



UL 979

STANDARD FOR SAFETY

Water Treatment Appliances

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UL Standard for Safety for Water Treatment Appliances, UL 979

Second Edition, Dated September 29, 2016

Summary of Topics

This revision of UL 979 includes the addition of requirements for button or coin cell batteries of lithium technologies.

The new requirements are substantially in accordance with Proposal(s) on this subject dated October 3, 2016.

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

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UL 979

Standard for Water Treatment Appliances

First Edition – May, 2005

Second Edition

September 29, 2016

This UL Standard for Safety consists of the Second Edition including revisions through December 2, 2016.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated water treatment appliances for household and commercial use. These appliances are intended for installation and use in accordance with the National Electrical Code, NFPA 70, and are rated 600 V or less.

1.2 These requirements cover appliances utilizing features that treat water through the use of cation exchange water softeners, ionization, filters, ultraviolet radiation, ozone generation, and reverse osmosis.

1.3 These requirements do not cover water treatment appliances for use with pools or spas, water distillers, aquariums, or other equipment connected to plumbing that is covered by individual requirements.

1.4 These requirements do not cover appliances for use in hazardous locations as defined in the National Electrical Code, NFPA 70.

1.5 These requirements do not cover the aesthetic effects or the effectiveness of water treatment.

2 Glossary

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

2.2 APPLIANCE – A collective term to designate all products covered by this Standard.

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, PERMANENTLY-CONNECTED – An appliance intended to be permanently connected electrically.

2.6 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.

2.7 APPLIANCE, PORTABLE – An appliance with the following characteristics:

- a) The appliance is cord- and plug-connected;
- b) The operating literature and installation instructions illustrate connecting the water lines to the output of a sink-type faucet. The connection to the sink-type faucet does not require tools, or the appliance is provided with its own water container;
- c) The operating literature and installation instructions do not portray placing the appliance under the cabinet or a dedicated space, and they only illustrate placing the appliance on a counter top near the sink; and
- d) The appliance has feet or keyhole slots and does not have non-keyhole slots or other more permanent mounting means.

2.8 APPLIANCE, STATIONARY – An appliance connected to plumbing and not expected to be moved except during servicing or storage. A stationary appliance may have wheels or casters.

2.9 BARRIER – A partition for the insulation or isolation of electric circuits, for the isolation of electric arcs, or for isolation of moving parts or hot surfaces. In this respect, a barrier may serve as a portion of an enclosure or as a functional part.

2.10 CAPACITOR, CLASS X – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor or RC unit would not lead to danger of electrical shock but could result in a risk of fire. Examples would be units connected phase to phase or phase to neutral.

Notes:

1) X1 capacitors are generally used in circuits of permanently connected appliances. However, if the appliance is provided with a separate surge protective device that limits the impulse voltage to $\leq 2.5\text{KV}$, an X2 capacitor is permitted.

2) X2 capacitors are generally used in circuits of cord-connected appliances.

2.11 CAPACITOR, CLASS Y – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock. Examples would be capacitors connected across the primary and secondary circuits where electrical isolation is required to prevent an electric shock or between hazardous live parts and accessible parts.

Notes:

1) Y1 capacitors are used in circuits where the prevention of electric shock is afforded solely by the isolation provided by the capacitor. Two Y2 capacitors connected in series is considered to provide the same level of protection as one Y1 capacitor.

2) Y2 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages $\geq 150\text{V}$ and $\leq 300\text{V}$.

3) Y4 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages $\leq 150\text{V}$.

2.12 CIRCUIT, HIGH-VOLTAGE – A circuit involving a potential of more than 600 V.

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

2.14 CIRCUIT, LOW-VOLTAGE – A circuit involving a peak open-circuit potential of not more than 42.4 V supplied by a primary battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that as a unit, complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

2.15 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.

2.16 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.

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

2.18 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.

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

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

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

2.22 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.

2.23 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.

2.24 DANGEROUS MALFUNCTION – Unintended operation of the appliance that may impair safety. Operating Control functions whose failure would result in a Dangerous Malfunction would be considered Safety Critical Functions. See 29.5.

Note – Control functions whose failure might result in a Dangerous Malfunction would include:

- a) Unexpected operation of the appliance where the operation would result in risk of electric shock, fire or mechanical hazard.
- b) Unattended energization of a heating appliance where the user has placed flammable materials near the appliance based on the assumption the appliance would remain off.

2.25 ENCLOSURE – A part that by itself or in conjunction with barriers:

- a) Renders inaccessible all or any parts that may otherwise present a risk of electric shock;
- b) Reduces the risk of contact with parts that may cause injury to persons; or
- c) Prevents propagation of flame due to electrical disturbances occurring within. A cabinet that serves to enclose electrical components or wiring is considered to be an enclosure.

2.26 FIELD WIRING TERMINAL – A terminal to which a supply or other wire can be connected by an installer in the field.

2.27 MAXIMUM WORKING PRESSURE – The maximum operating pressure recommended by the manufacturer.

2.28 MOTOR, ACCESSIBLE – A motor that may be contacted without opening or removing any part and that is located so as to be accessible to contact.

2.29 MOTOR, INACCESSIBLE – A motor that is accessible only by opening or removing a part of the outer enclosure, such as a panel or service door, which can be removed without the use of tools, or a motor that is located in such a position or is otherwise guarded or enclosed so that it is unlikely to be contacted.

2.30 OPPOSITE POLARITY – A difference of potential between two points, where shorting of these two points would result in a condition involving overload, rupturing of printed wiring-board tracks, components or fuses, and similar components.

2.31 PRESSURE-RELIEF DEVICE – A pressure-actuated valve or rupture member designed to relieve excessive pressures automatically.

2.32 PRESSURE VESSEL – A component of the system intended to hold water under pressure higher than atmospheric pressure.

2.33 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist within a circuit unless the circuit meets one of the following criteria. The circuit shall be supplied by an isolating source such that the following items are met:

- a) The following voltage limits shall be met:
 - 1) The voltage does not exceed 30 V rms;
 - 2) The voltage does not exceed 42.4 V peak;
 - 3) The voltage does not exceed 60 V dc continuous; or
 - 4) The voltage does not exceed 24.8 V peak for DC interrupted at a rate of 200 Hz or less with approximately 50 percent duty cycle.
- b) When protective impedance is used, the current available through a 1500 ohm resistor between the part or parts and either pole of the supply source does not exceed 0.7 mA peak or 2 mA DC:

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1) For frequencies exceeding 1 kHz, the limit of 0.7 mA (peak value) is multiplied by the value of the frequency in kHz but shall not exceed 70 mA peak;

2) For voltages over 42.4 V peak and up to and including 450 V (peak value) the capacitance shall not exceed 0.1 μ F.

2.34 SAFETY CRITICAL FUNCTION (SCF) – Control, protection and monitoring functions which are being relied upon to reduce the risk of fire, electric shock or casualty hazards.

2.35 USER SERVICING – Any form of servicing that can be performed by personnel other than those who are trained to maintain the particular appliance. Some examples of user servicing are:

- a) Attaching accessories by means of attachment plugs and receptacles or by means of other separable connectors;
- b) Replacing lamps and fuses and resetting circuit breakers located in an operator-access area unless the lamps, fuses, or circuit breakers are marked to indicate replacement or resetting only by qualified service personnel;
- c) Making routine operating adjustments necessary to adapt the appliances for its different intended functions; and
- d) Any operation described or implied in the operator's manual, whether or not tools are required.

2.36 VOLTAGE FOLDBACK – A circuit design feature intended to protect the power supply output transistors. When overcurrent is drawn by the load, the supply reduces the output voltage and current to within the safe power dissipation limit of the output transistors.

2.37 WORKING VOLTAGE – The highest voltage to which the insulation or the component under consideration is, or can be, subjected when the equipment is operating under conditions of normal use. Overvoltages that originate outside the equipment are not taken into account.

3 Safety Critical Functions

3.1 Any function involved in the control, protection, and monitoring of safety-related attributes of a unit whereby a loss/malfunction of its functionality would represent an unacceptable risk of fire, electric shock, or casualty hazards would be considered a Safety Critical Function.

3.2 Electronic circuits that manage a Safety Critical Function (SCF) shall be:

- a) Reliable as defined as being able to maintain the SCF in the event of single defined component faults; and
- b) Not susceptible to electromagnetic environmental stresses encountered in the anticipated environments of the appliance.

3.3 Functions specified in the table represent the common safety critical circuit functions of typical water treatment units. It is not intended to represent all possible Safety Critical Functions.

Table 3.1
Safety Critical Functions

Function ^a	Hazard	Location of parameters and tests
Motor running overload protection	Risk of fire or electric shock	33.3
Motor locked rotor protection	Risk of fire or electric shock	33.3
Motor short circuit protection	Risk of fire or electric shock	33.3
^a Functions specified in the table represent the common safety critical circuit functions of water treatment equipment. It is not intended to represent all possible safety critical functions. Any function involved in the control, protection, and monitoring of safety-related attributes of a pump whereby a loss/malfunction of its functionality would represent an unacceptable risk of fire, electric shock, or casualty hazards would be considered a Safety Critical Function.		

4 Units of Measurement

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

5 Undated 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.

CONSTRUCTION

6 Components

6.1 General

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

- a) Comply with the requirements for that component as indicated in 6.2 – 6.26;
- b) Be used in accordance with its rating(s) established for the intended conditions of use;
- c) Be used within its established use limitations or conditions of acceptability; and
- d) Additionally comply with the applicable requirements of this end product standard.

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

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

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

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

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

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

6.1.3 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in 6.2 – 6.26, and that involves a risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 6.1.1 (b) – (d).

6.1.4 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 the requirements of this end product standard.

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

6.2 Attachment plugs, receptacles, connectors, and terminals

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

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

Exception No. 2: A fabricated pin terminal assembly need not comply with the Standard for Attachment Plugs and Receptacles, UL 498 if it complies with Accessibility, Section 9; Mechanical Assembly, Section 12; Live Parts, Section 16; Electrical Insulation, Section 17; Spacings, Section 21, of this end product standard; and the applicable performance requirements when tested in the end product.

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

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

Exception No. 2: A connector that complies with UL 310 may be used with an appropriately sized tab that complies with Tabs Used in Electrical Quick-Connect Terminals, Section 19. The connector is the part of a quick-connect terminal that is pushed onto the male tab, and the tab is the part that receives the female connector.

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

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

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

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

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

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

Exception: A fabricated part performing the function of a terminal block need not comply with the Standard for Terminal Blocks, UL 1059 if the part complies with the requirements of Wiring Terminals and Leads, 14.3; Live Parts, Section 16; Electrical Insulation, Section 17; and Spacings, Section 21, of this end product standard; and the applicable performance requirements when tested in the end product. This exception does not apply to protective conductor terminal blocks.

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

6.3 Batteries and battery chargers

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

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

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

6.3.4 Primary batteries (non-rechargeable) that comply with the relevant UL standard and 6.1 are considered to fulfill the requirements of this standard.

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

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

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

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

6.3A Button or coin cell batteries of lithium technologies

6.3A.1 The battery compartment of an appliance or any accessory, such as a wireless control, incorporating one or more coin cell batteries of lithium technologies 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 32 mm (1.25 in) maximum with a diameter greater than its height; and
- b) The appliance is intended for household use.

Exception: Not applicable to appliances and accessories intended for use where the battery is not intended to be replaced and is not referenced in instructions and markings.

6.4 Boxes and raceways

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

6.5 Capacitors and filters

6.5.1 The component requirements for a capacitor are not specified. A capacitor complying with the Standard for Capacitors, UL 810 is considered to comply with the requirements of 23.1.

6.5.2 Electromagnetic interference filters with integral enclosures that comply with one of the following standards are considered to comply with the requirements of 23.1.

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

6.5.3 Capacitors that comply with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, are considered to comply with the requirements of 23.1.

6.6 Controls

6.6.1 General

6.6.1.1 Auxiliary controls shall be evaluated to the requirements in (a) or (b):

- a) Using the applicable requirements of this end product standard and the requirements in Controls – End Product Test Parameters, Section 28; or
- b) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.1.2 Operating (regulating) controls shall be evaluated to either the requirements in a or b:

- a) Using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and the parameters in Controls – End Product Test Parameters, Section 28, unless otherwise specified in this end product standard; or
- b) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

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6.6.1.3 Operating controls that rely upon software for the normal operation of the end product that manage a Safety Critical Function shall comply with:

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, and the Standard for Software in Programmable Components, UL 1998;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, or
- c) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.1.4 Protective Electronic Circuits shall be evaluated to either the requirements in a or b:

- a) Using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and if applicable, the parameters in Controls – End Product Test Parameters, Section 28, unless otherwise specified in this end product standard; or
- b) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.1.5 Solid-state Protective Electronic Circuits that do not rely upon software as a protective component shall comply with:

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except for the Controls Using Software requirements; or
- c) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.1.6 Solid-state Protective Electronic Circuits that rely upon software as a protective component shall comply with:

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and the Standard for Software in Programmable Components, UL 1998;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or
- c) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.1.7 An electronic, auxiliary or operating control (e.g. a non-protective control) that does not manage a Safety Critical Function, need only be subjected to the applicable requirements of this end product standard.

6.6.2 Electromechanical and electronic controls

6.6.2.1 A control, other than as specified in 6.6.3 – 6.6.7, shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or
- d) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.3 Liquid level controls

6.6.3.1 A liquid level control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Industrial Control Equipment, UL 508; or
- d) The Standard for Automatic Electrical Controls Part 1: General Requirements, UL 60730-1; and
 - 1) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls, UL 60730-2-15; or
 - 2) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water and Air Flow Sensing Controls, Including Mechanical Requirements, UL 60730-2-18; or
- e) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

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

6.6.4 Motor and speed controls

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

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Industrial Control Equipment, UL 508;
- d) The Standard for Power Conversion Equipment, UL 508C;
- e) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1;
- f) The Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1, and the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1; or
- g) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.5 Pressure controls

6.6.5.1 A pressure control shall comply with one of the following; see also 26.8 and 26.9:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Industrial Control Equipment, UL 508;
- c) The Standard for Automatic Electrical Controls– Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6; or
- d) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.6 Temperature controls

6.6.6.1 A temperature control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;
- c) The Standard for Industrial Control Equipment, UL 508;
- d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9; or
- e) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.6.6.2 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that is part of a circuit that manages a Safety Critical Function shall comply with:

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

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

6.6.7 Timer controls

6.6.7.1 A timer control shall comply with:

- a) The Standard for Solid-State Controls for Appliances, UL 244A;
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7; or
- c) Using the requirements for Electronic Circuits Evaluated to the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, based requirements, Section 29.

6.7 Cords, cables, and internal wiring

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

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

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

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

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

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

6.8 Cooling fan

6.8.1 A cooling (ventilation) fan shall comply with the applicable requirements of the Standard for Electric Fans, UL 507.

Exception: A component type motor-operated fan that is completely enclosed within the end product enclosure that complies with the applicable requirements of this end product standard, is considered to comply with 6.8.1.

6.8.2 Low voltage component fans that comply with the Standard for Electric Fans, UL 507, are considered to fulfill the requirements in Motors, Section 33.

6.9 Film-coated wire (magnet wire)

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

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

6.10 Gaskets and seals

6.10.1 Gaskets and seals that comply with the applicable requirements of the Standard for Gaskets and Seals, UL 157, are considered to fulfill the requirements in Seals, Gaskets, and Diaphragms, Section 32.

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

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

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

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

6.11.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Arc-Fault and Leakage Current Detectors/Interrupters, Section 34.

6.11.5 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 Arc-Fault and Leakage Current Detectors/Interrupters, Section 34.

6.12 Heaters and heating elements

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

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

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

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

6.13 Insulation systems

6.13.1 Materials used in a Class 105 (A) insulation system shall comply with 24.3.

6.13.2 Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446.

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

6.14 Light sources and associated components

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

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

6.14.2 Lighting ballasts shall comply with:

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

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

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

6.14.3 Automatic starters for electric discharge lamps shall comply with the Standard for Fluorescent Lamp Starters, UL 542. Holders for automatic starters shall comply with the Standard for Lampholders, UL 496.

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

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

Exception No. 2: Individual LED light sources mounted on printed wiring boards and intended for indicating purposes need not comply with UL 8750, but shall comply with the applicable requirements of this end product standard.

6.15 Marking and labeling systems

6.15.1 A marking and labeling system shall comply with the Standard for Marking and Labeling Systems, UL 969, under the specified environmental conditions; see 68.2.

6.16 Motors and motor overload protection

6.16.1 General

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

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

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

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

6.16.2 General-purpose type motors

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

6.16.3 Component type motors

6.16.3.1 Component type motors shall comply with either 6.16.3.2 or 6.16.3.3.

6.16.3.2 The motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, except as noted in Table 6.1.

Table 6.1
Superseded requirements

UL 1004-1 exempted requirement	Superseded by the requirements in this standard
Current and Horsepower Relation	Paragraph 33.3.3
Cord-Connected Motors	Section 13
Factory Wiring Terminals and Leads	Section 18
Electrical Insulation	Section 17
Non-Metallic Functional Parts	Sections 8, 17, 33
Solid-State Controls, 7.2	Paragraph 6.6
Non-metallic enclosure thermal aging, 9.1.4	Paragraph 8.8
Motor enclosure, 9.2 – 9.4	Section 8
Grounding	Section 15
Ventilation Openings: only applicable where the openings are on surfaces considered to be the appliance enclosure.	Section 8
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts	Section 9
Protection Against Corrosion	Section 10
Available fault current ratings for motor start and running capacitors, 26.6: not applicable for cord and plug connected appliances.	Section 23
Switch: not applicable to centrifugal starting switches	Section 27
With the exception of Resilient Elastomer Mounting and Electrolytic Capacitor Tests requirements, the performance tests in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, are not applicable	All applicable performance tests
Only the following marking requirements are applicable: manufacturer's name or identification; rated voltage; rated frequency; number of phases if greater than 1; and multi-speed motors, other than a shaded-pole or a permanent-split-capacitor motor, shall be marked with the amperes and horsepower at each speed.	Paragraph 68.6

6.16.3.3 The motor shall comply with the applicable component requirements for Components, Section 6, 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 14 (14.2);
- c) Grounding, Section 15;
- d) Electrical Insulation, Section 17;
- e) Internal Wiring, Section 18;

- f) Spacings, Section 21;
- g) Capacitors, Section 23; and
- h) Motors, Section 33.

6.16.4 Motor overload protection

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

- a) The Standard for Overheating Protection for Motors, UL 2111;
- b) The Standard for Thermally Protected Motors, UL 1004-3; or
- c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Thermal Motor Protectors, UL 60730-2-2; in conjunction with the Standard for Thermally Protected Motors, UL 1004-3 (to evaluate the motor-protector combination).

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

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

6.16.4.4 Except as indicated in 6.16.4.3, electronically protected motor circuits shall comply with one of the following. See Motor and Speed Controls, 6.6.4, for basic control requirements.

- a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the Standard for Tests for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1; or
- b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; If software is relied upon to perform a safety function, it shall be considered software Class B.

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

6.17 Overcurrent protection

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

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

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

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

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

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

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

6.18 Polymeric materials

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

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

6.19 Power supplies

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

- a) The Standard for Class 2 Power Units, UL 1310;
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, with an output marked “Class 2”, or that complies with the limited power source (LPS) requirements and is marked “LPS”; or
- c) The Standard for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements, UL 61010-1, with NEC Class 2 output (output category 2).

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

- a) The Standard for Power Units Other Than Class 2, UL 1012;
- b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or
- c) The Standard for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements, UL 61010-1, with NEC Class 1 output (output category 1).

6.20 Printed wiring boards

6.20.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed Wiring Boards, UL 796; see 17.6.

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

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

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

6.21 Semiconductors and small electrical and electronic components

6.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. If considered necessary, the dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Dielectric Voltage-Withstand Test, Section 44.

6.21.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with the Standard for Optical Isolators, UL 1577. If considered necessary, the dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Dielectric Voltage-Withstand Test, Section 44. The dielectric test voltage is to be applied between the input and output terminals of the optical isolator.

6.21.3 Surge protective devices are to comply with the Standard for Surge Protective Devices, UL 1449, and be a type suitable for the end-use application.

6.21.4 Except as specified in 6.21.5, component requirements are not specified for small electronic components on printed wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

6.21.5 Where an electronic component is determined to be a critical component during the Component Breakdown Test specified in 45.2, one of the following standards shall be applied. See 28.4 for the test parameters to be used.

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

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

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

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

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6.22 Supplemental insulation, insulating bushings, and assembly aids

6.22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 18.14 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; or
- c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

6.22.2 Wire positioning devices shall comply with Electrical Insulation, Section 17, and Separation of Circuits, Section 20. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to fulfill this requirement.

6.22.3 Insulating bushings that comply with 6.1 and 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.

6.23 Switches

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

- a) The Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;
- b) The Standard for General-Use Snap Switches, UL 20; or
- c) The Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A.

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

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

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

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

- a) The Standard for Solid-State Controls for Appliances, UL 244A; or
- b) The Standard for Automatic Electrical Controls - Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

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

6.24 Transformers

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

Exception: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component complies with the intent of this requirement.

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

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

6.25 Valves (electrically operated) and solenoids

6.25.1 Electrically operated valves shall comply with the:

- a) The Standard for Electrically Operated Valves, UL 429; or
- b) The Standard for Automatic Electrical Controls - Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, UL 60730-2-8.

Exception: Automatic valves intended for use with natural gas, manufactured gas, LP-gas or LP-gas-air mixtures shall comply with the Standard for Automatic Valves for Gas Appliances, ANSI Z21.21a/CSA 6.6.

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

6.26 Water pumps

6.26.1 A motor-operated water pump shall comply with the following the Standard for Motor-Operated Water Pump, UL 778.

Exception: A component type motor-operated pump that is completely enclosed within the end product enclosure that complies with the applicable requirements of this end product standard, is considered to comply with 6.26.1.

6.27 Power-switching semiconductors (mounted to accessible metal parts)

6.27.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. It shall have a minimum isolation voltage of 1500 V.

6.28 Thermistors

6.28.1 Thermistors shall comply with the Standard for Thermistor-Type Devices, UL 1434. The thermistors shall be suitable for the application at the specified electrical and thermal ratings.

7 General

7.1 An appliance shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

7.2 An appliance shall be acceptable for both indoor and outdoor use unless marked for restricted use in accordance with 68.8.

7.3 A waste connection or drain outlet of appliances connected to a potable water system shall be designed and constructed to provide for connection to the sanitary waste system through an air gap of 2 pipe diameters or 1 in (25.4 mm), whichever is larger.

7.4 A low voltage circuit shall be judged under the requirements for primary circuits in this standard unless the transformer or power supply that supplies the circuit complies with 30.1 or 30.3.

8 Frame and Enclosure

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

8.2 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or similar part, of an appliance shall be smooth and rounded and not sufficiently sharp to cause a cut-type injury when contacted during normal use or maintenance.

8.3 A door or cover of an enclosure shall be provided with a means for securing the door or cover in place in the closed position.

8.4 A device, such as a lampholder, fuseholder, or circuit breaker, of the replaceable type shall be designed and installed so that persons servicing the lamps, fuses, circuit breakers, or other devices will not unintentionally contact any uninsulated live part other than a screwshell or the clips of a fuseholder.

8.5 The enclosure of an appliance shall be complete. The enclosure shall not depend on adjacent walls or equipment to complete the enclosure.

8.6 Mounting holes shall be located or guarded so that nails or similar hangers shall not come in contact with any bare, covered, or uninsulated live part.

8.7 Among the factors to be considered when determining the acceptability of an enclosure are:

- a) Physical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Flammability;
- e) Resistance to corrosion;
- f) Resistance to distortion at temperatures to which the enclosure is subjected under conditions of intended use;
- g) For a sheet-metal enclosure, in addition to the factors in (a) – (f), the size and shape of the metal, the thickness of the metal, and the conditions of intended use;
- h) For a nonmetallic enclosure exposed to an ultraviolet radiation weathering source, resistance to degradation from exposure to ultraviolet radiation; and
- i) For a nonmetallic enclosure, all of the factors are to be considered with respect to thermal aging.