher is acceptable for this purpose.

13 Reservoir

13.1 If a reservoir is part of a product, a live part shall be so located or protected that it will not be subject to dripping if the reservoir fails.

Exception No. 1: This requirement does not apply if the reservoir is resistant to corrosion from the liquid intended for use in it and if the reservoir does not develop cracks as a result of aging.

Exception No. 2: The live parts need not be protected from contact with a dripping liquid if the reservoir is resistant to corrosion from the liquid intended for use in it, and the product is subjected to the Reservoir Overflow Test (Section 56) with acceptable results.

14 Dispensers

14.1 Live parts of a product that employs a device for dispensing a liquid, shall be located or otherwise protected so that they will not come in contact with the liquid under any condition of failure of the dispenser or its associated parts (reservoir, washer, plunger, etc.)

Exception: The live parts need not be protected from contact with a liquid if:

a) All parts with which the liquid is in contact during normal use, and which can be contacted as a result of failure of the dispenser – or its associated part – are resistant to chemical reaction from any liquid intended to be used; and

b) A sample of the product is subject to the Dispenser Leakage Test (Section 57) with acceptable results.

15 Internal Wiring

15.1 The wiring and connections between parts of a product shall be protected or enclosed.

Exception: A necessary length of flexible cord may be employed for external connections between parts of the product if flexibility is essential.

15.2 Wires within an enclosure, compartment, raceway, or the like shall be located or protected to reduce the likelihood of contact with any sharp edge, burr, fin, moving part or the like that may abrade the insulation on conductors or otherwise damage wires.

15.3 A hole in a sheet metal wall through which insulated wires pass shall be provided with a smooth rounded bushing or shall have a smooth, well rounded surface upon which the wires may bear so that the insulation will not be damaged.

15.4 A separate foot switch provided with a product shall be connected to the product by flexible cord no lighter than Type SJ or an equivalent construction.

15.5 Unless it is to be considered as an uninsulated live part, insulated internal wiring of a product, including a grounding conductor, shall consist of wire of a type or types that are acceptable for the particular application, when considered with respect to:

a) The temperature and voltage to which the wiring is likely to be subjected,

b) Exposure to oil, grease, or other substances likely to have a harmful effect on the insulation,

c) Exposure to moisture, and

d) Other conditions of service to which it is likely to be subjected.

15.6 A splice and connection shall be mechanically secure and shall provide a positive electrical contact.

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

15.8 If a wire-binding screw construction, or a pressure wire connector is used as a terminating device for aluminum it shall be acceptable for use with aluminum under the conditions involved– for example, temperature, heat cycling, vibration.

15.9 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection might result in a risk of fire, electric shock or injury to persons.

15.10 A wire binding screw or nut shall be provided with a lockwasher under the head of the screw, or under the nut, to keep it from becoming loosened due to vibration if such loosening might permit shifting of parts, thereby reducing spacings, or otherwise result in a risk of fire, electric shock or injury to persons.

15.11 An open-end spade lug is not acceptable unless additional means, such as upturned ends on the tangs of the lug, are provided to hold the lug in place if the wire-binding screw or nut becomes slightly loosened.

15.12 The means of connecting stranded internal wiring to a wire binding screw shall be such that loose strands of wire will be kept from contacting other live parts not always of the same polarity as the wire, and from contacting dead metal parts. This is to be accomplished by use of a pressure terminal connector, soldering lug, crimped eyelet, soldering all strands of the wire together, or the equivalent.

15.13 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 is not provided.

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

16 Separation of Circuits

16.1 An insulated conductor shall not touch any other insulated conductor or uninsulated live part operating at a higher potential unless the conductor is acceptable for use at the higher potential. This includes the conductors in terminal compartments and boxes as well as internal wiring.

16.2 Conductors that operate at different potentials but are not insulated for the highest potential between them as indicated in 16.1 shall be permanently separated from one another by an insulating barrier, routing, or acceptable clamping.

17 Printed Wiring

17.1 Because of risk of electric shock or fire, that could occur due to loosening of the bond between the conductor and the base material, printed-wiring boards used in primary circuits and secondary circuits shall be acceptable for the application, see 8.2 and 8.3.

17.2 Printed-wiring boards used in circuits where loosening of the bond between the conductor and the base material does not result in a risk of fire or electric shock are considered to be acceptable for the application without further investigation.

17.3 The securing of components, such as resistors, capacitors, inductors, transformers, and the like, to a printed-wiring board to form a printed-wiring board assembly, and the mounting of the printed-wiring assembly itself, shall be such that any forces that might be exerted on the components or board during assembly, shipping or handling of the equipment, or during use or servicing, will not displace the components or deflect the board so as to produce a risk of electric shock or fire.

18 Heating Element

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

18.2 In determining whether a heating element is acceptably supported, consideration is to be given to sagging, loosening, and other adverse conditions of the element resulting from continuous heating.

19 Electrical Insulation

19.1 An insulating washer, bushing, and the like, that is an integral part of a product, and a base or support for the mounting of a current carrying part, shall be of a moisture resistant material that will not be adversely affected by the temperatures to which it will be subjected under conditions of intended use. Molded parts shall be so constructed that they will have strength and rigidity to withstand the stresses of intended service.

19.2 Insulating material employed in a product is to be investigated with respect to its acceptability for the particular application. Materials such as mica, some molded compounds, and certain refractory materials are usually acceptable for use as the sole support of live parts. Other materials not acceptable for general use, such as magnesium oxide, may be acceptable if used in conjunction with other insulating materials, or if so located and protected that the risk of mechanical damage and the absorption of moisture

are reduced. When it is necessary to investigate a material to determine its acceptability, consideration is to be given to its mechanical strength, insulation resistance, heat resistant qualities, the degree to which it is enclosed or protected, and any other features having a bearing on the risk of fire, electric shock, and injury to persons involved in conjunction with conditions of actual service. All of these factors are to be considered with respect to thermal aging. For a product in which a polymeric enclosure also serves as an insulating material, or as the direct or indirect support for any live part, the polymeric material shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

19.3 In the mounting or supporting of a small fragile insulating part, a screw or other fastening is not to be tight enough to result in cracking or breaking with expansion and contraction. Generally, such parts should be slightly loose.

19.4 A small molded part, such as a brush cap, shall be so constructed that it will have strength and rigidity to withstand the stresses of intended service.

20 Thermal Insulation

20.1 Combustible thermal and electrically conductive insulation shall not contact an uninsulated live part.

20.2 Some types of mineral wool thermal insulation contain conductive impurities in the form of slag that, if in contact with any uninsulated live parts, may involve a risk of fire, electric shock or injury to persons.

20.3 Thermal insulation shall be rated for the temperature to which it is exposed when tested under the conditions described in 50.2.1.1 – 50.2.5.1.

21 Overload Protection

21.1 If overload conditions that could result in a risk of fire or electric shock are likely to occur, the product shall be provided with a circuit breaker, fuse, or inherent electronic circuitry in order to keep such an overload from occurring.

21.2 Overcurrent protection at not more than 20 A shall be provided by means of a circuit breaker or fuse, as a part of a product, for each general use receptacle circuit and each lampholder circuit independent of a heating element, included in the product, unless the product would be correctly connected to a branch circuit rated at 20 A or less.

21.3 The overcurrent protection mentioned in 21.2 shall be of a type acceptable for branch circuit protection.

22 Overtemperature Protection

22.1 A product shall be provided with a temperature limiting device if malfunction of the temperature regulating control results in a risk of fire or electric shock due to overheating.

23 Arc-Fault, and Leakage Current Detectors / Interrupters

23.1 An arc-fault circuit-interrupter (AFCI) or leakage-current detector-interrupter (LCDI), if provided, 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.

23.2 Arc fault detection testing shall include the applicable tests in the Standard for Safety for Arc-Fault Circuit-Interrupters, UL 1699, 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 Receptacles

24.1 For a product provided with a grounding means, any convenience receptacle shall be of the grounding type.

24.2 A product provided with one or more general-use receptacles shall not be equipped with a flexible cord smaller than 16 AWG (1.31 mm^2).

25 Switches and Controls

25.1 A switch or other control device shall be acceptable for the application, with a rating per circuit, or in the case of a multiple position device, a rating per position not less than that of the load that it controls.

25.2 With reference to the requirement in 25.1, the current-carrying capacity of a switch that controls an inductive load, such as a transformer or an electric-discharge lamp ballast, is required to not be less than twice the rated full-load current of the transformer or ballast unless the switch is rated for the particular application.

25.3 If a product that is intended for connection to the branch-circuit supply by means of a flexible cord and an attachment plug contains a motor rated at more than 1/3 hp (249 W), an acceptable manually-operated motor-control device shall be provided in the product.

25.4 A switch shall be so located or protected that it will not be subjected to mechanical damage in intended use.

26 Controls – End Product Test Parameters

26.1 General

26.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Section 3.6, Controls.

26.2 Auxiliary Controls

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

26.2.2 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 Section 3.6, Controls, is considered to fulfill this requirement.

26.3 Operating Controls (regulating controls)

26.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 1431, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions.

c) Installation class 2 per IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 26.1;

e) For the applicable Material Group, see Table 26.2; and

f) For the applicable Pollution Degree, see Table 26.3.

Table 26.1
Overvoltage Categories

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

Table 26.2
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 26.3
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

26.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 1431, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions.

c) For the applicable Overvoltage Category, see Table 26.1;

d) For the applicable Material Group, see Table 26.2; and

e) For the applicable Pollution Degree, see Table 26.3.

26.4 Protective Controls (limiting controls)

26.4.1 An electronic control that performs a protective function shall comply with the requirements in Section 3.6 while tested using the parameters in this section. Examples of protective controls are: a control used to sense abnormal temperatures of components within the appliance; an interlock function to de-energize a motor; temperature protection of the motor due to locked rotor, running overload, loss of phase; or other function intended to reduce the risk of electric shock, fire, or injury to persons.

26.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using 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; see Section 50;

c) Surge immunity test – installation class 3 shall be used;

d) Electrical fast transient/burst test, a test level 3 shall be used;

e) Electrostatic Discharge Test;

f) Radio-frequency electromagnetic field immunity:

1) Immunity to conducted disturbances – When applicable, test level 3 shall be used; and

2) Immunity to radiated electromagnetic fields; field strength of 3 V/m shall be used;

g) Thermal Cycling test of clause H.17.1.4.2 shall be conducted at ambient temperatures of 10.0 +2°C and the maximum ambient temperature determined by conducting the Temperature Test; see Section 50. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (Tmax) or as determined by conducting the Temperature Test; see Section 50; and

i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class B.

26.4.3 The test parameters and conditions used in the investigation of the circuit covered by 26.4.1 shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;

b) A field strength of 3 V 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) When the Demonstrated Method Test is conducted, 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.

26.4.4 Unless otherwise specified in UL 1431, 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 50.3 and 50.4.

26.5 Controls using a Temperature Sensing Device

26.5.1 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 a 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.

27 Transformers

27.1 A transformer intended to be connected across a supply circuit shall be housed within its own enclosure or within the overall enclosure of the product.

27.2 The insulation between uninsulated, primary wires of opposite polarity shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of not less than 0.013 inch (0.33 mm).

b) Other insulating material mechanically and thermally equivalent to that of (a) and having a dielectric breakdown strength of not less than 2500 V in the thickness used.

Exception: Insulation need not be provided if the spacings required by 29.2.1 are provided.

27.3 Insulation between the primary and secondary windings shall be one of the following (for additional requirements applicable to flanged bobbin-wound transformers, see 27.4):

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of not less than 0.013 inch (0.33 mm).

b) A polymeric coil form having a thickness of not less than 0.025 inch (0.64 mm).

c) Insulation as specified in 27.2(b).

27.4 A flanged, bobbin-wound transformer, having:

a) The primary winding wound over the secondary winding or the secondary winding wound over the primary winding and

b) The primary insulation from the secondary winding by a layer of insulating material, shall comply with the following:

1) The insulation shall have a continuous 1/32-inch (0.8-mm) wide bent-up edge against both bobbin end flanges, and

2) The tests described in 54.2.1 – 54.2.8 shall be continued for 15 days.

27.5 Insulation between the primary winding and the core shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist moisture, having a total thickness of not less than 0.013 inch (0.33 mm).

b) A polymeric coil form having a thickness of not less than 0.025 inch (0.64 mm).

c) Insulation as specified in 27.2(b).

27.6 Insulation between the primary-winding-lead connections and a metallic enclosure (end bells) shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, not less than 0.013 inch (0.33 mm) thick if used in conjunction with an air spacing of one-half that specified in 29.2.1.

b) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture having a total thickness of not less than 0.028 inch (0.71 mm) when the insulation is in contact with the end bell.

c) Insulation that is thermally and mechanically equivalent to that in (a) or (b) and having a dielectric breakdown strength of 2500 V and 5000 V in the thickness specified in (a) and (b), respectively.

Exception: Insulation need not be provided if the spacings required by 29.2.1 are provided.

27.7 Insulation between a crossover lead and the turns of the winding to which it is connected, the adjacent winding, the metallic enclosure, and the core shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of not less than 0.013 inch (0.33 mm).

b) Insulation as required by 27.2(b).

Exception No. 1: The spacings required by 29.2.1 may be provided in lieu of insulation.

Exception No. 2: Insulation between a crossover lead and the winding to which it is connected is not specified if:

a) The coil withstands the dielectric voltage-withstand test described in 51.2.1 with the potential applied between the coil leads and with the coil lead cut at the point where it enters the inner layer or

b) The coil withstands the induced-potential test described in 51.5.1 – 51.5.3. See 27.8.

Exception No. 3: This requirement does not apply to insulation between a Class 2 secondary crossover lead and

a) The secondary winding to which the crossover lead is connected,

b) The metallic enclosure, and

c) The core.

27.8 With reference to Exception No. 2 to 27.7, the magnet coil of a molded-bobbin transformer having a slot for the crossover or start lead – unspliced at the windings – need not incorporate a slot fill if the magnet-coil winding withstands the induced-potential test described in 51.5.1 – 51.5.3.

27.9 Insulation between the primary-lead connections and the adjacent winding, and between secondary-lead connections and the primary winding shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness of not less than 0.028 inch (0.71 mm).

b) Other insulating materials mechanically and thermally equivalent to that in (a) and having a dielectric breakdown strength of not less than 5000 V.

27.10 A plug-in transformer unit shall comply with the requirements for plug-in transformer units, UL 1310.

28 Motors

28.1 Construction

28.1.1 A motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the appliance as described in 50.2 without creating a risk of fire, electric shock, or injury to persons.

28.1.2 A motor winding shall resist the absorption of moisture.

28.1.3 With reference to the requirement in 28.1.2, 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.

28.1.4 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.

28.1.5 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.

28.2 Overload Protection

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

a) Thermal protection complying with the requirements specified, in 3.16.4.1

b) Impedance protection complying with the requirements specified in 3.16.4.2, or

c) Electronic protection complying with the requirements specified in 3.16.4.3 or 3.16.4.4.

28.3 Insulation Systems

28.3.1 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 in Table 28.1 at the thicknesses specified are permitted to be used without further evaluation.

Table 28.1
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)

28.3.2 For Class A insulation systems employing other materials or thinner materials than those indicated in Table 28.1 or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements in 28.3.3.

28.3.3 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 64.

Exception: Other polymeric materials used in a Class 105 (A) insulation system shall comply with the requirements for thermal aging in 64.4.

28.3.4 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.

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

29 Spacings

29.1 Field-wiring terminals

29.1.1 The spacings between field-wiring terminals of opposite polarity and the spacings between a field-wiring terminal and any other uninsulated metal part (dead or live) not of the same polarity shall not be less than indicated in Table 29.1.

Table 29.1
Minimum acceptable spacings in inches (mm) at field-wiring terminals

Potential involved in volts (RMS)	Between wiring terminals through air or over surface[a]	Between terminal and other uninsulated metal parts not always of the same polarity[a]	
		Over surface	Through air
250 or less	1/4 (6.4)	1/4 (6.4)	1/4 (6.4)

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

29.2 Primary circuits

29.2.1 In primary circuits, other than at field-wiring terminals, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and any other uninsulated conductive part, (dead metal part or live part) not of the same polarity shall not be less than indicated in Table 29.2, except that internal motor spacings shall comply with spacing requirements in the Standard for Safety for Rotating Electric Machines, – General Requirements, UL 1004-1. If an insulated live part is not rigidly fixed in position by a means other than friction between surfaces or if a movable part is in proximity to an uninsulated live part, the construction shall maintain at least the minimum acceptable spacings shown regardless of the position of the part.

29.2.2 At closed-in points only, where contamination is unlikely to occur, such as the screw-and-washer construction of an uninsulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable. Within a thermostat, except at contacts, the spacings between uninsulated live parts on opposite sides of the contacts are not to be less than 1/32 inch (0.8 mm) through air and 3/64 inch (1.2 mm) over the surface of insulating material, and the construction is to be such that the spacings will be maintained permanently.

29.2.3 The spacing requirements given in Table 29.2 do not apply to the inherent spacings of a component of the product, such as a snap switch; such spacings are investigated on the basis of the requirements for the component in question.

Table 29.2
Minimum acceptable primary-circuit spacings in inches (mm) at other than field-wiring terminals or inside motors

Potential involved in volts (RMS)	Over surface[b]	Through air
125 or less	1/16 (1.6)	1/16 (1.6)
126—250	3/32[a] (2.4)	3/32[a] (2.4)

[a] In products employing heaters, such as sterilizers, warmers, and the like the spacings may be 1/16 inch (1.6mm) at the heating element.

[b] On printed-wiring boards, their connectors and board-mounted electrical components, wired on the load side of line filters or similar-voltage-peak-reduction networks or components or both, a minimum spacing of 0.023 inch (0.58 mm) plus 0.0002 inch (0.005 mm) per volt peak shall be maintained over the surface and through air between uninsulated live parts and any other uninsulated conductive part (live or dead) not of the same polarity.

29.2.4 At terminal screws and studs to which connection can be made in the field by means of wire connectors, eyelets, or the like, as indicated in 2.19, it is required that the spacings be not smaller than shown in Table 29.2 while such connectors, eyelets, and the like are in such position that minimum spacings (opposite polarity and to dead metal) exist.

29.2.5 An insulating liner or barrier of vulcanized fiber or similar material employed where a spacing would otherwise be less than the minimum acceptable value shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing.

Exception: Vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50-percent of the minimum acceptable through-air spacing.

29.2.6 Insulating material having a thickness less than that specified in 29.2.5 may be used if, upon investigation, it is found to be acceptable for the particular application.

29.2.7 The barriers shall be reliably held in place by means more secure than friction between surfaces. The elasticity of tubing shall not be depended upon to hold the tubing in place, but dilated or heat-shrunk tubing is acceptable.

29.2.8 Unless protected from mechanical abuse during any user assembly or servicing and intended functioning of a product, a barrier of mica shall be 0.010 inch (0.25 mm) or more thick.

29.3 Secondary circuits

29.3.1 Primary-circuit spacings apply in all secondary circuits supplied by a transformer winding of a 200-VA or higher capacity (maximum available power) at a potential higher than 100 V. The spacings in all other secondary circuits are to be investigated on the basis of the dielectric voltage-withstand test in 51.3.1.

29.4 Spacings on printed wiring boards

29.4.1 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, are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

29.4.2 The following end use factors from UL 1431 shall be applied:

a) For the applicable Overvoltage Category, see Table 26.1;

b) For the applicable Material Group, see Table 26.2;

c) For the applicable Pollution Degree, see Table 26.3.

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

29.4.4 All printed wiring boards are identified as having a minimum comparative tracking index (CTI) of 100 without further investigation, for evaluation to UL 840.

30 Grounding

30.1 All permanently connected products shall have provision for grounding all exposed dead metal parts that might become energized.

30.2 A double-insulated product shall not be provided with a means for grounding.

30.3 If a grounding means is provided on the product, whether required or not, all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any servicing operation and that are likely to become energized shall be reliably connected to the grounding means, see Grounding Impedance Test, Section 53.

30.4 The following are considered to constitute means for grounding:

a) In a product intended to be permanently connected – an equipment-grounding terminal or lead,

b) In a cord-connected product – an equipment-grounding conductor in the cord.

30.5 An equipment grounding conductor of a flexible cord shall be:

a) Finished to show a green color with or without one or more yellow stripes;

b) Conductively connected to

1) All exposed dead-metal parts that are likely to become energized and

2) All dead-metal parts within the enclosure that are exposed to contact during any user servicing and that are likely to become energized. The grounding conductor shall be connected by means of a screw or other means not likely to be removed during any servicing operation not involving the power supply cord. Solder alone shall not be used for securing this conductor; and

c) Connected to the fixed grounding member of an attachment plug of the grounding type.

31 Brushes and Brush Holders

31.1 A brush cap shall be recessed, enclosed, or otherwise protected from mechanical damage that might occur during use of the product.

31.2 A brush cap that is accessible to the user without the removal of a guard or enclosure shall be provided with a positive means so that it will not disengage from the brush-holder assembly. Screw threads only on the brush cap are not considered a positive means.

31.3 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 will be retained to the degree necessary to reduce the likelihood of accessible dead-metal parts becoming energized and live parts becoming accessible.

32 Double Insulation

32.1 A product constructed with double insulation and marked as such shall comply with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, in addition to requirements contained here. Where requirements supersede requirements in the standard, the more severe would apply.

32A Button Batteries or Coin Cell Batteries of Lithium Technologies

32A.1 The battery compartment of an appliance or any accessory, such as a wireless control, incorporating one or more button batteries or coin cell batteries shall comply with the Standard for Products Incorporating Button or Coin Cell Batteries of Lithium Technologies, UL 4200A, if the appliance or any accessory:

a) Is intended for use with one or more single cell batteries having a diameter of 1.25 inch (32 mm) maximum with a diameter greater than its height; and

b) The appliance is intended for household use.

PROTECTION AGAINST INJURY TO PERSONS

33 General

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

33.2 When investigating a product with respect to the requirement in 33.1, consideration shall be given to reasonably foreseeable misuse of the product.

33.3 The adequacy of a guard, a release, an interlock, and the like, and whether such a device is required, are to be determined from an investigation of the complete product, 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 the breakdown or malfunction of a particular component can result in a risk of injury to persons, that component is to be investigated for reliability.

33.4 Specific constructions, tests, markings, guards, and the like are detailed for some common constructions. Specific features and products not covered herein are to be given appropriate consideration. See the requirements for marking in Details, Section 68.

34 Sharp Edges

34.1 Each edge, projection, and corner of an enclosure, opening, frame, guard, knob, handle, or the like of a product shall be smooth and shall not cause injury to persons during intended use or during operator maintenance of the product.

34.2 For edges whose acceptability cannot be determined by inspection, compliance with the requirements in 34.1 is to be investigated by the test procedure in the Standard for Determination of Sharpness of Edges in Electrical Equipment, UL 1439.

35 Enclosures and Guards

35.1 A moving part that may cause risk of injury to persons shall be enclosed, guarded, located, or otherwise arranged to reduce the likelihood of unintentional contact.

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 35.3.

35.2 A moving part that may involve a risk of injury to persons shall be located or enclosed to reduce the risk of unintentional contact by persons. Such a part shall be considered with respect to

a) The degree of exposure necessary to perform the intended function,

b) The sharpness of the moving part,

c) The likelihood of unintentional contact therewith,

d) The speed of the moving part, and

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

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

35.3 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.

35.4 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.

36 Materials

36.1 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.

36.2 The requirement in 36.1 applies to those portions of a part adjusted to a moving part considered to involve a risk of injury to persons.

37 Surface Temperatures

37.1 During the normal temperature test described in Temperature Test, Section 50, the temperature of a surface that may be contacted by the user shall not be more than the maximum acceptable value specified in Table 37.1.

Table 37.1
Surface temperatures

Location	Composition of surface[a]	
	Metallic	Nonmetallic
A handle or knob that is grasped for lifting, carrying or holding	50°C (122°F)	60°C (140°F)
A handle or knob that is contacted but does not involve lifting, carrying, or holding and other surfaces subject to contact in operation and user maintenance	60°C (140°F)	85°C (185°F)
A surface subject to casual contact	70° (158°F)	95°C (203°F)

[a] A handle, knob or the like made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is evaluated as a nonmetallic part.

37.2 All values for temperatures specified in Table 37.1 are based on a 25° C (77° F) ambient temperature; however, tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F) and corrected to 25°C (77°F). See 50.1.3 – 50.1.8.

38 Stability

38.1 Overturning of a portable or free-standing product, one not secured in place, when it is tested as described in 38.2 and 38.3, shall not result in a risk of injury to persons.

Exception: A product that is completely hand supported in use need not be tested.

38.2 The product is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the product 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 product;

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

c) Provision or omission of any intended load if the product is intended to contain a liquid or other mechanical load; and

d) Direction in which the product is tipped or the supporting surface is inclined. See 38.3.

38.3 In conducting the stability test, the product 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.

39 Strength of Handles

39.1 A handle used to completely support or carry a product during use shall withstand a force of four times the weight of the product without damage – to the handle, its securing means, or that portion of the enclosure to which the handle is attached – that will affect the performance of the handle or the product.

39.2 To determine whether a product complies with the requirements in 39.1, the weight of the product plus a force of three times its weight are to be used. The load is to be uniformly applied over a 3 inch (76.2 mm) width at the center of the handle without clamping. The load is to be started at zero and gradually increased so that the test value will be reached in 5 to 10 seconds and is to be maintained for 1 minute. If more than one handle is furnished on a product, and the product cannot be carried by one handle, the force is to be distributed between the handles. The distribution of force is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle is to sustain the total force.

40 Rotating or Moving Members

40.1 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.

40.2 To determine whether a product employing a series motor complies with the requirement in 40.1, it is to be tested as described in 40.3. A part that can become a risk of injury to persons shall not work loose as a result of the test.

40.3 For the test referenced in 40.2, a product 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.

40.4 A product with a user-removable rotating part, secured by threaded hardware - such as a nut - shall be constructed so that the direction of rotation tends to tighten the nut that secures the rotating part in place.

40.5 Unless secured as described in 40.4, a removable rotating part not intended to be removed by the user, shall be secured by a keyed nut, a jam nut, a nut locked in place with a pin, or other equivalent means.

41 Parts Subject to Pressure

41.1 A part of a product that is subjected to air or vapor pressure during normal or anticipated abnormal operation shall withstand, without rupture, a pressure corresponding to five times:

a) The relief-valve pressure setting provided in the system,

b) The maximum pressure that can be developed in the system – but not greater than the relief valve setting, or

c) The marked maximum pressure to which the system may be exposed by an external pressure source.

Exception: A section of a pressure system constructed of continuous tubing or of lengths of tubing connected by conventional tubing fittings or hard-soldered, brazed, or welded joints if study and analysis indicate that the strength of the part is adequate for the purpose.

41.2 If a test is necessary to determine whether a part complies with the requirement in 41.1, two samples of the part are to be subjected to the hydrostatic strength test and withstand without rupture for one minute a hydrostatic pressure per 41.1. The results are not acceptable if either sample bursts.

41.3 With reference to the requirements in 41.2 the test is to be conducted by filling the part with water so as to exclude all air, connecting the pressure vessel to a hydraulic pump, gradually increasing the pressure to the specified test value, and holding it at that value for 1 minute.

42 Pressure-Relief Devices

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

42.2 A means for relieving pressure – a pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent means – shall be employed to comply with the requirement in 42.1.

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

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

42.5 A vessel having an inside diameter of more than 3 inches (76 mm) and subject to air or stream pressure generated or stored within the product shall be protected by a pressure-relief device.

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

42.7 A pressure-relief device shall:

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

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

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

1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture, and

2) The likelihood of scalding persons is reduced.

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

42.9 If a pressure-relief device is required in accordance with 42.5, a control depended upon to limit the pressure in a vessel shall:

a) Comply with 3.6.5 and shall have a maximum pressure setting of not more than 90 percent of the rating of the pressure-relief device, or

b) Operate so that the pressure-relief device described in 42.7 does not operate during or after the test described in 42.10.

42.10 A pressure-limiting control shall perform under rated load for 30,000 cycles of operation with no shift in calibration greater than 5 percent above the initial calibration pressure setting. An adjustable control is to be tested at its highest pressure setting unless the adjusting means is reliably sealed at a lower setting.

43 Switches, Controls, and Interlocks

43.1 A product shall be constructed so that unexpected operation will not occur that may cause injury to persons, such as from moving parts, hot liquids, and the like.

43.2 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.

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

43.4 A device that automatically starts a product, such as a pressure control, timer, an automatically reset overload-protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not present a risk of injury to persons.

43.5 The requirement in 43.4 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.

43.6 The actuator of an interlock switch shall be located so that unintentional operation is unlikely. See 43.3.

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

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

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

a) Damaging the product,

b) Making wiring connections or alterations, or

c) Using materials that are not readily available.

43.10 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirement in 43.6.

43.11 A product that is provided with a maintained contact switch or a switch that can be locked on shall not create a risk of injury to persons when the product is in an at rest position and connected to the source of supply with the switch on.

43.12 For a product that is partially or completely hand-supported, the requirement in 43.11 will necessitate a means to keep the product from traveling more than 6 inches (152 mm) in any one direction in 15 seconds when the product is placed on a hardwood surface while energized.

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

PERFORMANCE

44 General

44.1 The sample used for the Temperature Test, Section 50, shall be employed in the dielectric-withstand test, see 51.2.1 – 51.3.4.

44.2 Unless otherwise noted in the individual requirements, all tests are to be conducted with the product connected to a supply circuit of rated frequency, and having a potential of:

a) For a product rated from 110 V to 120 V, inclusive, 120 V;

b) For a product rated from 220 V to 240 V, inclusive, 240 V; and

c) For a product other than as mentioned in (a) or (b), the maximum rated voltage of the product.

44.3 A product having a single frequency rating is to be tested at that frequency. A product rated ac/dc or dc-60 Hz is to be tested on direct current or 60-Hz alternating current, whichever results in the most severe condition. A product rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

44.4 Wherever cloth is mentioned in the abnormal tests, the cloth is to be bleached cheesecloth, running 14 – 15 yd^2/lb (approximately 26 – 28 m^2/kg) and having what is known in the trade as a "count of 32 by 28," that is, for any square inch 32 threads in one direction and 28 threads in the other direction – or any square centimeter, 13 threads in one direction and 11 in the other direction.

45 Operational Test

45.1 Operation of a product as described in 45.2 shall not increase the risk of fire, electric shock, or injury to persons.

45.2 With reference to 45.1, an as-received sample of the product 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 product, including maintenance and cleaning recommended by the manufacturer and lack of such maintenance and cleaning; and with all accessories recommended by the manufacturer for use with the product. The product 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 product is to be operated for a sufficient length of time or through a sufficient number of cycles so that all reasonably foreseeable complications are revealed.

46 Leakage Current Test

46.1 The leakage current of a cord- and plug-connected product when tested in accordance with 46.3 – 46.7 shall be no more than 0.5 mA.

Exception No. 1: For a grounded (3-wire) product, fastened in place, the leakage current shall not be more than 0.75 mA.

Exception No. 2: For a grounded (3-wire) product, intended for use in a dedicated location, see 11.1.1.3, the leakage current shall not be more than 0.75 mA.

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

46.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered as protection against electric shock as defined in Frame and Enclosure, Section 8. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages considered not to present a risk of electric shock.

46.4 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. Where 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 product.

46.5 The measurement circuit for leakage current is to be as shown in Figure 46.1. The measurement instrument is defined in (a) – (d). The meter actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 uf.

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

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

d) Unless the meter is being used to measure leakage from one part of a product to another, the meter is to be connected between an accessible part and the grounded supply conductor.

46.6 A sample of the product 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 (open at receptacle as shown in Figure 46.1). The "as received" condition is without prior energization, other than that which may have occurred as part of the production line testing. The supply voltage is to be adjusted to 120 or 240 V depending on the rating. Thermostats are to be closed. The test sequence, with reference to the measuring circuit (Figure 46.1) is to be as follows:

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

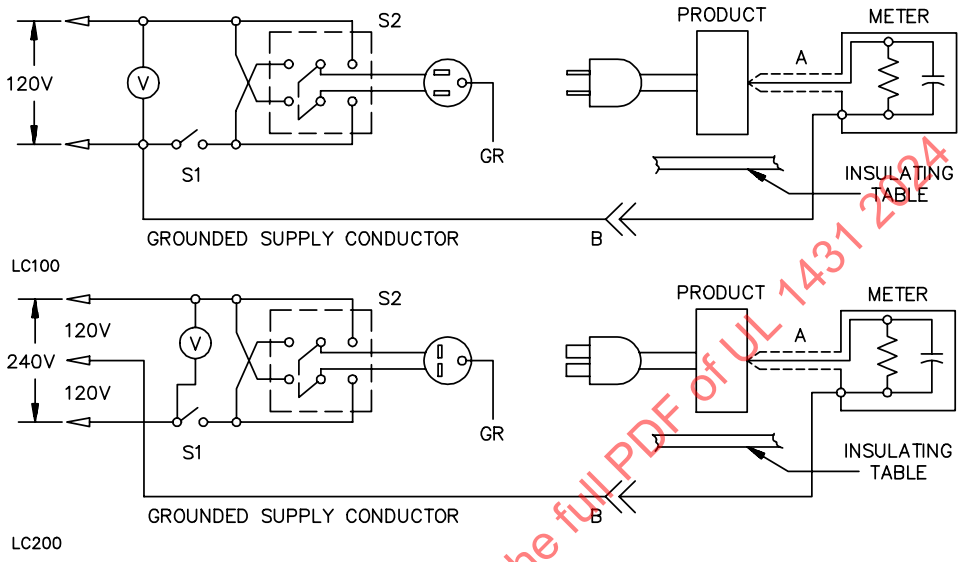
b) Switch S1 is then to be closed, energizing the product, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the product operated at the maximum heat setting of controls.

c) Leakage current is to be monitored until thermal stabilization under the maximum heat conditions, Both positions of switch S2 are to be used. The equivalent of thermal stabilization is considered to be obtained as in the normal temperature test, if any temperature-regulating thermostat does not cycle at the maximum setting, the setting is to be lowered until the thermostat does cycle before the final measurements at thermal stabilization are taken. Measurements are to be made with the thermostat, if any, open and closed. Upon evidence of stabilizing readings, monitoring periods may be increased.

d) If the product employs a single pole switch or a thermostat with an off position, monitoring of leakage current is to continue until the leakage current stabilizes or decreases after the product is turned off. Both positions of switch S2 are to be used.

Figure 46.1

Leakage current measurement circuits



NOTES –

A – Probe with shielded lead.

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

46.7 Usually, a sample will be carried through the complete leakage current test program as covered by 46.6, without interruption for other tests. With the concurrence of those concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive tests.

47 Leakage Current Following Humidity Conditioning Test

47.1 A product shall comply with the requirements for Leakage Current Test, Section 46, following exposure for 48 hours to moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). The product is to be tested as follows:

a) The product is to be at a temperature just above the test chamber temperature when it is placed in a humidity chamber.

b) The product is to remain in the humidity chamber for 48 hours.

c) Following this exposure, while still in the test chamber, the sample is to be tested unenergized as indicated in 46.6(a).

d) The sample is then to be tested energized as indicated in 46.6 (b) and (c), until the leakage current has stabilized or decreased.

48 Starting Current Test

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

48.2 In a test to determine whether a product complies with the requirement in 48.1, the product is to be started three times, with the product at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle, in the case of an automatic product – and the motor is to be allowed to come to rest between successive starts.

48.3 In addition to complying with the requirements of 25.1, a switch or other device that controls a solenoid, relay coil, or the like and has not been tested and shown to be acceptable for this purpose shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation as described in 48.4. The switch shall be electrically and mechanically operable at the conclusion of the test; at which time, the switch shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description that will appreciably diminish the usefulness and reliability of the switch.

48.4 In a test to determine whether a switch or other control device complies with the requirements in 48.3, the product is to be connected to a grounded supply circuit of rated frequency and 110-percent of maximum rated voltage. The load on the device under test is to be the same as that which it is intended to control in intended service. During the test, exposed metal parts of the product are to be connected to ground through a 3 A fuse, and the connection is to be such that any single-pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the product are to be connected to be positive with respect to a single-pole, current-rupturing, control device. The device is to be operated at a rate of not more than ten cycles per minute, except that a faster rate of operation may be employed if agreeable to all concerned. The performance is unacceptable if the fuse in the grounding connection is opened during the test.

48.5 In addition to complying with the requirements of 25.1, a switch or other device that controls a motor of a product – unless tested and shown to be acceptable for this application or unless so interlocked that it will not have to break the locked-rotor motor current – shall be capable of performing acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the motor. The switch shall be electrically and mechanically operable at the conclusion of the test; at which time the switch shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description that will appreciably diminish the usefulness and reliability of the switch.

48.6 In a test to determine whether the switch or other control device is capable of performing acceptably in the overload test mentioned in 48.5, the product is to be connected to a grounded supply circuit of rated frequency and maximum rated voltage (see 44.2) with the rotor of the motor locked in position. During the test, exposed dead metal parts of the product are to be connected to ground through a 3-A fuse, and the connection is to be such that any single-pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the product are to be so connected as to be positive with respect to a single-pole, current-rupturing, control device. 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 all concerned. The performance is unacceptable if the fuse in the grounding connection is opened during the test.

49 Input Test

49.1 The current or wattage input to a product shall not be more than 110 percent of the rated value when the product is operated under the condition of maximum normal load as described in 50.2.1.1 – 50.2.5.1 and when connected to a supply circuit as described in 44.2.

50 Temperature Test

50.1 General

50.1.1 A product, when operated under the conditions of maximum normal load as described in 50.2.1.1 – 50.2.5.1, and while connected to a supply circuit as described in 44.2, shall not attain a temperature at any point sufficiently high to constitute a risk of fire or to affect injuriously any materials employed in the product, nor shall the product show greater temperatures than specified in Table 50.1.

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

Exception: A combination temperature-regulating and -limiting thermostat may operate during the temperature test. See 59.3.2(c).

50.1.3 The temperatures specified in Table 50.1 are based on an assumed ambient temperature of 25°C (77°F). A test may be conducted at an ambient temperature within the range of 10 – 40°C (50 – 104°F).

50.1.4 During a test conducted at an ambient temperature of 25°C (77°F), an observed temperature shall not exceed the values specified in Table 50.1.

50.1.5 If a test is conducted at an ambient temperature other than 25°C (77°F), an observed temperature other than as mentioned in 50.1.6 shall be corrected as described in 50.1.7. Neither a corrected temperature nor an observed temperature as mentioned in 50.1.6 shall exceed the values specified in Table 50.1.

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

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

50.1.8 If a corrected temperature exceeds the values specified in Table 50.1, at the request of the manufacturer, the test may be repeated at an ambient temperature closer to 25°C (77°F).

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

50.1.10 In conducting a test to determine whether a product complies with the temperature requirements, the product is to be mounted or supported as in service, including recessed wall mounting if required. Installation against the wall, in a right angle corner of a room, or in an alcove is to be simulated if the product lends itself to such placement and if such placement results in restricted ventilation. Walls are to be formed by black painted vertical sheets of plywood not less than 3/8 inch (9.53 mm) thick and having such width and height that they extend not less than 2 ft (0.61 m) beyond the physical limits of the product.

50.1.11 Rubber and other material subject to deterioration is to be removed from feet and other supports of the product if absence of the material might result in the product or the supporting surface attaining higher temperatures.

50.1.12 An automatic temperature-regulating or -limiting control or other protective device provided as a part of a product is to be shunted out of the circuit, unless the results of an investigation, which would include overload and endurance tests, show the control to be rugged, reliable, and unlikely to be defeated by the user. See Thermostats Test, Section 59.

50.1.13 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.

Table 50.1
Maximum temperature

Material and components	°C	°F
A. MOTORS		
1. Class A insulation systems on coil windings of an a-c motor, not including a universal motor and on vibrator coil[a]		
(a) In an open motor and on a vibrator coil:		
Thermocouple or resistance method	100	212
(b) In a totally enclosed motor:		
Thermocouple or resistance method	105	221
2. Class A insulation systems on coil windings of a d-c motor and of a universal motor[a]		
(a) In an open motor:		
Thermocouple method	90	194
Resistance method	100	212
(b) In a totally enclosed motor:		
Thermocouple method	95	203

Table 50.1 Continued on Next Page

Table 50.1 Continued

Material and components	°C	°F
Resistance method	105	221
3. Class B insulation systems on coil windings of an a-c motor, not including a universal motor[a]		
(a) In an open motor:		
Thermocouple or resistance method	120	248
(b) In a totally enclosed motor:		
Thermocouple or resistance method	125	257
4. Class B insulation systems on coil windings of a d-c motor, and of a universal motor[a]		
(a) In an open motor:		
Thermocouple method	110	230
Resistance method	120	248
(b) In a totally enclosed motor:		
Thermocouple method	115	239
Resistance method	125	257
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	135	275
Resistance method	145	293
(b) In a totally enclosed motor		
Thermocouple method	140	284
Resistance method	150	302
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		
Thermocouple or resistance method	145	293
(b) In a totally enclosed motor		
Thermocouple or resistance method	150	302
B. COMPONENTS		
1. Capacitors:		
(a) Electrolytic[c]	65	149
(b) Other types[d]	90	194
2. Fuses[e]	90	194
3. Relay, solenoid, and coils (except motor coil windings and transformers) with		
(a) Class 105 insulation systems		
Thermocouple method	90	194
Resistance method	110	230
(b) Class 130 insulation systems		
Thermocouple method	110	230
Resistance method	130	266
4. Sealing Compound	b	b

Table 50.1 Continued on Next Page

Table 50.1 Continued

Material and components	°C	°F
5. Transformers		
(a) Class 105 insulation systems:		
Thermocouple method	90	194
Resistance method	100	212
(b) Class 130 insulation systems:		
Thermocouple method	110	230
Resistance method	120	248
C. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords[e,f]	60	140
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	90	194
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]		
(a) Laminated	125	257
(b) Molded	150	302
3. Varnished-cloth insulation	85	185
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[g]	90	194
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 68.2.1	60	140
3. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the product	90	194
4. A surface intended for body contact for periods up to 1 hour such as a heated toilet seat	41	106

[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 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, open type,

2. 10°C (18°F) for Class B insulation systems on coil windings of alternating-current motors, open type,

[b] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature is 15°C (27°F) less than the softening point of the compound as determined by the Ball and Ring Apparatus, ASTM E28-67.

[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum acceptable temperature on insulating material integral with the capacitor enclosure may be not more than 90°C (194°F).

[d] A capacitor that operates at a temperature of more than 90°C (194°F) may be investigated on the basis of its marked temperature limit.

[e] A component or material that has been investigated, and found acceptable for use at a higher temperature, may be used at the temperature.

[f] A rubber-insulated conductor within a 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] For surfaces that may be contacted by the user, see Surface Temperatures, Section 37.

50.1.14 Coil winding temperatures are to be measured by thermocouples or by using the change-of-resistance method, whichever is appropriate. For a thermocouple measured temperature of a coil of an alternating-current motor other than a universal motor the thermocouple is to be mounted on the integrally applied insulation on the conductor. For any other motor, the thermocouple may be applied on the outer

surface of a wrap that is not more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like.

50.1.15 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. A temperature is determined to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed test duration, but not less than 5-minute intervals, show no change. The thermocouple wire is to conform with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

50.1.16 When using the resistance method, the windings are to be at room temperature at the start of the test, and the temperature of a winding is to be calculated using the formula:

$$T = \frac{R(k + t_1)}{r} - k$$

in which:

T is the final temperature in °C,

R is the resistance of the coil in ohms at the end of the test,

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

t_1 is the temperature in °C of the coil at the time resistance r is being measured,

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

50.2 Maximum normal load

50.2.1 General

50.2.1.1 In tests on a product, maximum normal load is considered to be that load which approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions that are recommended by the manufacturer of the product. Usually a program designed to test all functions of the product suffices. The normal load includes the maximum marked ampere loading of any receptacles and accessory products. When not marked as mentioned in 68.1.5, the receptacle rating is to be used.

50.2.1.2 Test loads which have been found to be close approximations of the most severe conditions of normal use are indicated in 50.2.2.1 – 50.2.5.1 for some common forms of products. Products not mentioned having features not contemplated, are to be tested as necessary to meet the intent of these requirements with consideration given to the probable intermittent or short-time operation of products obviously not intended for continuous operation.

50.2.1.3 Products with forced air fan cooling shall have all filters covered with a thin layer of loose cotton, simulating an accumulation of dust on the filter.

50.2.2 Denture cleaners

50.2.2.1 The product is to be operated through four operation cycles, each of 15 minutes duration, with a 5 minute off period between successive operations.

50.2.3 Oral irrigation appliances

50.2.3.1 The product is to be operated through four cycles, emptying the reservoir each time at a reasonably strong pressure setting to result in a 4 minute operating on period, with a 5 minute off period between successive operations. A lesser on time may be employed if the reservoir empties during this time at the lowest pressure setting of the product. Tepid water, approximately 37° C (100° F) is to be employed for this test.

50.2.4 Charger units for battery-operated toothbrushes

50.2.4.1 The temperature test is to be conducted with the output of the charger unit short-circuited and operation continued until constant temperatures have been attained.

50.2.5 Toothbrushes

50.2.5.1 A cord-connected product is to be operated through six operational cycles, each of 3 minutes duration, with a 1 minute off period between successive operations.

51 Dielectric Voltage-Withstand Test

51.1 General

51.1.1 The insulation and spacings of a product shall be capable of withstanding for a period of 1 minute the application of the test potentials described in 51.2.1– 51.3.1, 51.4.1, and 51.5.1 – 51.5.3 for 1 minute without an indication of unacceptable performance. For a definition of unacceptable performance see 51.1.3.

Exception: The requirement is not applicable where an investigation shows that unacceptable performance will not result in a risk of fire or electric shock.

51.1.2 Where a separate source is employed to supply the required test potential, the source is to have the capacity to maintain the potential indicated, except in case of unacceptable performance. The voltage source is to be increased and, starting at zero, the test potential is to be increased gradually at a substantially uniform rate so as to arrive at the specified test potential in approximately 5 seconds or until unacceptable performance is indicated.

51.1.3 Unacceptable performance will usually be indicated by the tripping of an appropriate overload protector in the test equipment but an abrupt decrease or retarded nonlinear advance of the voltmeter reading or an abrupt increase in current could also be indicative of insulation breakdown. Particular attention shall be paid to high impedance circuits in the product so that breakdowns resulting in risk of fire or electric shock conditions are detected.

51.1.4 The sensitivity of the test equipment shall be such that when a 120,000 ohm resistor is connected across the output, the equipment does not indicate unacceptable performance for any output voltage less than the specified test voltage, and indicates unacceptable performance for any output voltage equal to or greater than the specified test voltage. The calibrating resistor is to be adjusted as close to 120,000 ohms as instrumentation accuracy can provide, but not more than 120,000 ohms.

Exception No. 1: The sensitivity of the test equipment may be reduced (a lower value of calibrating resistance used) if the circuits or components under test do not involve accessible conductive parts.

Exception No. 2: The sensitivity of the test equipment may be increased (a higher value of calibrating resistance used) if agreeable to those concerned.

51.2 Primary circuits

51.2.1 A 60-Hz essentially sinusoidal potential is to be applied between live parts conductively connected to the supply circuit and dead metal parts and across each capacitor, winding separation, or other insulation in the primary circuit that is required for the reduction of the risk of electric shock or, if short-circuited, would involve a risk of fire either directly or indirectly. The test potential is to be:

a) 1000 V plus twice the maximum rated voltage for a product.

b) 2500 V for a product that involves wet or moist contact directly with persons either during the operation or preparing it for operation – includes electric toothbrushes, lens disinfectors, and the like.

51.2.2 If an isolating type of power transformer is employed, wherein the primary and secondary windings are not conductively connected, a 60-Hz essentially sinusoidal potential is to be applied between any live part of the primary or power-supply circuit and any live part of the secondary circuits. The test potential shall be as indicated in 51.2.1.

51.2.3 A power transformer is to be capable of operating without unacceptable performance when potential is applied to the primary of the transformer to produce three times the open circuit secondary voltage or when tested separately using an appropriate supply on the primary to develop a secondary voltage comparable to that which would have existed had the transformer been tested with the balance of the circuit.

51.3 Secondary circuits

51.3.1 The test potential indicated in Table 51.1 is to be applied between:

a) Secondary circuits and grounded metal, with grounded secondary windings of transformers disconnected, and

b) Between secondary circuit parts of opposite polarity.

A 60-Hz essentially sinusoidal source is to be used for testing alternating-current circuits. A direct-current source may be used for testing a direct-current circuit but, if possible, the transformer in the product should be employed to supply the alternating current to the rectifier – or substitute high-voltage rectifier, if necessary – for the opposite polarity test on direct-current circuits.

Table 51.1
Test potential for secondary circuits

Maximum voltage in the circuit, V	Test potential, V
Less than 50	500
50 – 90	Ten times maximum voltage in circuit
91 – 333	1000
333 – 1000	Three times maximum voltage in circuit
More than 1000	1750 plus 1.25 times the maximum voltage in the circuit

51.3.2 All lamps and tubes are to be removed, and ballast tubes or other automatic regulating devices are to be rendered inoperative, if necessary, to carry out the test. All selector or other operating switches are to be adjusted to the various operating positions that enable the connection of these parts in the circuit under test. Bleeder resistors, electrolytic capacitors, transistors, and other power consuming devices are to be opened at the common return side of the circuit.

51.3.3 If the product transformer is included in this test, as per 51.2.3, the product is to be connected to a variable alternating-current source of supply. The test frequency is not to be less than three times the rated frequency of the product so that the secondary voltage of the transformer will provide the required potential without being limited by the saturation of the iron of the transformer core.

51.3.4 In the testing of rectified (d-c) secondary circuits, a high-voltage rectifier and an appropriate filter network is to be substituted for the rectifier of the product, if necessary, and the product electrolytic capacitors removed from the circuit.

51.4 Maximum voltage

51.4.1 The maximum voltage to be used as a basis for the calculation of the dielectric withstand potentials specified in 51.3.1 is to be determined in accordance with 51.4.2 and 51.4.3.

51.4.2 To obtain the maximum voltage, any combination of tubes and fuses may be removed. An automatic voltage-regulating device is to be rendered inoperative unless, upon investigation, it is found that it can be relied upon to keep the voltage from increasing. The investigation is to take into consideration any likely malfunctions in either the regulating device or the product, and the possibility of the device being disconnected, if it is not permanently connected in the circuit.

51.4.3 A connector or comparable part that is likely to be disconnected during intended operation or user servicing is to be both connected and disconnected during the test, in order that the maximum voltage may be obtained.

51.5 Induced potential

51.5.1 Three samples of a transformer as described in Exception No. 2 of 27.7 and 27.8 are to be subjected to this test. While in a heated condition from operation as described in Temperature Test, Section 50, the primary winding of each transformer shall withstand without breakdown an alternating potential of twice the rated voltage of the winding. The potential is to be applied for:

a) 7200 cycles, 120 Hz or more, and

b) 60 seconds if the test frequency is less than 120 Hz.

An increased test frequency may be necessary to prevent core saturation.

51.5.2 The test voltage is to be started at one-quarter or less of the full value and increased to full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one-quarter or less of the maximum value and the circuit is to be opened.

51.5.3 With reference to 51.5.1, a transformer may be conditioned in an oven to obtain the temperature reached in the Temperature Test, Section 50, before conducting the induced potential test.

52 Immersion Test

52.1 After being subjected to the immersion test described in 52.2, a line connected toothbrush or similar hand-held device shall comply with the leakage current requirements of 46.1, and the dielectric voltage-withstand requirements of 51.1.1.

52.2 Each of three samples is to be connected to a supply source as described in 44.2 and operated through repeated cycles of 5 minutes "on" and 5 minutes "off" for 7 hours. Following the last "on" period, and while still connected to the supply circuit, each sample is to be subjected to three 30-second immersions in a solution containing 1/2 gram of common table salt per liter of distilled water. Immediately

thereafter, the samples are to be subjected to the tests outlined in 52.1 and disassembled for examination for compliance with 52.3.

52.3 The test described in 52.2 shall not result in the entrance of water into the interior of the sample in such manner that it might come into contact with uninsulated live parts or film-coated insulated wire.

53 Grounding Impedance Test

53.1 For equipment with a grounding means, the impedance at 60 Hz between the point of connection of the equipment grounding means, including the supply cord, and any other metal part that is required to be grounded, see 30.3, shall not be more than 0.1 ohm when measured in accordance with 53.2.

53.2 Compliance with 53.1 is determined by measuring the voltage when a current of 25 A, derived from a 60-Hz source with a no-load voltage not exceeding 6 V, is passed between the grounding pin of the attachment plug or other grounding means and the metal part in question.

54 Abnormal Operation Tests

54.1 General

54.1.1 A product shall not present a risk of fire or electric shock when subjected to the following tests: output loading, switch position, and component breakdown. Each abnormal test shall be followed by a dielectric voltage-withstand test as required by 51.2.1(a) applied between the transformer primary and secondary windings and between the line and exposed dead-metal parts.

54.1.2 A risk of fire or electric shock is considered to exist if any of the following occur:

a) Opening of the grounding fuse;

b) Charring of cheesecloth;

c) Emission of flame or molten material from the product enclosure and output cord, if provided;

d) Any opening that develops in the enclosure that exposes live parts at a potential of more than 42.4 V peak to any other part or to ground; or

e) Loss of structural integrity to a degree where a plug-in unit cannot be removed from a receptacle immediately after the test without deformation or a risk of electric shock.

54.1.3 Each test is to be conducted on a separate sample unless agreeable to those concerned that more than one test can be conducted on the same sample.

54.1.4 During each test, the grounding means, if provided, is to be connected to ground through a 3-A nontime-delay fuse.

54.1.5 During the tests, the unit is to be draped with a double layer of cheesecloth conforming to the outline of the product.

54.1.6 The temperatures specified are based on an assumed ambient temperature of 25°C (77°F), but a test may be conducted at any ambient temperature of 21 – 30°C (70 – 86°F). However, if the operation of an automatic thermal control during the test limits the temperatures under observation, no temperatures higher than indicated is acceptable.

54.2 Output loading test

54.2.1 A transformer shall be tested under the short circuit output condition. If this does not result in the most severe output loading, the transformer shall be tested under the most severe condition, that may be maximum obtainable output current, or either of the conditions described in 54.2.3 and 54.2.4. A fuse or overcurrent protector provided as part of the transformer is to remain in the circuit, and the largest fuse a fuseholder will accept is to be installed. However, fuses that are located so as to be accessible only to qualified service personnel and marked in accordance with 70.1, may be left in the circuit under test. The test is to be continued until the overcurrent or overtemperature protection opens, constant temperatures are attained, or the transformer winding opens. If an automatically reset protector is provided, or constant temperatures are attained, the test is to be continued for 7 hours. A manually reset protector is to be operated for 50 cycles. The protector contacts are to be operative upon completion of the test.

Exception: For the transformer mentioned in 27.4, the tests are to be continued for 15 days.

54.2.2 The product shall comply with the requirements in 54.1.1 and with the following:

a) During the short-circuit condition, the temperature on the enclosure shall not exceed 90°C (194°F); a temperature of 150°C (302°F) is acceptable if the transformer permanently opens within 1 hour after initiation of the test, if no flame or molten metal is emitted from the unit and no other risk of fire or electric shock results;

b) The grounding fuse, if required by 54.1.4, shall not open; and

c) The branch-circuit overcurrent protective device shall not open.

54.2.3 In regard to 54.2.1, for some constructions it may also be necessary to conduct the test at conditions of maximum power transfer and no secondary load to determine the most severe operating condition.

54.2.4 For transformers with more than one output, one output is to be loaded as specified in 54.2.1 while the other outputs are open circuited or loaded to rated conditions whichever results in a more severe operating condition.

54.2.5 If short circuiting causes operation of an automatically or manually reset protective device, compliance is also to be determined using the maximum load value that allows continuous operation.

54.2.6 If short circuiting causes opening of a fuse, the transformer is to be tested starting with a load current that causes a current of 110 percent of the fuse rating to flow in the fused circuit. The load current is to be increased or decreased, as may be necessary, in steps of 2 percent until a current value is obtained at which the fuse does not open in 7 hours.

54.2.7 If short circuiting causes opening of a thermal cutoff or a single-operation bimetallic device, the device is to be shunted and a thermocouple attached to its body. The load current is to be raised slowly until a temperature equal to the rated trip temperature of the device plus 5°C (9°F) is reached. Without further readjustment of the load, the unit is to be operated for the remainder of the 7 hour period.

54.2.8 If short circuiting causes opening of a winding, tests are to be conducted with the secondary winding loaded to a current (I_L) equal to the rated current (I_R) plus X percent of the difference between the short-circuit current (I_{SC}) and the rated current (I_R). In the tests, the values of X are to be 75, 50, 25, 20, 15, 10, and 5, in that order. If a load current results in 7 hours of continuous operation, further tests need not be conducted. For the tests, a variable resistance load is to be adjusted to the required value as quickly as possible and readjusted, if necessary, 1 minute after application of voltage to the primary winding.

54.3 Switch position test

54.3.1 A product employing a user adjustable primary-voltage selector switch shall be connected to the maximum test voltage and to its rated intended load. The switch is then to be adjusted to the lowest voltage position. Operation of the product is to continue:

a) Until ultimate conditions are observed,

b) For 7 hours, if cycling of an automatically reset protector occurs, or

c) For 50 cycles of resetting a manually reset protector.

54.4 Component breakdown test

54.4.1 The components in the unit, such as diodes, resistors, transistors, capacitors, and the like, are to be shorted or opened, one at a time. The product is to be connected to the maximum test voltage and operated until ultimate conditions are observed, or for 4 hours if cycling of an automatically reset protector occurs. This test need not be conducted for component breakdowns that result in open or short circuiting of the output, in short circuiting of the transformer, or for a component in a low voltage circuit.

55 Connector Cycling Test

55.1 A separable connector shall perform acceptably, without injuriously affecting any part of the device, when subjected to the specified number of cycles of make and break at six-second intervals. A connector shall be operated for 10 cycles if it is in a circuit on the load side of a transformer, and for 50 cycles if it is in the primary-input circuit.

55.2 A separable connector is considered to be one that is not held in place by a screw, clamp, or the like, and that could be separated by the user.

56 Reservoir Overflow Test

56.1 If a product incorporates a reservoir or other liquid-storage chamber that can be overfilled in intended service, liquid overflowing from the reservoir or chamber shall not wet uninsulated live parts or film-coated wires, and shall not wet electrical insulation that is likely to be adversely affected by the liquid usually used in the reservoir or chamber.

Exception: Contact of the liquid with the parts described in 56.1 is acceptable when a sample of the product is subject to the test described in 56.3 and 56.4 with acceptable results.

56.2 To determine whether a product complies with the requirement in 56.1, it is to be tested as follows; water is to be used for the test, and it is to be poured into the reservoir. The reservoir is to be filled to the level recommended, if such level is plainly marked; otherwise, the reservoir is to be filled to maximum capacity. Additional water, equal to 50 percent of the volume just mentioned, but not more than one pint, is then to be poured into the reservoir. Usually, determination of whether uninsulated live parts have become wet as a result of the overflow is to be by means of visual inspection, but this may be supplemented by a leakage-current test or a dielectric voltage-withstand test, or both, if determined to be appropriate.

56.3 Substituting a saline solution of 1/2 gram of salt per liter of water for tap water, the procedure for the overflow test is conducted as described in 56.2.

56.4 Immediately following the procedure in 56.3 the, sample is to be tightly wrapped with conductive foil so as to be in contact with all exposed surfaces, and the sample required to withstand a potential of 2500 V ac applied between the metal foil and live parts (Dielectric Voltage-Withstand Test, Section 51); and

maintain a leakage current of less than 0.5 ma between the foil and ground when tested in accordance with the Leakage Current Test, Section 46.

57 Dispenser Leakage Test

57.1 A product that employs a device for dispensing a liquid and does not provide acceptable protection of live parts (14.1), shall be subject to the tests in 57.2.

57.2 With a sample of the product oriented in any position that may be encountered in normal use, an amount equal to 1/2 the capacity of the dispenser reservoir – but not more than one pint of a saline solution consisting of 1/2 gram of salt per liter of water is to be poured into the chamber or area containing any part of the dispenser.

57.3 Immediately following the procedure in 57.2, the sample is to be tightly wrapped with conductive foil so as to be in contact with all exposed surfaces, and the sample required to acceptably withstand a potential of 2500 V ac applied between the conductive foil and live parts (Dielectric Voltage-Withstand Test, Section 51); and maintain a leakage current of less than 0.5 ma between the foil and ground when tested in accordance with the Leakage Current Test, Section 46.

58 Cleaning Test

58.1 Each product, or portion of a product, that is intended to be cleaned by wiping or washing shall be conditioned as outlined in 58.2 and 58.3, after which the leakage-current test described in Leakage Current Test, Section 46 shall be repeated with no increase in the previously observed leakage current values.

58.2 For products intended to be wiped clean, the outer surface of one sample is to be wiped thoroughly with a folded cheesecloth applicator saturated in the cleaning agent specified in the instruction manual. The complete wiping procedure is to be repeated until a total of 5 operations has been completed.

58.3 For products intended to be washed, one sample of the product is to be submerged to the level indicated in a liquid bath as recommended in the instruction manual. Immersion time is to be for a total of one hour, after which the product is to be removed and dried thoroughly on the outside using a soft absorbent cheesecloth pad. The immersion and drying procedure is to be repeated until a total of 5 washings and dryings have been completed.

58.4 The cheesecloth shall be bleached, running 15 – 15 yd^2/lb (approximately 26 – 28 m^2kg) and have what is known in the trade as a "count of 32 by 28," that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

59 Thermostats Test

59.1 General

59.1.1 Unless it has been tested and found acceptable for the application, a thermostat shall acceptably complete the test program outlined in 59.2.1 – 59.3.2.

59.2 Overload

59.2.1 An automatic control for temperature regulating or temperature limiting shall be capable of performing successfully for 50 cycles of operation when the product is connected to a supply circuit having

a potential of 120-percent of the voltage specified in 44.2. There shall be neither electrical nor mechanical malfunction of the control, nor undue burning, pitting, or welding of the contacts.

59.2.2 In a test to determine whether an automatic control complies with the requirements in 59.2.1, the product is to be connected to a grounded supply circuit; the enclosure of the product, if of metal, is to be connected to ground through a 3-A fuse; and the control, if single-pole, is to be connected in an ungrounded conductor of the circuit. The control is to be operated at the rate of ten cycles per minute, except that a faster rate of operation may be employed if agreeable to all concerned. The performance is unacceptable if the fuse in the grounding connection opens during the test.

59.3 Endurance

59.3.1 A thermostat shall be capable of withstanding an endurance test that shall consist of the number of cycles indicated in Table 59.1. Unless it is specified that the test be made without load, the thermostat shall make and break its expected load in the product while connected to a circuit of rated voltage. There shall be neither electrical nor mechanical malfunction of the thermostat, nor undue burning, pitting, or welding of the contacts.

59.3.2 With reference to 59.3.1 and Table 59.1, thermostats are classified as follows:

a) A temperature-regulating thermostat is one that functions only to regulate the temperature of the heating element under intended conditions of use and whose malfunction would not result in a risk of fire.

b) A temperature-limiting thermostat is one that functions only under conditions that produce abnormal temperatures. The malfunction of such a thermostat might or might not result in a risk of fire.

c) A combination temperature-regulating and -limiting thermostat is one that functions to regulate the temperature of the heating element under intended conditions of use, and also serves to reduce the risk of fire that might result from conditions of abnormal operation of the product.

Table 59.1
Number of cycles of operation for endurance test

Type of thermostat	Automatically reset thermostat	Manual reset thermostat
Temperature-regulating	A number of cycles equivalent to 1000 hours of normal operation of the product, but not less than 30,000. However, the test may be omitted if, with the thermostat short-circuited, no temperatures higher than the limits given in Table 50.1 are attained during the normal temperature test of the product.	To be made the subject of special consideration. No value is specified because of unlikely use.
Temperature limiting	A number of cycles equivalent to 100 hours of operation of the product under any condition which causes the thermostat to function, or 100,000 cycles, whichever is greater. However, the test may be omitted if, with the thermostat short-circuited there is no evidence of risk of fire as described in 54.1.1 – 54.1.6 during the continuous abnormal operation of the product.	1000 cycles under the load and 5000 cycles without load. However, the test may be omitted if, with the thermostat short-circuited, there is no evidence of risk of fire as described in 54.1.1 – 54.1.6 during continuous abnormal operation of the product.
Combination temperature-regulating and -limiting	100,000 cycles if, with the thermostat short-circuited, there is evidence of a risk of fire as described in 54.1.1 – 54.1.6. If there is no evidence of risk of fire under this condition, the thermostat is to be tested as a temperature-regulating thermostat. (See above).	To be made the subject of special investigation. No value is specified because of unlikely use. Combination temperature-regulating and- limiting

60 Printed Wiring Assemblies Test

60.1 Dielectric voltage-withstand test

60.1.1 Where electrical breakdown would result in risk of electric shock, a printed wiring assembly shall be capable of withstanding without breakdown for a period of 1 minute the application of a direct potential of 2E + 1000 V between printed wiring parts and between printed wiring parts and other parts.

60.1.2 E is the maximum peak potential between parts measured with the product connected to a supply circuit and operated under the conditions described in 51.4.2 and 51.4.3.

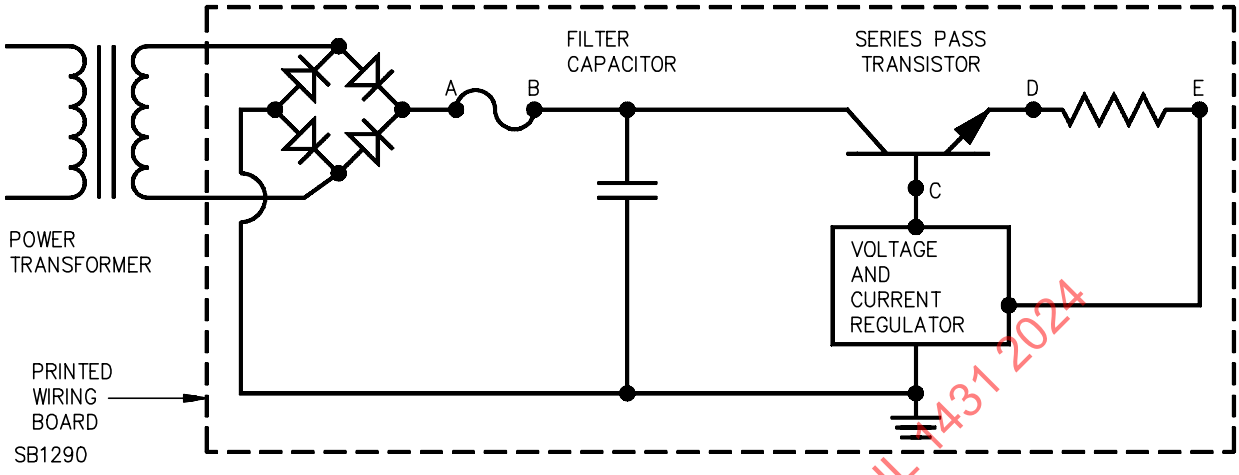
60.2 Limited power test

60.2.1 Unless the sources of power for printed wiring assemblies are limited so that they are not capable of delivering power of 50 W (or more) for more than one minute into an external resistor connected between any two points on a complete assembly, the assembly shall comply with the requirements of 60.3.1 and 60.4.1.

Exception: A printed-wiring assembly that complies with 60.2.3 need not comply with 60.3.1.

Figure 60.1

Power supply test example illustrating method of determination of the "less than 50 Watt" points



Example No. 1 – Refer to Figure 60.1 as an example illustrating the method of determining the points referred to in 60.2.1. Assume that the maximum readings of power delivered to a variable external resistive load connected singly between the power supply return and the points A and B are 50 plus and 40, respectively. The opening of the secondary fuse occurred at the 40 W point. Since the power reading at point B is less than 50 W, this is the point to be short-circuited and loaded to the maximum available power. Additionally, a single diode in the bridge rectifier is short circuited as this is a component between the first point less than 50 W and the supply circuit.

Example No. 2 – Now consider that the maximum reading variable resistive load connected between the power supply return and points C, D and E are: 50 W plus, 50 W plus, and 20 W respectively. Since the reading at point E is less than 50 W, this is the point to be short circuited and loaded to the maximum power. Shorting of the components back to the source of supply includes the series pass transistor, the voltage regulator, the first filter capacitor and a single diode in the bridge rectifier.

60.2.2 It is not necessary that a printed wiring assembly be regarded as a unit in applying the requirement in 60.2.1. For example, a part of the assembly may comply with 60.2.1, another part with 60.3.1 and the dielectric voltage-withstand test in 60.4.2 and 60.4.3, and another part with 60.3.1 and the arcing test in 60.4.4.

60.2.3 A printed-wiring assembly need not comply with the requirement of 60.3.1, as mentioned in the exception to 60.2.1, provided the printed-wiring assembly is powered from a secondary winding of an isolating transformer and the printed-wiring board of the assembly has a minimum flame classification of V-2 (as determined from the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94). The enclosure of such printed-wiring assemblies is to comply with (d), and either (a), (b), or (c) as follows:

a) Enclosure is to be made of metal. See Frame and Enclosure, Section 8.

b) Enclosure is to be made of a polymeric material having a minimum flame classification of V-1.

c) Enclosure is to be made of solid or laminated wood, at least 3/8 inch (9.5 mm) thick with no edge exposed to internal electrical parts and spaced at least 1/2 inch (12.7 mm) from arcing parts and sources of ignition. Parts considered to be sources of ignition are those connected in circuits having a capability of over 50 W and include resistor body, transistor body, diode body, inductor body (coil only), capacitor body, transformer (coil only), and integrated circuits.

d) Openings in the enclosure:

1) Are not to project vertically onto a horizontal plane above the product,

2) That are in the sides, are not to have a maximum minor dimension more than 1/8 inch (3.2 mm), and

3) That are in the bottom, are to be protected by a solid barrier or screen complying with 8.17 and that extends not less than 1 inch (25.4 mm) beyond the horizontal projection. A screen is to be 20 AWG (0.52 mm^2) mesh or equivalent with the maximum dimension of openings not greater than 3/32 inch (2.4 mm). A barrier is to be of metal not less than 0.014 inch (0.36 mm) thick, polymeric material having a minimum flammability classification of V-1, or wood not less than 3/8 inch (9.5 mm) thick.

60.3 Abnormal operation test

60.3.1 If the sources of power for a printed wiring assembly are not limited as described in 60.2.1, the assembly shall not produce risk of fire under both of the following conditions:

a) The short circuiting of those points of the power supply nearest the supply circuit that are not capable of delivering a power of 50 W (or more) for a period of 1 minute into an external resistor. When the condition of short circuiting results in the malfunction of a component or the rendering of a circuit inoperative, such as the biasing-off of a transistor, a condition of loading to maximum power is also to be conducted between those points.

b) The short circuiting (singly) of any rectifier, vacuum tube, transistor, or electrolytic capacitor in the circuit between the points mentioned in (a) and the supply circuit.

60.3.2 The reference to the external resistor in 60.2.1 and 60.3.1 is generally a variable resistor that can be adjusted so that the resistance equals the resistive portion of the characteristic impedance of the circuit in question, and hence, the maximum power availability can be determined. The desired setting of the external variable resistor can be found with the aid of a wattmeter or the plotting of a volt-ampere curve from several settings of the variable resistive load.

60.3.3 In conducting the test described in 60.3.1, a single layer of cheesecloth is to be loosely draped over the product as a whole, with the cloth within 1/8 inch (3.2 mm) of openings in the overall enclosure. A cord-connected product is to be placed on a white tissue paper covered softwood surface. The test is to be continued until a fire has been developed, the circuit under test burns open, or until no further change is likely to take place, but in no case for more than 7 hours. The results are unacceptable if the cheesecloth or tissue paper glows or flames.

60.4 Dielectric voltage-withstand or arcing test

60.4.1 If the sources of power for a printed wiring assembly are not limited as described in 60.2.1, the assembly shall be capable of withstanding:

a) A second dielectric voltage-withstand test as described in 60.4.2 and 60.4.3 or

b) An arcing test as described in 60.4.4.

60.4.2 For the second dielectric voltage-withstand test the printed wiring assembly is to be subjected to a direct potential of 2E + 1000 V, see 60.1.2, between parts of different potential on the assembly where electrical breakdown involves a path over the surface of insulating material. Compliance is determined by maintaining the dielectric withstand for one minute without breakdown.

60.4.3 At the option of those concerned, components need not be provided on the printed wiring boards subjected to the test outlined in 60.4.2 as it is a test of spacings on the printed foil pattern. Boards submitted for test should have been subjected to the production soldering process, however.

60.4.4 For the arcing test on the printed wiring assembly, with the complete product connected to a supply source in accordance with 44.2, and using the energy available, an arc is to be drawn over the surface of the insulating material between parts of different polarity by means of a carbon probe. The arc is to be maintained for a period of 15 minutes unless the circuit is interrupted by malfunction of a component, such as a resistor in a shorter time. If the circuit is interrupted by malfunction of a component, the test is to be repeated twice using new components for each test. Compliance is determined by discontinuation of any flaming of the material within one minute after interruption or discontinuation (15 minutes) of the test.

61 Strain Relief Test

61.1 Supply cord test

61.1.1 The strain relief means provided on an attached flexible cord, when tested in accordance with 61.1.2, shall withstand for 1 minute without displacement a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the product disconnected.

61.1.2 A 35-lb (15.9 kg) weight is to be suspended on the cord and supported by the product so that the strain-relief means will be stressed from any angle that the construction of the product permits. The 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.

61.2 Output or interconnecting cable strain relief test

61.2.1 When tested in accordance with 61.2.2, the strain relief means and an output cord or interconnecting cable shall withstand a direct pull of 20 lbf (89 N) applied to the cord, or cable, for 1 minute without displacement or breakage of the cord, or cable, or deformation of its anchoring surface.

61.2.2 The 20 lbf (89 N) force is to be applied to the cord, or cable, and supported by the product so that the strain-relief means is stressed from the most severe angle that the construction of the product permits.

62 Solenoids

62.1 A solenoid shall be investigated as part of the appliance and comply with the requirements of this Standard. In addition, it shall comply with the following:

a) A spring shall be protected against abrasion and shall be guided or arranged to reduce binding, buckling, or other interference with its free movement.

b) Protective devices may be used to interrupt the flow of current to the solenoid coil. If an integral protective device is provided, it shall be located inside the overwrap insulation of the solenoid coil.

c) Insulation between a crossover lead and the winding to which it is connected is not specified if the coil withstands the induced potential test described in 65.2.

d) A slot in a molded bobbin for guiding the crossover or start-lead – unspliced at the windings – of a magnet-coil is to be filled with an insulating material unless:

1) The slot provides a graduated spacing to the winding increasing to the end turns,

2) The magnet-coil winding withstands the induced potential test described in 65.2.

62.2 Where required in 62.1(c) and/or 62.1(d), each of three separate magnet-coil-winding samples shall withstand without breakdown an induced potential. They shall be operated under conditions representing those attained during the Normal Temperature Test. While still heated, the coil winding shall be subjected to an alternating potential of twice the rated voltage at any suitable frequency – typically 120 hertz or higher – for 7200 electrical cycles or for 60 seconds, whichever is less. The required test voltage is to be obtained by starting at one-quarter or less of the full value and increasing to the full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one-quarter or less of the maximum value, and the circuit is to be opened.

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

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

63 General Purpose Transformers

63.1 General

63.1.1 In addition to the end-product Temperature Test and Dielectric Voltage-Withstand Test, a general purpose transformer shall also be subjected to the tests of 63.2 – 63.4.

63.2 Voltage Measurement Test

63.2.1 For purposes of comparison with voltages measured as described in the Overload Test of Section 63.3, each secondary open-circuit voltage shall be measured with the primary connected to a test voltage and frequency supply source as indicated in Section 33.

63.3 Overload Test

63.3.1 A transformer shall be subjected to the test conditions described in 63.3.2. The stabilized surface or core temperature recorded on the transformer during the second 50 percent load operation shall not be more than 5°C (9°F) greater than the stabilized core temperature obtained during the initial 50-percent of load operation. The open-circuit output voltage determined following the final 50 percent load operation shall be within 2 percent of the output voltage measured during the Voltage Measurement Test in 63.2. As an option, a protective device, if provided, may be bypassed when conducting this test.

63.3.2 The transformer shall be operated as described in the Temperature Test in Section 50, except that the load shall be 50 percent of the rated value, until the core, or surface temperatures if encapsulated, stabilize. After stabilization, the load shall be adjusted until 200 percent of rated secondary current is reached. After 2 minutes of operation, the load shall be readjusted, if necessary, to restore the current to 200 percent, but no further adjustment is to be made thereafter. The duration of this overload shall be 30 minutes. The load is then to be restored to the original 50 percent of rated value. It shall be held at that value until the core temperature again stabilizes or until the temperature drops to within 5°C (9°F) of the original stabilized 50-percent load-current temperature (whichever occurs first). This temperature value shall be compared with the original 50-percent load stabilized condition, as specified in 63.3.1. Then, the secondary load shall be removed. With the primary energized, the secondary voltage (s) shall be measured and compared with the original output voltage measurements.

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

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

63.4 Repeated Dielectric Voltage-Withstand Test

63.4.1 Following the Overload Test in Section 63.3, the transformer shall be subjected to a repeated dielectric voltage-withstand test. The test potential shall be 65 percent of the value originally specified. After this test, the transformer shall perform as intended.

64 Thermoplastic motor insulation systems

64.1 General

64.1.1 Motors that employ thermoplastic materials to electrically isolate the windings and similar live parts from other live parts or noncurrent-carrying metal parts are to be subjected to the tests in 64.2 and 64.3.

Exception No. 1: A motor that functions to move air only with a direct mounted fan need not be subjected to the test in 64.3.

Exception No. 2: A double-insulated appliance is to be tested in accordance with abnormal operation and overload test on motors in the Standard for Safety for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

Exception No. 3: A motor that uses Class A insulation materials and has been subjected to the Standard for Safety for Rotating Electrical Machines – General Requirements, UL 1004-1 locked rotor cycling test need not be subjected to these tests.

Exception No. 4: A motor that complies with the Standard for Safety for Overheating Protection for Motors, UL 2111 or the Standard for Safety for Thermally Protected Motors, UL 1004-3, need not be subjected to these tests.

64.2 Abnormal conditioning

64.2.1 The motor is to be subjected to the abnormal conditioning described in 64.2.2 and shall comply with all of the following conditions:

a) The 3 ampere fuse shall remain intact; and

b) The material under test shall withstand without breakdown, the dielectric voltage-withstand potential specified in Section 51 immediately following the conditioning specified in 64.2.2 and with the 3 ampere fuse removed from the circuit.

64.2.2 The motor is to be operated with the armature locked until ultimate results have been determined or for 7 hours, whichever occurs first. Noncurrent-carrying metal parts of the motor that are insulated by the material under test are to be connected to ground through a 3-ampere, quick-acting, plug type fuse.

64.2.3 With reference to 64.2.2, when the length of the test is limited by an external factor - such as the functioning of a reliable, nonuser-serviceable device (such as a fuse or circuit breaker), or the functioning

of the maximum-size branch-circuit protective device that the equipment is likely to be connected (but not less than 30 amperes) - the test shall be terminated when the limiting device functions to open the circuit, if the device complies with the applicable component standard in Section 3, Components.

64.3 Overload-burnout conditioning

64.3.1 Thermoplastic insulating material employed in motors with a stalled-rotor current greater than twice the normal operating current shall comply with the following after the overload-burnout conditioning described in 64.3.2:

a) The 3 ampere fuse shall remain intact; and

b) The thermoplastic material under test shall comply with the dielectric voltage-withstand test described in Section 51 immediately following the overload-burnout conditioning.

64.3.2 Each of three samples of the motor is to be subjected to operation at normal load for 1 hour. Immediately following operating at normal load, the load is to be increased in steps of 10 percent of the rated current for each of four successive 1-hour periods, followed by two 1/2-hour periods, followed by eight 1/4-hour periods, followed by such additional periods of 5 minutes until the motor burns out. During the test, noncurrent-carrying metal parts of the motor that are insulated by the material under test are to be connected to ground through a 3-ampere, quick-acting fuse.

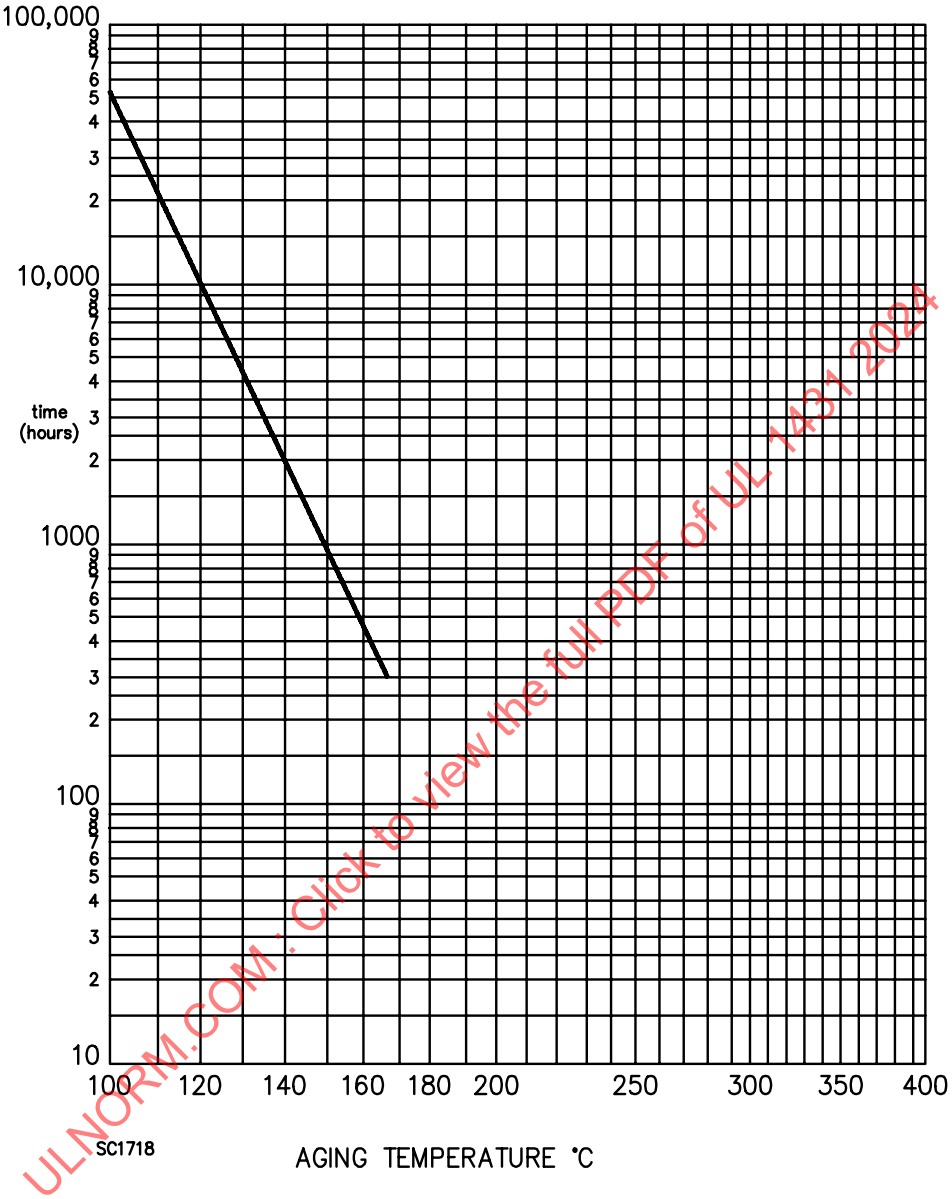
64.3.3 With reference to 64.3.2, the clearing of the circuit by an overtemperature or overcurrent protective device that complies with the applicable component standard in Section 3 is considered an acceptable end of test.

64.4 Thermal aging

64.4.1 A polymeric material employed in a Class 105 (A) motor insulation system in accordance with the Exception to 28.3.3 is to be aged for the amount of time corresponding to an aging temperature that appears on the Class 105 (A) system response shown in Figure 64.1. The motor insulation system is to cool to room temperature and the applicable dielectric voltage-withstand requirements specified in Section 51 are to be applied between live parts and noncurrent-carrying metal parts that are isolated from each other by the material under consideration.

Figure 64.1

Class 105 (A) system response



MANUFACTURING AND PRODUCTION TESTS

65 Dielectric Voltage-Withstand Test

65.1 Each product shall withstand without an indication of unacceptable performance, as a routine production-line test, the application of a 40 – 70 Hz potential between:

a) The primary wiring, including connected components, and accessible dead metal parts that are likely to become energized, and

b) Between primary and accessible low voltage (42.4 V peak or less) metal parts, including terminals, and

c) Between the primary wiring, including components, and metal foil wrapped around a polymeric enclosure. For a definition of unacceptable performance see 65.8(d).

65.2 The production-line test shall be in accordance with either condition A or condition B of Table 65.1.

Table 65.1
Production-line test conditions

Product rating and form	Condition A		Condition B	
	Potential volts	Time – seconds	Potential volts	Time – seconds
105 – 130V with or without a motor rated 1/2 hp (373 W) or less and not applied to or contacted by persons in normal use.	1000	60	1200	1
105 – 130V and applied to or contacted by persons in the intended use or with a motor rated more than 1/2 hp (373 W)	1000 + 2V[a]	60	1200 + 2.4V[a]	1
210 – 600V	1000 + 2V[b]	60	1200 + 2.4V[b]	1
Patient connected circuits (regardless or voltage rating)[c]	2500	60	3000	1

[a] Maximum marked voltage, but not less than 120 V.

[b] Maximum marked voltage but not less than 240 V.

[c] Applied between primary circuits and patient connections only.

65.3 The product may be in a heated or unheated condition for the test.

65.4 The test shall be conducted when the product is complete (fully assembled). It is not intended that the product be unwired, modified or disassembled for the test.

Exception No. 1: Parts such as snap covers or friction-fit knobs that would interfere with performance of the test need not be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed product.

65.5 When the product employs a solid-state component that is not relied upon to reduce the risk of an electric shock and that can be damaged by the dielectric potential, the test may be conducted before the component is electrically connected provided that a random sampling of each day's production is to be tested at the potential specified in Table 65.1. The circuitry may be rearranged for the purpose of the test

to minimize the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

65.6 The test equipment, when adjusted for production-line testing, is to produce an output voltage that is not less than the factory test value specified, nor is the magnitude of the test voltage to be greater than 120 percent of the specified test potential when the tester is used in each of the following conditions:

a) If the test duration is 1 second, the output voltage is to be maintained within the specified range,

1) When only a voltmeter having an input impedance of at least 2 megohms and a specimen of the product being tested are connected to the output terminals, and

2) When a relatively high resistance is connected in parallel with the voltmeter and the product being tested, and the value of the resistance is gradually reduced to the point where an indication of unacceptable performance just occurs.

b) If the test duration is 1 minute, the output voltage is to be maintained within the specified range, by manual or automatic means, throughout the 1 minute duration of the test or until there is an indication of unacceptable performance.

65.7 The specified control of the applied voltage, manual or automatic, shall be maintained under conditions of varying line voltage. Higher test potentials may be used if the higher dielectric stress is not likely to adversely affect the insulating system of the product.

65.8 In addition to the characteristics indicated in 65.6, the test equipment is to have the following features and characteristics:

a) A means of indicating the test voltage that is being applied to the product under test. This may be accomplished by sensing the voltage at the test leads or by an equivalent means.

b) An output voltage that:

1) Has a sinusoidal waveform,

2) Has a frequency that is within the range of 40 – 70 Hz, and

3) Has a peak value of the waveform that is not to be less than 1.3 and not more than 1.5 times the root-mean-square value.

c) A means of effectively indicating unacceptable performance. The indication is to be:

1) Auditory if it can be readily heard above the background noise level,

2) Visual if it commands the attention of the operator, or

3) A device that automatically rejects an unacceptable product. If the indication of unacceptable performance is auditory or visual, the indication is to remain active and conspicuous until the test equipment is reset manually.

d) When the test equipment is adjusted to produce the test voltage and a resistance of 120,000 ohms is connected across the output, the test equipment is to indicate an unacceptable performance within 0.5 second. A resistance of more than 120,000 ohms may be used to produce an indication of unacceptable performance, if the manufacturer elects to use a tester having higher sensitivity.

65.9 There is not to be any transient voltage applied to the appliance under test that results in the instantaneous voltage applied to the product exceeding 120 percent of the peak value of the test voltage

that the manufacturer elects to use for this test. This requirement applies for the entire duration of the test, including the time that the voltage is first applied to the product and the time that the voltage is removed from the product.

65.10 During the test, a sufficient number of primary switching components shall be in the on position so that all primary circuitry will be stressed. Both sides of the primary circuit of the product are to be connected to one terminal of the test equipment. The second test equipment terminal is to be connected to accessible dead metal.

66 Grounding Continuity Test

66.1 Each product that has a power supply cord having a grounding conductor shall be tested, as a routine production line test, to determine grounding continuity between the grounding blade of the attachment plug and the accessible dead metal parts of the product that are likely to become energized.

66.2 Only a single test need be made if the accessible metal selected is conductively connected by construction to all other accessible metal.

66.3 Any effective indicating device – an ohmmeter, a battery and buzzer combination, or the like – may be used to determine compliance with the grounding continuity requirement in 66.1.

RATINGS

67 Details

67.1 A product shall be rated:

a) In amperes or watts,

b) In volts, and

c) For alternating current only or direct current only.

The rating shall include the frequency if needed for a motor, relay coil or other component.

67.2 The current rating of a product shall include 15 A for a single receptacle provided as part of the product and intended for use as a general use outlet, 20 A for two or more receptacles, including a single duplex receptacle, or, if the outlet is marked as noted in 68.1.5, that marked rating shall be included in the current rating of the product.

MARKINGS

68 Details

68.1 General

68.1.1 A product shall have a plain and legible marking. The marking shall be readily visible after installation in the case of a permanently-connected product. The marking shall include:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified,

b) The day or other dating period of manufacture not exceeding any three consecutive months,

c) The catalog number or the equivalent, and

d) The electrical rating.

Exception No. 1: The date of manufacture may be abbreviated in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

Exception No. 2: The marking may be located where visible behind a cover that is movable without the use of a tool. If the cover is removable the marking shall be on other than the cover.

68.1.2 The repetition time cycle of a date code shall be not less than 10 years. The date code shall not require reference to the manufacturer's records to determine when the product was manufactured.

68.1.3 A "CAUTION", "WARNING", or "DANGER" marking shall be:

a) Paint-stenciled, die-stamped, molded, or indelibly stamped,

b) In the form of pressure-sensitive labels, or

c) In a form that has been determined to be the equivalent.

A pressure-sensitive label, if used, shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969.

68.1.4 Block lettering shall be used for the marked word "CAUTION", "WARNING", or "DANGER".

68.1.5 A product provided with general use receptacles intended for limited current loads shall have each such receptacle permanently marked "___amperes, maximum, ___watts, maximum", or equivalent, adjacent to the receptacle.

68.1.6 If a manufacturer produces or assembles products at more than one factory, each product shall have a distinctive marking, that may be in code, by which it may be identified as the product of a particular factory.

68.1.7 Equipment that complies with the Standard for Double Insulation Systems for use in Electrical Equipment, UL 1097, shall be permanently marked with the words "Double Insulation – When servicing, use only identical replacement parts." The words "Double-Insulated" may be used instead of "Double Insulation" in the marking.

68.1.8 The double-insulation symbol (a square within a square) may be used in addition to but not in place of the words "Double Insulation".

68.2 Permanently-connected products

68.2.1 If any point within a terminal box or wiring compartment of a permanently-connected product in which the power-supply conductors are intended to be connected, including such conductors themselves, attains a temperature of more than 60°C (140°F) during the temperature test, the product shall be permanently marked "For supply connection, use wires acceptable for at least ... C (... F)," or with an equivalent statement, and the temperature value shall be in accordance with Table 68.1. This statement shall be located at or near the point where the supply connections are to be made, and shall be clearly visible both during and after installation of the product.

Table 68.1
Outlet-box marking

Temperature attained during test in terminal box or compartment	Temperature marking
61 – 75°C (142 – 167°F)	75°C (167°F)
76 – 90°C (168 – 194°F)	90°C (194°F)

69 Servicing

69.1 The extent of user or operator servicing is defined in 2.24. To deter attempts at further servicing of the product by unqualified personnel that will result in the exposure of live parts, a caution notice shall be provided on the product where readily visible during any approach to attempt servicing. The marking shall consist of the word "CAUTION" and the following wording or equivalent – "Risk of electric shock, do not remove cover (or back). Refer servicing to qualified service personnel".

70 Fuse Replacement

70.1 There shall be a legible and durable marking for each fuse used to meet the requirements in this standard indicating the ampere rating (and voltage if more than 125 V) of the fuse to be used for replacement. The marking is to be located so that it is obvious to which fuse or fuseholder the marking applies. In addition, the word "WARNING" and the following or the equivalent shall be provided – "For continued protection against risk of fire, replace only with same type and rating of fuse".

71 Oxygen

71.1 Oxygen enrichment or oxygen-administering equipment shall be marked "WARNING" – and the following wording or equivalent, "RISK OF FIRE – Keep matches, lighted cigarettes, and all other sources of ignition out of the room in which the product is located. Textiles, oils, and other combustibles are easily ignited and burn with great intensity in air enriched with oxygen. " The letter height shall not be less than 7/64 inch (2.8 mm) for the word "WARNING" and the first sentence of the above notice, and not less than 3/32 inch (2.4 mm) for the remainder of the notice.

71.2 Additional statements relating to the use of oxygen (see 73.1) shall be contained in the operating instructions accompanying each product.

USE AND CARE INSTRUCTIONS

72 General

72.1 A product shall be provided with a user instruction manual that warns the operator of reasonably foreseeable uses or misuses so as to reduce the risk of fire, electric shock, and injury to persons:

a) The instructions shall be legible and contrast with the background. Upper case letters in the instructions shall be not less than 5/64 inch (2.0 mm) high, and lower case letters shall be not less than 1/16 inch (1.6 mm) high. The heading "IMPORTANT SAFEGUARDS" and "SAVE THESE INSTRUCTIONS" shall be in letters at least 3/16 inch high. "READ ALL INSTRUCTIONS BEFORE USING" and "DANGER" shall be in letters at least 5/64 inch (2.0 mm) high, but less than 3/16 inch (4.8 mm) high.

b) The instructions shall:

1) Be in the first part of the manual,

2) Be before the operating instructions,

3) Be separate in format from other detailed instructions related to assembly, operation and maintenance, and

4) Be a permanent part of the manual.

72.2 The manual shall include the instructions specified in 73.1 and the appropriate instructions in 73.3 and in User Instructions, Section 74 and Grounding Instructions, Section 75.

72.3 The instruction manual shall include instructions or illustrations to identify important parts of the product. Illustrations may be used with a required written instruction to clarify its intent, but shall not be used in place of a required written instruction.

72.4 Unless otherwise indicated, the instructions shall be in the exact words specified or shall be in equally definitive terminology.

Exception: Specified wording that is not appropriate for a product or part being judged may be omitted, or may be changed as found to be necessary for that product or part.

72.5 Wording in parentheses in Sections 72 – 78 is explanatory, indicating options, alternatives, or cross-references. Wherever the words "the (or this) product" are used, the name of the specific product may be substituted in the final text.

72.6 The items may be numbered. In the list of items the first shall be "READ ALL INSTRUCTIONS BEFORE USING THE APPLIANCE", and the last shall be "SAVE THESE INSTRUCTIONS". Other important and precautionary items considered appropriate by the organization responsible for the product may be inserted.

73 Warning Instructions

73.1 User instructions may be numbered. "READ ALL INSTRUCTIONS BEFORE USING" shall precede the list of items following the word "DANGER," and "SAVE THESE INSTRUCTIONS" shall be last. The sequence of the instructions of 73.1 under the word "DANGER" should follow the expected sequence of user exposure to the situation during use of the product such as to address the most important item first, and, in descending order, the remaining instructions. The other items in 73.3 should follow in the stipulated sequence. Other instructions pertaining to the risk of fire, electric shock, or injury to persons that the organization responsible for the product considers to be needed may be included.

IMPORTANT SAFEGUARDS

When using electrical products, especially when children are present, basic safety precautions should always be followed, including the following:

READ ALL INSTRUCTIONS BEFORE USING

DANGER– To reduce the risk of electrocution:

1. Always unplug this product immediately after using.

Exception: Battery chargers while recharging batteries and permanently connected products such as toilet seat assemblies.

2. Do not use while bathing.

Exception: Hydromassage units and similar products.

3. Do not place or store product where it can fall or be pulled into a tub or sink.

4. Do not place in or drop into water or other liquid.

5. Do not reach for a product that has fallen into water. Unplug immediately.

WARNING – To reduce the risk of burns, electrocution, fire, or injury to persons.

1. A product should never be left unattended when plugged in.

Exception: Contact lens disinfectors, toilet seat assemblies, and similar products.

2. Close supervision is necessary when this product is used by, on, or near children or invalids.

3. Use this product only for its intended use as described in this manual. Do not use attachments not recommended by the manufacturer.

4. Never operate this product if it has a damaged cord or plug, if it is not working properly, if it has been dropped or damaged, or dropped into water. Return the product to a service center for examination and repair.

5. Keep the cord away from heated surfaces.

6. Never block the air openings of the product or place it on a soft surface, such as a bed or couch, where the air openings may be blocked. Keep the air openings free of lint, hair, and the like.

7. Never use while sleeping or drowsy.

Exception: Alternating pressure point pad control units and the like.

8. Never drop or insert any object into any opening or hose.

9. Do not use outdoors or operate where aerosol (spray) products are being used or where oxygen is being administered.

Exception: Oxygen therapy equipment.

10. Connect this product to a properly grounded outlet only. See Grounding Instructions.

Exception: A cord-connected product that is not provided with a means for grounding or a product intended for permanent connection.

11. Unplug this product before filling. Fill (reservoir) with water only unless otherwise specified by manufacturer. Do not overfill (or specify filling instructions).

Exception: The instructions for a product with a separable water reservoir need only include "Fill reservoir with water only unless otherwise specified by manufacturer."

SAVE THESE INSTRUCTIONS

73.2 Instructions in addition to those specified in 73.1 are not required unless specifically indicated.

73.3 As applicable, the following instructions shall be included in addition to the instructions in 73.1:

For oxygen therapy equipment:

12. The use of oxygen in therapy requires that special care be taken to reduce the risk of fire. Any materials which will burn in air and some that will not are easily ignited and burn rapidly in high concentrations of oxygen. Accordingly, for safety it is necessary that all sources of ignition be kept away from the product and preferably out of the room in which it is being used. "NO SMOKING" signs should be prominently displayed.

13. A spontaneous and violent ignition may occur if oil, grease or greasy substances come in contact with oxygen under pressure. These substances must be kept away from oxygen regulators, cylinder valves, tubing and connections, and all other oxygen equipment.

74 User Instructions

74.1 Immediately following the warning instructions specified in 73.1 and the appropriate specific instructions in 73.3, the instruction manual shall include the following:

a) Instructions and caution statements for cleaning, user maintenance, operations recommended by the manufacturer, such as lubrication or nonlubrication, and a warning to the user that any other servicing should be performed by an authorized service representative or that the product has no user serviceable parts. The manual or other literature packaged with the product shall also indicate the product is for household use.

b) In the case of a product employing an automatically reset thermal limiter, that shuts off the entire product, instructions to the user on what to expect in the event the thermal limiter operates.

c) Specific instructions for the proper method of cord storage, total product storage, and the like when the product is not in use; and for cord care while in use, such as for hand supported products, untwisting, and the like.

d) In the case of a product intended to be used with water, additives, conditioners, or other solutions with or without water, or a product that relies on the conductivity of water for normal operation (electrode type product), and for which the use of baking soda, salt, or other substances to improve the conductivity of the water is stipulated, specific instructions on the proper liquid or additive to use and the exact amount to be used in conjunction with the product.

e) In the case of a dual voltage product with a voltage selector switch, instructions to the user on how to change the voltage selector switch setting and proper adaptors to be employed.

75 Grounding Instructions

75.1 The instruction manual shall include those instructions in (a) – (e) applicable to the product. The word "**DANGER**" shall be entirely in block letters.

a) For all grounded, cord connected products:

GROUNDING INSTRUCTIONS

This product should be grounded. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for the electric current. This product is equipped with a cord having a grounding wire with a grounding plug. The plug must be plugged into an outlet that is properly installed and grounded.

DANGER– Improper use of the grounding plug can result in a risk of electric shock.

If repair or replacement of the cord or plug is necessary, do not connect the grounding wire to either flat blade terminal. The wire with insulation having an outer surface that is green with or without yellow stripes is the grounding wire.

Check with a qualified electrician or serviceman if the grounding instructions are not completely understood, or if in doubt as to whether the product is properly grounded.

b) For a grounded, cord connected product rated 15 A or less and intended for use on a nominal 120 V supply circuit:

This product is for use on a nominal 120 V circuit, and has a grounding plug that looks like the plug illustrated in sketch A in Figure 75.1. A temporary adapter, which looks like the adapter illustrated in sketches B and C, may be used to connect this plug to a 2-pole receptacle as shown in sketch B if a properly grounded outlet is not available. The temporary adapter should be used only until a properly grounded outlet (sketch A) can be installed by a qualified electrician. The green colored rigid ear, lug, and the like extending from the adapter must be connected to a permanent ground such as a properly grounded outlet box cover. Whenever the adapter is used, it must be held in place by the screw.

c) For all other grounded, cord connected products:

This product is factory equipped with a specific electric cord and plug to permit connection to a proper electric circuit. Make sure that the product is connected to an outlet having the same configuration as the plug. No adapter should be used with this product. Do not modify the plug provided — if it will not fit the outlet, have the proper outlet installed by a qualified electrician. If the product must be reconnected for use on a different type of electric circuit, the reconnection should be made by qualified service personnel.

d) Extension Cords:

If it is necessary to use an extension cord, use only a three wire extension cord that has a three-blade grounding plug, and a three-slot receptacle that will accept the plug on the product. Replace or repair a damaged cord.

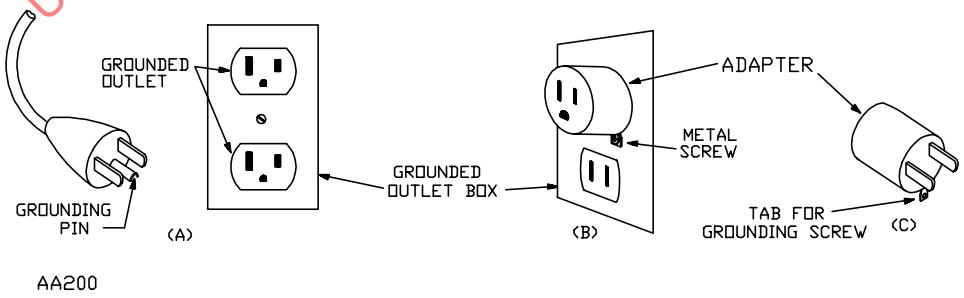
e) For a permanently connected product:

GROUNDING INSTRUCTIONS

This product should be connected to a grounded, metallic, permanent wiring system, or an equipment-grounding conductor should be run with the circuit conductors and connected to the equipment grounding terminal or lead on the product.

Figure 75.1

Grounding methods



76 Two-Wire Polarized Attachment Plug Instructions

76.1 For an appliance required to have a polarized plug, the following instructions shall be provided: “This appliance has a polarized plug (one blade is wider than the other). As a safety feature, this plug will fit in a polarized outlet only one way. If the plug does not fit fully in the outlet, reverse the plug. If it still does not fit, contact a qualified electrician. Do not attempt to defeat this safety feature.”

HYDROMASSAGE UNITS

77 General

77.1 The requirements in Sections 78 – 80 supplement and, in some cases, modify the general requirements in Sections 6 – 76.

78 Construction

78.1 General

78.1.1 A hydromassage unit shall not have provision for connection to the household plumbing system.

78.1.2 A hydromassage unit shall be provided with a "non-detachable", Type SJE, SJT, or SJO or heavier power supply cord that is a minimum of 10 feet (3.0 m) in length.

Exception: For a floor mounted air blower type air hydromassager the power supply cord can be type SPT-2, NISPT-2, SVT or the equivalent.

78.1.3 A grounding conductor provided as a part of the power supply cord described in 78.1.2 shall be connected to inaccessible dead metal parts. See 8.10 – 8.12.

78.1.4 Any dead-metal part that is likely to become energized shall be inaccessible to contact by the user. See 8.10 – 8.12.

78.1.5 The construction of hydromassage units shall be such that all electrical components are located outside the bathtub confines after mounting.

78.1.6 The center of balance shall be such that the product would not fall into the tub if the securing means were loosened.

78.1.7 A hydromassage unit shall be constructed so that water does not contact live parts, wiring, or inaccessible dead metal parts that are likely to become energized under each of the conditions (a) – (c) outlined below:

a) The unit is to be placed in its operating position on a tub filled with a saline solution of 1/2 gram of common table salt per liter of distilled water to a level just below overflow, and the motor operated so as to cause a surging action of the water,

b) The unit is to be splashed with one pint (473 ml) of the saline solution described above, expelled from an open beaker, onto the top and any side of the unit, and

c) The unit is to be placed in an overturned position, after being removed from a tub filled with the saline solution.

78.1.8 Under each of the conditions stated in 78.1.7 (a) – (c), a hydromassage unit shall comply with the applicable requirements for the Dielectric Voltage-Withstand Test (Section 51) and the Leakage Current Test (Section 46).

78.2 Cord-Connected Hydromassage Unit Immersion Protection

78.2.1 A cord-connected hydromassage unit shall be constructed to reduce the risk of electric shock when the appliance is energized, with its power switch in either the "on" or "off" position, and immersed in water having an electrically conductive path to ground.

78.2.2 Compliance with 78.2.1 may be accomplished with the use of an:

a) Integral ground-fault circuit-interrupter (GFCI), or

b) Integral protective device of another type, such as an ALCI (Appliance Leakage-Current Interrupter), that de-energizes all current-carrying parts (hereafter referred to as a protective device) when the free-standing hydromassage unit is immersed in water having an electrically conductive path to ground.

78.2.3 If a free-standing hydromassage unit is provided with a GFCI, the GFCI shall comply with the requirements for Class A cord-connected GFCIs in the Standard for Ground-Fault Circuit-Interrupters, UL 943.

78.2.4 *Deleted*

78.2.5 If a hydromassage unit is provided with a protective device other than a GFCI, the protective device shall be investigated and determined to be acceptable for the application. Investigation of the protective device shall include, but need not be limited to, consideration of:

a) Electrical rating,

b) Operating temperatures,

c) Reliability of operation,

d) Resistance to the effects of abnormal operating conditions,

e) Resistance to mechanical abuse,

f) Resistance to electrical transients, and

g) Resistance to moisture.

Exception: A protective device is deemed acceptable for the application if it complies with the requirements for Class A cord-connected GFCIs in the Standard for Ground-Fault Circuit-Interrupters, UL 943, except that it is not required to:

a) Have a grounding conductor;

b) Have the same type of power supply cord;

c) Comply with the high-resistance ground-fault test under the condition that any power conductor is open-circuited; or

d) Provide grounded neutral protection by compliance with the High-Resistance Ground Faults Test, under the test condition that the neutral conductor is grounded at a point in the load circuit.

78.2.6 A GFCI or other protective device shall be integral with the attachment plug of the power-supply cord of the hydromassage unit.

78.2.7 A user-resettable protective device shall incorporate a supervisory circuit as described in the Standard for Ground-Fault Circuit-Interrupters, UL 943, for GFCIs.

Exception: A user-resettable protective device may be provided with a reset feature not having a test function based on all of the following:

a) The protective device complies with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. If the computational investigation is conducted, the maximum predicted failure rate (λp) shall not exceed 1.5 failures per million hours predicted. If the demonstrated method is conducted, the test acceleration multiplier shall be 5763.

b) The instructions provided with the appliance alert the user to the reset feature and how and when to use it.

c) The instructions provided with the appliance alert the user to not reset and reuse the appliance should the protective device trip as a result of immersion.

78.2.8 A switch included for testing a user resettable protective device shall be permanently marked "Test" and "Reset" on or adjacent to the switch actuators.

78.2.9 After a protective device de-energizes current-carrying parts, it shall not automatically reset.

78.3 Immersion-Detection Circuit Interrupters (IDCIs)

78.3.1 *Deleted*

78.3.2 *Deleted*

78.3.3 *Deleted*

78.3.4 *Deleted*

78.3.5 *Deleted*

78.3.6 *Deleted*

78.3.7 *Deleted*

78.3.8 *Deleted*

78.3.9 *Deleted*

78.3.10 *Deleted*

79 Performance

79.1 Stability test – all types

79.1.1 In addition to the stability tests conducted in 38.1 – 38.3, a hydromassage unit that is intended to be mounted on a tub shall not fall as a result of the following conditions:

a) The hydromassage unit is to be mounted on a tub, its securing means loosened and the unit oriented in the most unfavorable position permitted by its configuration. While in this condition, the motor of the unit is to be started and permitted to run for not more than five minutes.

b) The hydromassage unit is to be mounted on the edge of a 1 inch (25.4 mm) thick plywood board, and a 50 lbf (222 N) is to be applied for 1 minute to any part of the top of the unit. The force is to be applied by means of a 1/2 inch (12.7 mm) diameter rod, the end of which is rounded to a 1/2 inch hemisphere.

79.2 Siphoning and back flow test – air blower type

79.2.1 A hydromassage unit of the air blower type is to be placed on the floor or in any position recommended by the manufacturer (See User Instructions, Section 74), and operated for 5 cycles, each cycle consisting of a minimum of 15 seconds on and 15 seconds off, under all of the following conditions:

a) Hoses and any other parts that are capable of being displaced so as to contact the water are to be placed in a tub that is filled with a saline solution consisting of 1/2 gram of common table salt per liter of distilled water,

b) Any check valve that is provided as part of the unit is to be rendered inoperative, and

c) Any control knob that can be removed without the use of a tool is to be removed.

Upon completion of the fifth cycle, the hoses and any other parts that were in contact with the saline solution are to be removed from the solution and held above the pump. Immediately following, and while still wet from this procedure, the unit is to meet the requirements for Leakage Current (Section 46) and Dielectric Voltage-Withstand (Section 51) Tests.

79.3 Exposure to water test

79.3.1 The leakage current from a hydromassage unit shall not exceed 5 mA at any time during the 1 hour that it is continuously being monitored while immersed in water having a resistivity of 200 or 20,000 ohm-centimeters – whichever resistance provides the more adverse condition for the product tested – and energized under the conditions outlined in 79.3.2 – 79.3.4.

Exception No. 1: A hydromassage unit that employs a GFCI or other type circuit interrupter need not comply with the 5 mA limit when it has been tested and shown that the device interrupts the supply circuit in compliance with the "time vs. current" requirements for Class A units (GFCI) outlined in the Standard for Ground-Fault Circuit-Interrupters, UL 943, when measured with respect to the conductive metal tub.

Exception No. 2: A cord connected hydromassage unit that is to be installed over the side of a tub such that the electrical parts are located in the section outside of and along the outer wall of the tub is not subject to this requirement.

79.3.2 With any combination of the hydromassage unit's operating switches in the "on" position, the unit is to be placed in a tub having a metal conductive surface and filled with water (200 or 20,000 ohm-centimeters resistivity) to a depth that permits the unit to be completely submerged below the surface of the water while lying in contact with the bottom of the tub. The power supply cord is to be immersed in the water so that 12 inches, measured from the face of the plug, protrudes from the surface of the water. The test is to be conducted with the hydromassage unit oriented in any position permitted by its configuration.

79.3.3 With the hydromassage unit energized from a supply circuit as described in 44.2, the leakage current on the metal tub is to be continuously monitored through a 500 ohm non-inductive resistor in parallel with an 0.45 microfarad capacitor connected between the grounded side of the power supply