UL 1018

STANDARD FOR SAFETY

Electric Aquarium Equipment

UL Standard for Safety for Electric Aquarium Equipment, UL 1018

Sixth Edition, Dated April 29, 2011

Summary of Topics

This revision to UL 1018 dated September 17, 2020 includes the following:

> ***Revision to Replace the References to the Standard For Power Conversion Equipment, UL 508C, With Reference to the Standard For Adjustable Speed Electric Power Drive Systems, UL 61800-5-1; 6.6.4.1***
>
> ***Revision for Additional Receptacles Allowed Under Exception No. 2 to 10.1.9, 67.8 and 68.1.12.***

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated May 4, 2020 and July 24, 2020.

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UL 1018

Standard for Electric Aquarium Equipment

Previous numbered and unnumbered editions of standards covering electric aquarium equipment have been published since April 1978.

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Second Edition – September, 1984
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Sixth Edition

April 29, 2011

This UL Standard for Safety consists of the Sixth Edition including revisions through September 17, 2020.

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 commercial and household electric equipment for use on or in aquariums in indoor locations at 300 volts or less, in accordance with the National Electrical Code, NFPA 70, such as heaters, pumps, filters, aerators, reflectors, hoods, electrically wired stands, and similar equipment.

1.2 These requirements do not cover:

a) Illuminators or stands not specifically intended for use with aquariums or

b) Aquarium tanks except when part of the tank acts as enclosure or water barrier for fittings, such as, but not limited to, filter, heating, or UV units that are integrated into the base or wall of the aquarium tank.

1.3 Aquarium equipment involving tungsten-halogen or high intensity discharge lamps shall comply with the additional applicable requirements specified in the Standard for Portable Electric Luminaires, UL 153.

2 Units of Measurement

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

2.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

3 Undated References

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

4 Glossary

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

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

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

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

4.5 AQUARIUM APPLIANCE – An appliance falling within the scope of these requirements. Requirements that apply only to specific appliances are identified by reference in the text to such specific appliances.

4.6 AQUARIUM STAND – Equipment intended to support an aquarium. Such a stand may contain lamps for illumination, heater elements to control the temperature of the aquarium, and other aquarium-related appliances and devices.

4.7 AUTOMATICALLY CONTROLLED – An appliance is considered to be automatically controlled under any one or more of the following conditions:

a) If the repeated starting of the appliance, beyond one complete, predetermined cycle of operation to the point where some form of limit switch opens the circuit, is independent of any manual control.

b) If, during any single, predetermined cycle of operation, a motor is caused to stop and restart one or more times.

c) If, upon energizing the appliance, the initial starting of a motor is likely to be intentionally delayed beyond conventional starting.

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

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

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

4.10 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.

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

4.12 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”.

4.13 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 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.

4.14 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.

4.15 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.

4.16 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.

4.17 REMOTELY CONTROLLED – An appliance is considered remotely controlled if it is not within sight of the operator at the location of the starting switch or other device.

4.18 USER SERVICING – Any form of servicing of an appliance that may be performed by personnel other than those who have been trained to maintain the particular appliance. Examples include:

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

b) Replacement of removable lamps with or without the use of tools.

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

d) Routine cleaning, and maintenance of components such as filters and diffusers.

4.19 UV EMITTER (UV LIGHT SOURCE) – Radiating source constructed to emit non-ionizing electromagnetic energy at wavelengths of 100 nm to 400 nm. They can be gas-discharge lamp, LED or other technologies.

4.20 UV RADIATION WATER TREATMENT APPLIANCE – Appliance that treats water using electromagnetic energy at wavelengths in the ultraviolet band using UV EMITTER, such as UV Water Filter.

CONSTRUCTION

5 Frame and Enclosure

5.1 General

5.1.1 An appliance shall be formed and assembled so that it shall have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected. There shall be no likelihood of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

5.1.2 The enclosure of an appliance, other than a reflector, shall be such that water will not contact live parts when the appliance is subjected to the Resistance to Overflow Test, Section 59, to simulate conditions that might occur during routine use. All accessories required for operation shall remain in place during the test. The Leakage Current Test, Section 38, shall be used to determine whether water has contacted any live part.

5.2 Thickness of metal

5.2.1 For unreinforced, flat surfaces in general, cast metal shall not be less than 1/8 inch (3.2 mm) thick. Malleable iron shall not be less than 3/32 inch (2.4 mm) thick. Die cast metal shall not be less than 5/64 inch (2 mm) thick if the surface is curved, ribbed, or otherwise reinforced, or if the shape or size (or both) of the surface is such that equivalent mechanical strength is provided.

5.2.2 An enclosure of sheet metal other than a hood or reflector shall be evaluated with regard to the size, shape, and thickness of the metal. Consideration shall be given to the intended use of the complete appliance. The use of sheet steel having a thickness of less than 0.026 inch (0.66 mm) if uncoated, or

0.029 inch (0.74 mm) if galvanized, or of nonferrous metal having a thickness of less than 0.036 inch (0.91 mm) is not recommended.

Exception: It is acceptable for a relatively small area or surface that is curved or otherwise reinforced to be less than the specified thickness. A form of construction that uses metal thinner than specified may be used if found to provide equivalent physical strength and protection.

5.2.3 The thickness of sheet metal in an aquarium hood or reflector shall not be less than indicated in Table 5.1.

5.2.4 The maximum dimension specified in Table 5.1 is considered to be:

a) The diameter of a circular appliance,

b) The longest diameter of an elliptical appliance,

c) The longest side of a triangular appliance,

d) The diagonal of a rectangular appliance, or

e) The longest diagonal of a multisided appliance.

Table 5.1
Minimum sheet metal thicknesses for aquarium reflectors

Type of metal	Where used	Minimum acceptable thickness when maximum dimension[a] is:			
		36 inches (914 mm) or less,		More than 36 inches (914 mm),	
		inch	(mm)	inch	(mm)
Stainless steel	At lampholders	0.015	0.38	0.018	0.46
	Elsewhere in reflectors	0.013	0.33	0.018	0.46
Plated steel	At lampholders	0.015	0.38	0.018	0.46
	Elsewhere in reflectors	0.015	0.38	0.018	0.46
Aluminum, brass, or copper	At lampholders	0.025	0.64	0.032	0.81
	Elsewhere in reflectors	0.020	0.51	0.025	0.64

[a] In accordance with 5.2.4.

5.2.5 Table 5.1 applies to any single surface or single flat sheet. A rigid member consisting of 1/2 by 1/2 inch (12.7 by 12.7 mm) 90 degree angle strips formed of sheet steel not less than 0.032 inch (0.81 mm) thick, or flat steel bars not less than 3/8 inch (9.5 mm) wide and 1/8 inch (3.2 mm) thick can be used to reinforce and divide a large area into sections for which lighter metal may be used. Such reinforcement, unless along the longer dimension of the surface, shall be secured to the adjacent sides of the enclosure. A single piece of sheet metal that is corner bent to form an angle of not more than 120 degrees is considered to be reinforced along the bend, and its thickness may be based on the length of the largest flat surface involved.

5.2.6 The thickness of metal is not specified for a purely ornamental part or for a reflector part not relied upon to enclose wiring or support a live part. A part relied upon to reduce the risk of a reflector falling into an aquarium tank is not considered ornamental.

5.2.7 There is no minimum thickness specified for a reflective strip utilized as a heat sink for a reflector; however, the means of adhesion of the strip to the frame shall be investigated as described in 60.1 – 60.3.

5.3 Barriers

5.3.1 The enclosure of a remotely or automatically controlled appliance, or one intended to operate unattended, shall reduce the risk of molten metal, burning insulation, flaming particles, and the like falling on combustible surfaces or materials, including the surface upon which the appliance is supported.

5.3.2 The requirement in 5.3.1 necessitates the use of a barrier of combustion-resistant material:

a) Under a motor unless one of the following items applies:

1) The structural parts of the motor or of the appliance provide what is determined to be the equivalent of such a barrier.

2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions:

i) 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.)

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

4) The motor complies with the requirements for impedance-protected motors in the Standard for Overheating Protection for Motors, UL 2111.

b) Under wiring, unless it is of the flame retardant type. Neoprene or thermoplastic insulated wires are considered to be flame retardant types.

5.3.3 The requirement in 5.3.1 will also necessitate that a switch, relay, solenoid, or similar device be individually and completely enclosed unless it can be shown that:

a) Failure of the component would not result in a risk of fire, electric shock, or other injury to persons or

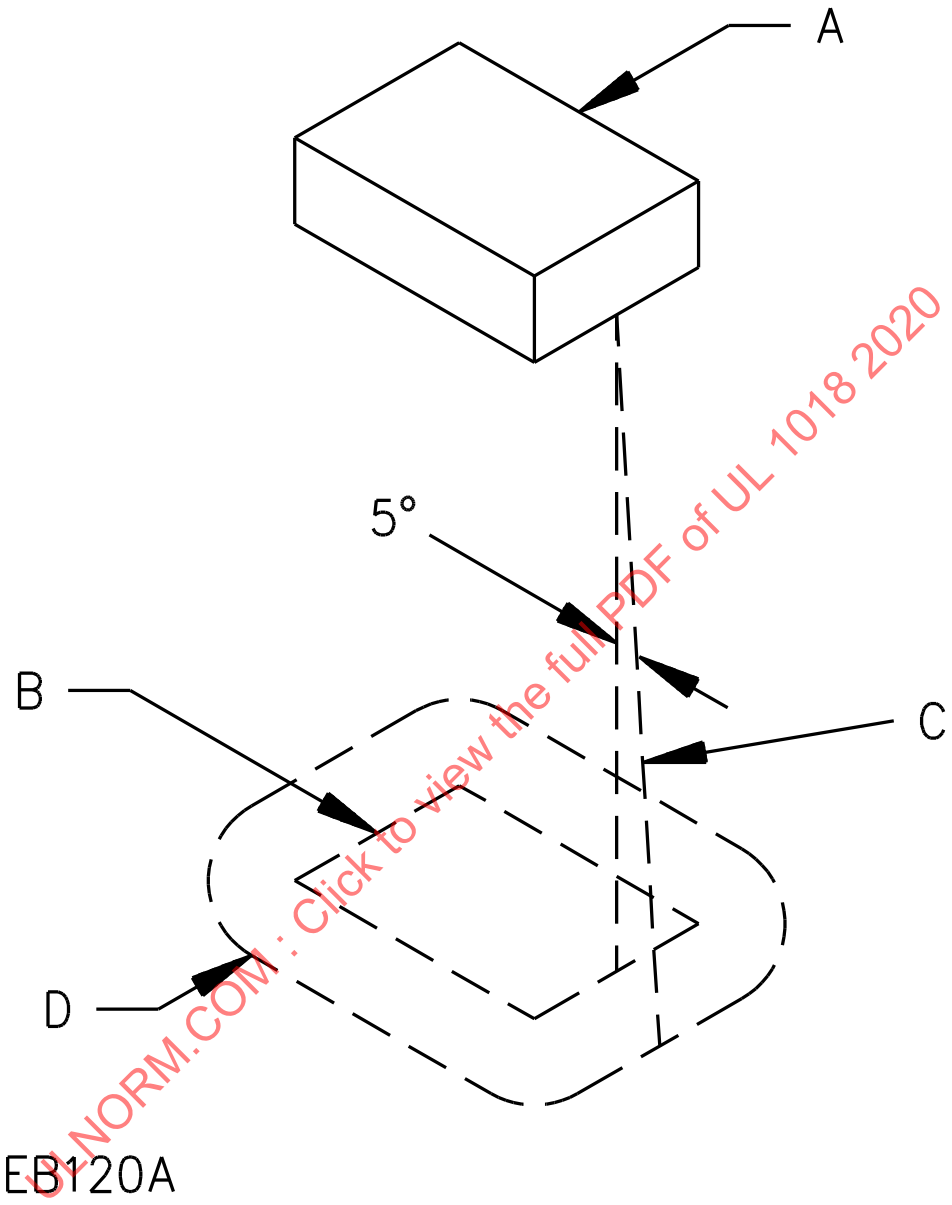
b) There are no openings in the bottom of the appliance overall enclosure.

Exception: A terminal of a switch, relay, solenoid, or a similar device may protrude from such an individual enclosure.

5.3.4 The barrier mentioned in 5.3.2 shall be horizontal, shall be located as indicated in Figure 5.1, and shall have an area not less than that shown in the figure. Openings for drainage, ventilation, and similar needs may be provided in the barrier if they do not permit molten metal, burning insulation, or like materials to fall on combustible material.

Figure 5.1

Location and extent of barrier



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

B – Projection of outline of component on horizontal plane.

C – Inclined line which traces out minimum area of barrier. When moving, the line is always:

a) Tangent to the component,

b) 5 degrees from the vertical, and

c) 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.

5.4 Polymeric material

5.4.1 A polymeric enclosure material shall be investigated in accordance with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The ball impact value referred to in UL 746C shall be 5 foot-pounds force (6.78 J) in all cases.

5.4.2 A polymeric material used for parts other than the enclosure in aquarium equipment shall be evaluated in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

5.4.3 Among the factors that shall be taken into consideration when judging the acceptability of magnesium and nonmetallic material are resistance to:

a) Mechanical damage,

b) Impact,

c) Moisture absorption,

d) Combustion,

e) Distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use, and

f) Aging, where the material may be exposed to ultraviolet light (from an ultraviolet lamp bulb, for example), or other similar exposure.

5.4.4 A polymeric appliance material enclosing uninsulated live parts or live parts having insulation less than 0.028 inch (0.71 mm) thick or equivalent, shall comply with the Polymeric Enclosure Tests (mold stress, impact, strain relief, etc.) detailed in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C and shall have a flammability class determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94 as follows:

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

Exception: In lieu of the required 5VA flame rating for stationary or permanently installed appliances, the polymeric enclosure may be subjected to the 127 mm end-product flame test in accordance with UL 746C.

b) Class V-2 minimum for all other aquarium appliances.

Exception No. 1: In lieu of the required V2 flame rating for all other aquarium appliances, the polymeric enclosure may be subjected to the 12 mm or 20 mm end-product flame test in accordance with UL 746C.

Exception No. 2: In lieu of the required V2 flame rating for household aquarium appliances, the polymeric enclosure may be comprised of HB rated materials if the household aquarium equipment is found to comply with the requirements for UL 746C, Portable Unattended Household Equipment - Alternate Path. The appliance shall be marked to indicate it is suitable for household use only.

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

6 Component Specifications

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 – 6.25;

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. Fluorescent lamps are exempt.

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.

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

a) Involves a feature or characteristic not required in the application of the component in the product; or

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 complying with a UL component standard other than those cited in 6.2 – 6.25 is acceptable if:

a) The component also complies with the applicable component standard of 6.2 – 6.25; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements of the National Electrical Code, ANSI/NFPA 70, where appropriate;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

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 component standard(s) need not be applied.

6.1.3 A component not anticipated by the requirements of this standard, not specifically covered by the component standards of 6.2 – 6.25, 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 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 this Standard.

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 covered under the requirements of the Standard for Cord Sets and Power-Supply Cords, UL 817 and need not comply with UL 498.

Exception No. 2: A fabricated pin terminal assembly(ies) need not comply with UL 498 if it complies with Current-Carrying Parts, Section 16, Insulating Material, Section 18, and Spacings, Section 22.

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 0.110, 0.125, 0.187, 0.205, and 0.250 inch (2.8, 3.2, 4.8, 5.2, and 6.3 mm), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

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.

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 Use in 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 UL 1059 if the part complies with the requirements of Wiring terminals and leads, 10.3.3, Current-Carrying Parts,

Section 16, Insulating Material, Section 18, and Spacings, Section 22. 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. A lithium ion multiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

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 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 Component Specifications, General, 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) 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".

6.3.6 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.

6.4 Boxes and raceways

6.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of the National Electrical Code, 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 Component Specifications, General, 6.1, are considered to fulfill the requirements of this Standard.

6.5 Capacitors and filters

6.5.1 The component requirements for a capacitor are not specified. A capacitor complying with the Standard for Capacitors, UL 810, is considered to fulfill the requirements of 29.1.

6.5.2 Electromagnetic interference filters with integral enclosures that comply with the Standard for Electromagnetic Interference Filters, UL 1283, are considered to fulfill the requirements of 29.1.

6.6 Controls

6.6.1 General

6.6.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and the parameters in Controls – End Product Test Parameters, Section 27.

6.6.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 6.6.2 – 6.6.7, and if applicable, the parameters in Controls – End Product Test Parameters, Section 27, unless otherwise specified in this end product standard.

6.6.1.3 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 the Standard for Software in Programmable Components, UL 1998 or

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

6.6.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 6.6.2 – 6.6.7, and if applicable, the parameters in Controls – End Product Test Parameters, Section 27, unless otherwise specified in this end product standard.

6.6.1.5 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 – Part 1: General Requirements, UL 60730-1 except Clause H 11.12 (Controls using software).

6.6.1.6 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 the Standard for Software in Programmable Components, UL 1998; or

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

6.6.1.7 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 Abnormal Operation Test, Section 46.

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 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 – Part 1: General Requirements, UL 60730-1.

6.6.3 Liquid level controls

6.6.3.1 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.

d) Standard for Automatic Electrical Controls – 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 Air Flow, Water Flow and Water Level Sensing Controls, UL 60730-2-15 or

2) Deleted

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 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 – Part 1: General Requirements, UL 60730-1.

6.6.5 Pressure controls

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

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

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

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

6.6.6 Temperature controls

6.6.6.1 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 – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

6.6.6.2 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.

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 the:

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

b) 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.

6.7 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 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.

6.8 Cord reels

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

6.9 Film-coated wire (magnet wire)

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

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

6.10 Gaskets and seals

6.10.1 Gaskets and seals that comply with the Standard for Gaskets and Seals, UL 157, are considered to fulfill the requirements of Aging Test on Seal Materials, Section 57.

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.

Note – An ALCI is not considered an acceptable substitute for a GFCI when the National Electrical Code, ANSI/NFPA 70 requires a GFCI.

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 Controls – End Product Test Parameters, Section 27.

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 Controls – End Product Test Parameters, Section 27.

6.12 Heaters and heating elements

6.12.1 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 No. 1: 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.

Exception No. 2: Open wire resistance elements are not required to comply with the construction requirements detailed in UL 499.

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 Insulation systems, 20.3.

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 shall comply with the Standard for Lampholders, UL 496.

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

6.14.2 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 appropriate UL luminaire standard are considered to fulfill this requirement.

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

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

Exception No. 1: LED light sources forming part of a luminaire that complies with an appropriate 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 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.

6.16 Motors and motor overload protection

6.16.1 General

6.16.1.1 A motor located in a low voltage circuit shall be evaluated for the risk of fire, electric shock and personal injury in accordance with the applicable requirements of this end product standard.

6.16.1.2 A motor requiring a motor insulation system greater than Class 105 (A) due to the temperatures obtained on the motor windings during the testing of the appliance, shall comply with 6.16.2.1.

6.16.1.3 An oil-filled motor or a motor employing integral ground insulation of any insulation class shall comply with 6.16.2.1.

6.16.2 Motors

6.16.2.1 A motor as specified in 6.16.1.2 or 6.16.1.3 shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

6.16.2.2 A motor other than as specified in 6.16.1.2 or 6.16.1.3 shall comply with:

a) 6.16.2.1 or

b) The construction and performance requirements of this Standard, when tested in conjunction with the appliance, and the following additional construction requirements of the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1:

1) A motor with aluminum windings shall comply with the Protection Against Corrosion requirements of UL 1004-1 with respect to galvanic compatibility. All winding terminals shall be suitable for the connection of aluminum windings and the motor leads.

2) The resilient mounting of a motor in an appliance provided with grounding shall comply with UL 1004-1, if the dead metal parts of the motor are accessible during normal use or servicing of the appliance or conductively connected to accessible dead metal parts of the appliance.

3) A starting or running capacitor of a motor in a permanently-connected appliance shall comply with UL 1004-1 with respect to the maximum available fault current.

4) The motor shall be marked with the motor manufacturer name or identification, catalog or model number, rated voltage and rated frequency

6.16.2.3 With respect to 6.16.2.2(a), the following exceptions may be applied:

a) Motor controls shall be evaluated in accordance with Controls, 6.6.

b) Parts of phenolic material in direct contact with live parts other than magnet wire, such as brush holders or commutator insulation, shall be considered suitable without further evaluation of the material's electrical insulating properties.

6.16.3 Motor overload protection

6.16.3.1 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 – 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.

6.16.3.2 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.

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

6.16.3.4 Except as indicated in 6.16.3.3, electronically protected motor circuits shall comply with one of the following:

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 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) 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, or the Standard for Automatic Electrical Controls – Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. If software is relied upon to perform a safety function, it shall be considered software Class B.

Exception: Compliance with the above standards is not required for an electronically protected motor circuit if there is no risk of fire, electric shock, or casualty hazard during abnormal testing with the motor electronic circuit rendered ineffective.

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 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.

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 UL 489.

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

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

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

6.18 Polymeric materials and enclosures

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

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

6.19 Power supplies

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

a) 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".

6.19.2 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 – Safety – Part 1: General Requirements, UL 60950-1.

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.

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

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 Internal Wiring, Section 14.

6.20.3 Unless otherwise specified, the flammability class and temperature rating shall be that specified for insulating materials in Internal Wiring, Section 14.

6.21 Semiconductors and small electronic components

6.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of the Dielectric Voltage-Withstand Test, Section 42.

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. The dielectric voltage withstand tests required by UL 1577 shall be conducted applying the criteria of the Dielectric Voltage-Withstand Test, Section 42.

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

6.21.4 Where an electronic component is determined to be a critical component during the testing of Abnormal Operation Test, Section 46, one of the following standards shall be applied. See Protective controls (limiting controls), 27.4, 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 – Part 1: General Requirements, UL 60730-1.

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

6.21.6 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with Failure-Mode and Effect Analysis (FMEA), Section 7 of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

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

6.22 Supplemental insulation, insulating bushings, and assembly aids

6.22.1 The requirements for supplemental insulation (e. g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill the requirements of 15.3 or a performance requirement of this Standard. In such cases:

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

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

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

6.22.2 Wire positioning devices shall comply with Separation of Circuits, Section 17 and Insulating Material, Section 18. 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 Construction, General, Section 6, 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, Section 50) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

6.23 Switches

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

a) Deleted

b) 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.

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) Standard for Clock-Operated Switches, UL 917 or

b) 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 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 – 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 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.

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, and 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) Standard for Electrically Operated Valves, UL 429 or

b) 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 ANSI Z21.21/CSA 6.5, Automatic Valves for Gas Appliances.

6.25.2 Solenoids shall comply with the applicable construction and performance requirements of this Standard.

7 Mechanical Assembly

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

7.2 A switch, lampholder, or any similar component shall be mounted securely and restrained from turning.

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

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

b) The means for mounting the switch make it unlikely that operation of the switch will loosen it.

c) The electrical spacings would not be reduced below the minimum required values if the switch should rotate.

d) The operation of the switch is by mechanical means rather than by persons.

Exception No. 2: A lampholder of the type in which the lamp is not replaceable (such as a neon pilot or indicator lamp in which the lamp is sealed in a nonrenewable jewel) is not required to be restrained from turning if such rotation does not reduce spacings below those required.

7.3 A properly sized and applied lock washer is acceptable as a means to restrain turning of a stem-mounted switch.

7.4 An aquarium appliance intended to be installed on a tank shall be tested as described in 56.1, and provided with instructions in accordance with 70.3.3.

Exception: The test described in 56.1 is not required to be performed if the shape or size of the appliance is such that it cannot fall into the tank in any position.

7.5 An uninsulated live part shall be secured to the base or surface so that it is restrained from turning or shifting in position during use if such motion may result in a reduction of spacings below the minimum required values.

8 Accessibility of Live Parts

8.1 An electrical part of an appliance shall be located or enclosed so that the risk of unintentional contact with uninsulated live parts is reduced. The method of evaluating openings in an enclosure is specified in 8.2 – 8.6.

8.2 An opening in the enclosure of an appliance that does not permit entrance of a 1-inch (25.4-mm) diameter rod can be used if a probe, as illustrated in Figure 8.1, when inserted into the opening, does not touch any part that involves electric shock to earth ground.

8.3 Regarding the application of 8.2, 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. The penetration may be to any depth allowed by the opening size, including minimal depth combined with maximum articulation.

8.4 If any part of the enclosure must be opened or removed for user servicing with or without the use of tools, or can be opened or removed without the use of tools, the probe is to be applied without the part in place.

8.5 If an appliance is supported directly by the floor, the probe illustrated in Figure 8.1 is to be applied to every part of the bottom of the enclosure that is accessible without tipping, turning over, or otherwise moving the appliance from its intended position. Any other type of appliance shall be moved in whatever way necessary to make the entire bottom of the enclosure accessible for the application of the probe.

8.6 An opening that permits entrance of a 1-inch (25.4-mm) diameter rod can be used under the conditions described in Figure 8.2.

Exception: Such openings cannot be used in an appliance that is hand- or body-supported or hand-held in use.

Figure 8.1

Probe

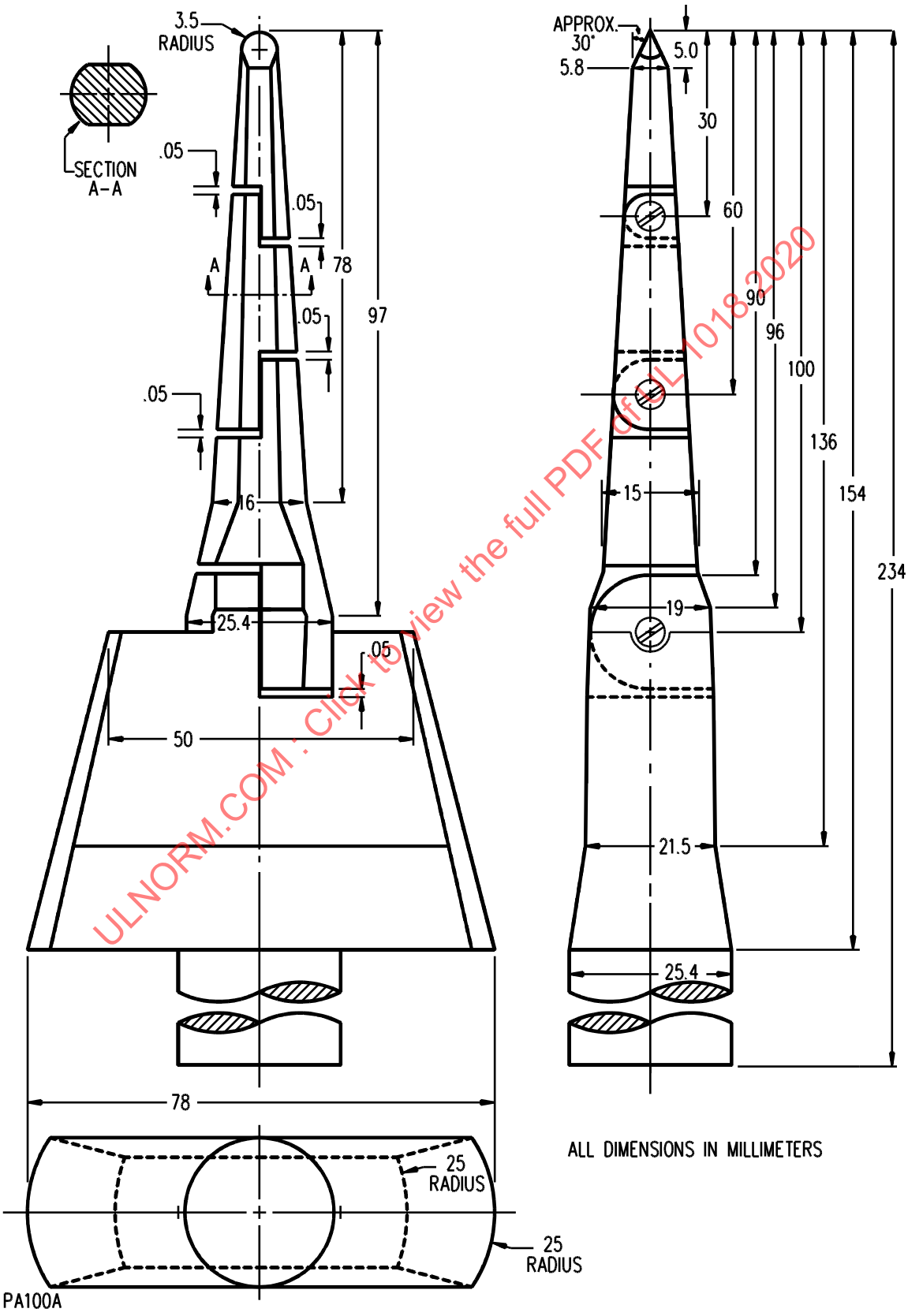
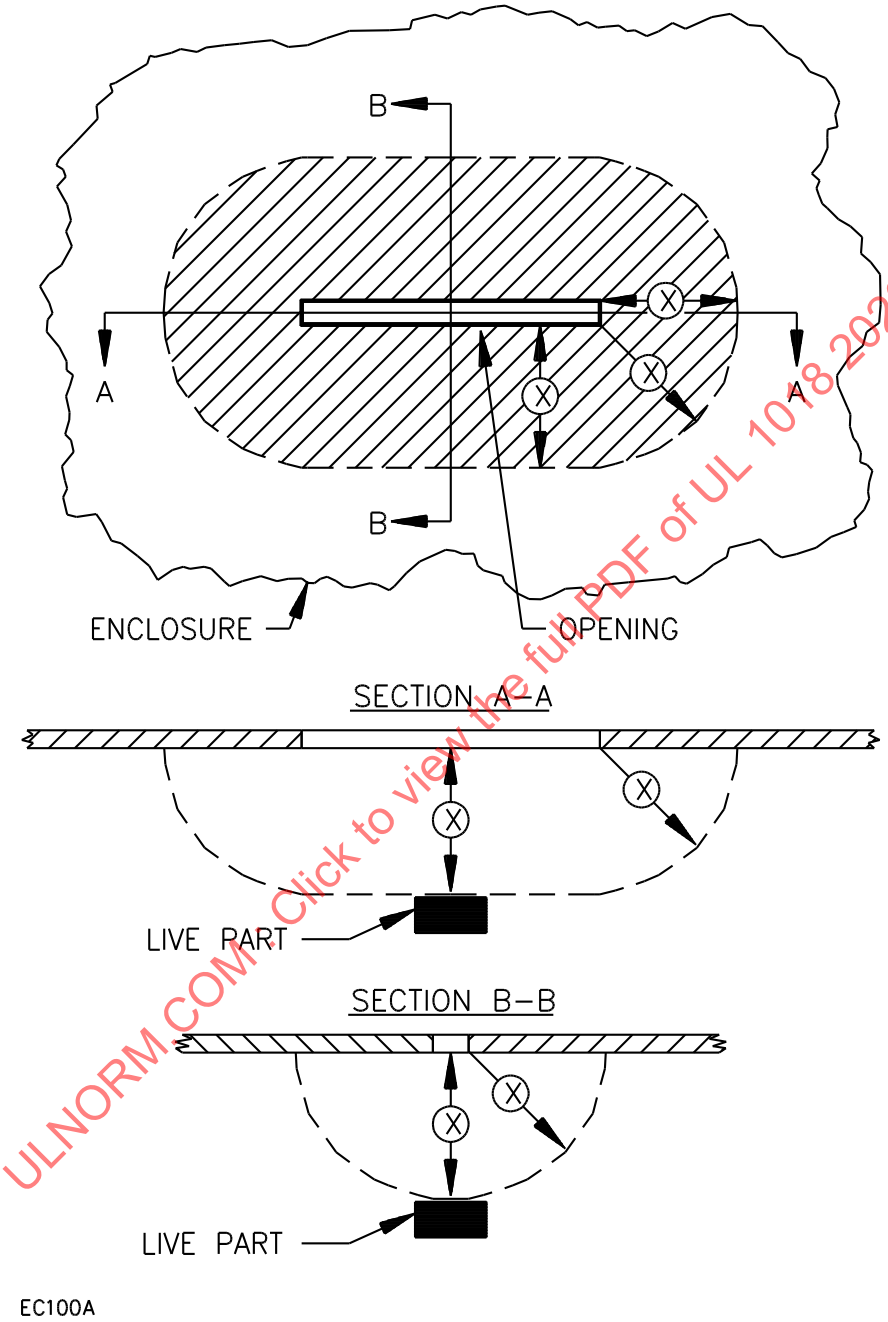


Figure 8.2

Opening in enclosure



(proportions exaggerated for clarity)

The opening complies if, within the enclosure, there is no uninsulated live part or enamel-coated wire:

a) Less than X inches from the perimeter of the opening and

b) Within the volume generated by projecting the perimeter X inches normal to its plane.

X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 4 inches (102 mm).

9 Protection Against Corrosion

9.1 An iron or steel part shall be made corrosion resistant by enameling, plating, galvanizing, or other means determined to be equivalent, if the breakdown of the part is likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: Stainless steel is not required to be additionally protected as described.

Exception No. 2: Corrosion protection may not be required for the following types of materials:

a) Surfaces of sheet steel within an enclosure in certain appliances where the oxidation of steel is not likely to be accelerated (due to the exposure of the metal to air and moisture or to other oxidizing influences) – the thickness of the metal and temperature shall also be considered.

b) Cast iron.

c) A sheath used on a heating element operating in air and a terminal part attached directly to such an element.

9.2 The aging characteristics of plating or other finish used in an appliance shall be such that deterioration of the finish will not eventually result in unacceptable performance of the appliance.

10 Supply Connections

10.1 Cord-connected appliances

10.1.1 A cord-connected aquarium appliance shall be supplied with a minimum 6-foot (1.83-m) long flexible cord and an attachment plug. The cord shall be measured from the face of the plug to the point where the cord enters the appliance.

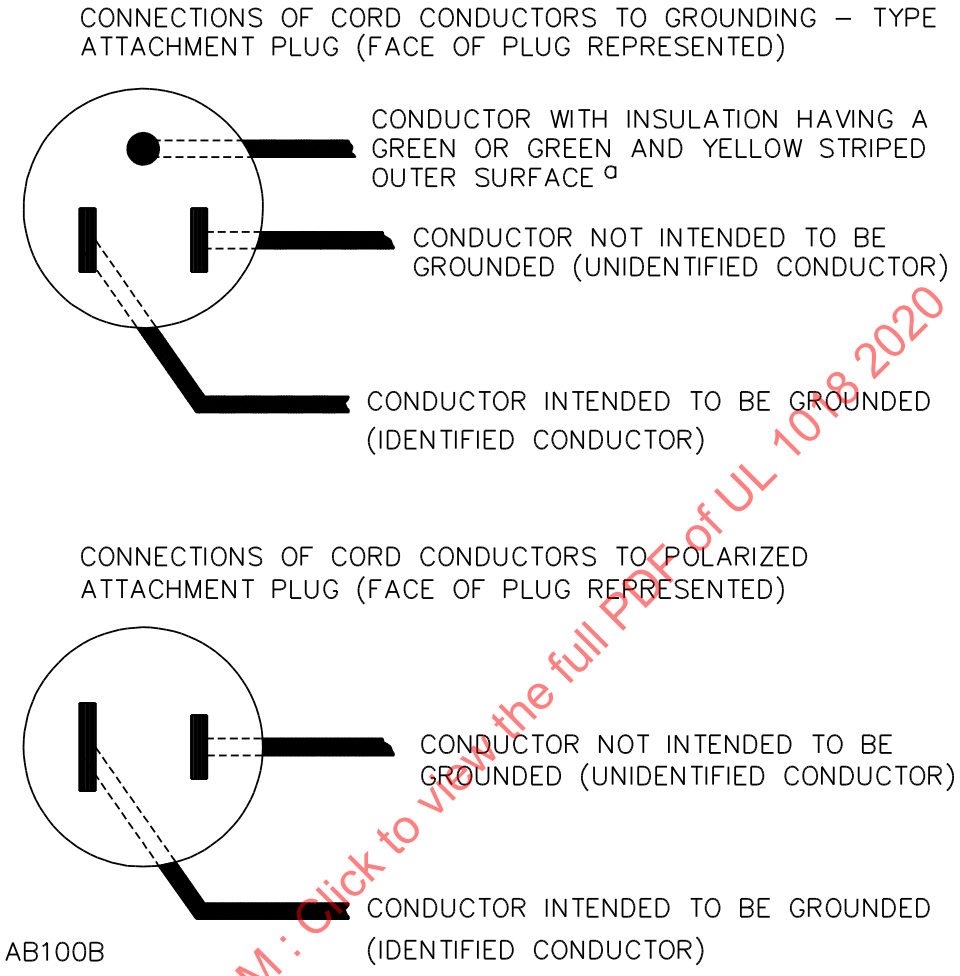
10.1.2 A flexible cord shall be of a type that is for the intended use. It shall be rated for use at a voltage not less than the rated voltage of the appliance and shall have an ampacity at least equal to the current rating of the appliance. The minimum cord size shall be 18 AWG (0.82 mm^2).

10.1.3 A flexible cord shall terminate in a grounding-type attachment plug or in a polarized attachment plug. Figure 10.1 illustrates attachment plug connections, and Table 10.1 indicates the method of polarity identification of flexible cords.

Exception: A flexible cord is not required to be supplied with a polarized attachment plug if the appliance does not include any single-pole on-off switches, polarized receptacles, or lampholders with screwshells.

Figure 10.1

Connections to attachment plug



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

Table 10.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations		
	Wire intended to be grounded[a] – Wire connected to the screw shells of lampholders		All other wires[a]
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 braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	C[b]	Solid white or gray	Solid color other than white or gray
	C1[c]	Light blue	Solid color other than light blue, white, or gray
Color of separators	D[d]	White or gray	Color other than white or gray
Other means	E[e]	Tin or other white metal on all strands of the conductor	No tin or other white metal on the strands of the conductor
	F[d]	A stripe, ridge, or groove on the exterior surface of the cord	

[a] 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 13.2 and Figure 10.1.

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

[c] For jacketed cords.

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

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

10.1.4 If the flexible cord includes an equipment grounding conductor, that conductor shall comply with 13.2.

10.1.5 The attachment plug shall be of a type for use at the rated current and voltage of the appliance. If the appliance is intended to be adapted for use on two or more different supply voltages by field alteration of internal connections, the attachment plug provided with the appliance shall be intended for the voltage for which the appliance is connected at the factory.

10.1.6 A flexible cord shall be permanently attached to the appliance.

10.1.7 A flexible cord shall be Type S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO for:

a) A commercial appliance,

b) A household aquarium stand, or

c) A household appliance as covered by the Exception to 10.3.1.2.

The flexible cord of all other appliances intended for household use and marked in accordance with 68.1.8 shall be Type SP-1, SPE-1, SPT-1, or heavier cord.

10.1.8 A cord of an appliance intended to operate in fresh water or salt water shall be water resistant and shall be so marked. A cord of an appliance intended to operate in a liquid other than fresh water or salt water, shall be investigated for that application.

10.1.9 A convenience outlet or other means for field connections of additional loads to an aquarium appliance shall not be provided.

Exception No. 1: A convenience outlet on an aquarium stand may be used if protection against splashing is provided.

Exception No. 2: A maximum of four grounding type receptacles for aquarium appliances may be used on an integral aquarium system (more than one appliance mounted together in one complete unit) when the receptacles are enclosed within the overall enclosure. The combined maximum current for all receptacles shall be marked per 68.1.12.

10.1.10 The face of a receptacle as described in 10.1.9 shall:

a) Be flush with or project beyond a nonconductive surrounding surface or

b) Project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

10.1.11 An aquarium reflector employing an in-line ballast shall be supplied with a cord as specified in 10.1.1 such that there is a minimum of 5 feet (1.52 m) between the ballast and the point where the cord enters the reflector.

10.2 Multiple power supply cords

10.2.1 Cord connected equipment shall not be provided with more than one power supply cord unless all of the following conditions are met:

a) Not more than two cords are provided;

b) Each flexible cord is of the type, size, and rating required for the type of product and the load supplied;

c) Each attachment plug cap is sized based on 10.1.5;

d) The total current input per Input Test, Section 40, is not more than 80 percent of the branch circuit supply for the single branch circuit to which it is connected (based on the plug configuration);

Exception: The total current input is not required to be less than 80 percent of the branch circuit rating when both attachment plugs are rated 15 Amps or less, and the total current input is equal to or less than the attachment plug rating.

e) The appliance is provided with a single accessible control or switch with a marked "off" position that disconnects all ungrounded conductors of the product;

Exception: The appliance is not required to have a single disconnect when multiple disconnect means are provided in accordance with any of the following:

1) There is a control or switch for each of the two power supply cords, and the controls or switches are grouped and identified;

2) The appliance is provided with a mechanical or electrical interlock system that results in all ungrounded conductors of the supply being disconnected in the event that either cord is disconnected; or

3) A marking is provided and located adjacent to each switch or disconnect means in accordance with 68.1.10.

Note: The disconnect means may be considered the supply cord. In this case the marking of 68.1.10 should be located near the cord entries into the appliance.

f) The appliance is rated in accordance with 67.7;

g) The appliance contains the markings in 68.1.11;

h) The appliance is provided with instructions as indicated in 70.1.2;

i) The appliance is comprised of two different types of aquarium equipment, such as a reflector hood and pump; and

j) Each appliance is provided with their own enclosure such that they could be individually evaluated to the requirements of this standard.

10.3 Permanently-connected appliances

10.3.1 General

10.3.1.1 An appliance intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems determined to be acceptable for the appliance in accordance with the National Electrical Code, ANSI/NFPA 70.

10.3.1.2 An appliance that is intended to be fastened in place or located in a dedicated space, or both, shall have provision for permanent connection to the power supply.

Exception: Not more than 8 feet (2.44 m) of one of the cord types specified in 10.1.7 and an attachment plug may be used for power supply connection if the need for such a connection is determined by investigation. In such a case, the following shall be considered:

a) The utility of the appliance and

b) The necessity for having it readily detachable from its source of supply by means of a plug.

10.3.1.3 A knockout in a sheet-metal enclosure supplied for connection of the appliance to a wiring system installed in accordance with the National Electrical Code, ANSI/NFPA 70, shall be securely attached and removable without deformation that would impair the intended performance of the enclosure.

10.3.1.4 The diameter of a knockout shall accommodate conduit of the trade size for which the knockout is intended as specified in Table 10.2.

Table 10.2
Dimensions associated with knockouts for conduit

Trade size of conduit,		Unthreaded openings			
		Nominal knockout diameter,		Minimum diameter of flat surface at knockout,	
inch	(mm)	inches	(mm)	inches	(mm)
1/2	12.7	7/8	22.2	1.152	29.26
3/4	19.1	1-3/32	27.8	1.450	36.83
1	25.4	1-23/64	34.5	1.804	45.82

10.3.1.5 There shall be a flat surface surrounding a knockout sized to accommodate attachment of a rigid metallic conduit of a size corresponding to the size of the knockout. The flat area shall have a minimum diameter in accordance with Table 10.2.

10.3.2 Field-wiring compartment

10.3.2.1 A field-wiring compartment in which power supply connections are to be made shall be located so that:

a) During the making of electrical connections, the internal wiring and electrical components will not be exposed to mechanical abuse or stress and

b) After the appliance has been installed as intended, such connections will be readily accessible for inspection.

10.3.2.2 A field-wiring compartment intended for connection of a supply raceway and integrally mounted with the appliance shall be attached so that it is prevented from turning with regard to the appliance.

10.3.2.3 The minimum usable volume of an outlet box or terminal compartment in which field-installed wiring connections to the power supply are to be made shall be as specified in Table 10.3.

Exception: A motor containing an integral wiring compartment that complies with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, is not required to comply with this requirement.

Table 10.3
Minimum usable volume of terminal compartment

Size of field-installed conductors,		Volume for each field-installed wire originating outside of the compartment and terminating inside the compartment[a],	
AWG	(mm^2)	cubic inches	(cm^3)
14	2.1	2.00	33
12	3.3	2.25	37
10	5.3	2.50	41
8	8.4	3.00	50
6	13.3	5.00	82

[a] Including a grounding conductor.

10.3.2.4 An electrical component shall not be mounted on a part, such as the cover of a wiring-terminal compartment, that must be moved in order for field-wiring connections to be made or inspected.

10.3.2.5 If the constructional features of an appliance are such that it is acceptable for field-wiring connections to be made in the motor terminal compartment, the compartment shall comply with the applicable requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

10.3.3 Wiring terminals and leads

10.3.3.1 A permanently-connected appliance shall be supplied with wiring terminals, including an equipment grounding terminal, for the connection of conductors having an ampacity rated for the appliance; or the appliance shall be supplied with leads for such connection.

10.3.3.2 A field-wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire and a means of making the connection (for example, a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or similar parts, factory-assembled to the wire) are supplied as a part of the appliance.

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

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

Exception No. 2: A wire-binding screw or stud-and-nut combination may be used at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or a cupped washer, or a means determined equivalent, are supplied to hold the wire in place.

10.3.3.4 A wiring terminal shall be prevented from turning by a means other than friction between surfaces. This is to be accomplished by two screws or rivets; square shoulders or mortises; a dowel pin, lug, or offset; a connecting strap or clip fitted into an adjacent part; or by a means that has been determined equivalent.

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

Exception: A No. 8 (4.2 mm diameter) screw or stud-and-nut combination may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

10.3.3.6 According to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor that is acceptable to be used for branch-circuit wiring and, therefore, is the smallest conductor that may be anticipated at a terminal for connection of a power-supply wire.

10.3.3.7 A wire-binding screw shall thread into metal.

10.3.3.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick and shall have two or more full threads in the metal. The metal 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, may be used if the tapped threads have been determined to have the necessary mechanical strength.

10.3.3.9 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size required in 10.3.3.1 under the head of the screw or washer.

10.3.3.10 A lead intended for field connection shall comply with the following:

a) The lead shall not be smaller than 18 AWG (0.82 mm^2);

b) The insulation thickness shall comply with Table 10.4; and

c) The free length of the lead inside an outlet box or wiring compartment shall be at least 6 inches (152 mm).

Table 10.4
Characteristics of leads intended for field connection

Insulation	Nominal wall thickness of insulation, inch	(mm)	Braid or jacket required	Nominal thickness of braid or jacket, inch	(mm)
Thermoplastic or neoprene	1/32[a]	0.8	No[a]	–	–
Rubber	1/32[b]	0.8	Yes[a]	1/64[a]	0.4
Cross-linked synthetic polymer[c]	1/64	0.4	No	–	–

[a] The nominal wall thickness may be less than 1/32 inch (0.8 mm) but not less than 1/64 inch (0.4 mm) when the wire is provided with a braid or jacket having a nominal thickness not less than 1/64 inch.

[b] For heat-resistant rubber other than of a silicone type, the nominal wall thickness is not to be less than 3/64 inch (1.2 mm) and no braid is required.

[c] Synthetic compounds other than neoprene or rubber, such as that used on Type XHHW wire.

10.3.4 Identified terminals and leads

10.3.4.1 A permanently-connected appliance rated 125 or 125/250 volts (3-wire) or less that employs a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent-protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for connection of the grounded conductor of the supply circuit. The terminal or lead intended for connection to the grounded supply circuit conductor shall be the one that is connected to the screwshell of the lampholder. It shall not have connection to a single-pole switch, a single-pole automatic control with an on or off position, or an overcurrent protective device.

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

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

11 Strain Relief

11.1 Strain relief shall be provided to reduce the risk of mechanical stress on a flexible cord from being transmitted to terminals, splices, or internal wiring.

11.2 A metal strain relief clamp or band is acceptable with Type SP-2 or lighter general use rubber insulated cord only if auxiliary insulation is provided over the cord for mechanical protection. A clamp of metal or other material may be acceptable on Types SPT-1, SVT, SVTO, and SPT-2 cords if supplementary protection in the form of varnished cloth tubing or the equivalent is used under the clamp. For heavier types of thermoplastic insulated cord, clamps may be used. In such cases, the auxiliary insulation is not required unless it is determined that the construction of the clamp is damaging to the cord insulation.

11.3 Means shall be provided to reduce the risk of the flexible cord being pushed into the appliance through the cord entry hole if such displacement is likely to:

a) Subject the cord to mechanical abuse or exposure to temperatures higher than that for which the cord is rated or

b) Reduce spacings (such as to a metal strain relief clamp) below the minimum required values.

11.4 If a knot in a flexible cord serves as the strain relief, a surface with which the knot may come in contact shall be free from projections, sharp edges, burrs, fins, and similar hazards that could cause abrasion of the insulation.

11.5 The strain relief device shall be subjected to the test described in 50.1.

12 Bushings

12.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, a bushing shall be provided that is secured in place and has a smooth, well-rounded surface against which the cord may bear. If Type SP-1, SPT-1, SP-2, or SPT-2 cord is used, if the wall or barrier is of metal, or if the construction is such that the cord may be subjected to strain or motion, an insulating bushing shall be provided.

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

12.3 A separate soft rubber, neoprene, or polyvinyl chloride bushing that complies with the applicable requirements may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor, but not elsewhere in the appliance, when:

a) The bushing is no less than 1/16 inch (1.6 mm) thick and

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

Exception: A bushing of any of the materials mentioned in this paragraph may be used at any point in an appliance if used in conjunction with a type of cord determined to be acceptable for use without an insulating bushing. If a bushing of one of these materials is used anywhere in an appliance, the edges of the hole in which the bushing is mounted shall be smooth and free of burrs, fins, and similar hazards.

12.4 At any point in an appliance, a bushing of the same material as, and molded integrally with, the supply cord is acceptable on a Type SP-1 or heavier supply cord if the built up section is not less than 1/32 inch (0.8 mm) thick and fills the cord entry hole completely.

13 Grounding

13.1 General

13.1.1 An appliance that has exposed dead metal parts that are likely to become energized shall be provided with grounding means as described in 13.1.2 – 13.1.9. Examples of conditions under which an exposed dead metal part is likely to become energized are:

a) Contact between the part in question and wire or splices,

b) Reduction of spacings caused by moisture or contamination or both, and

c) Failure of any single insulation system.

Exception: An appliance protected by a system of double insulation in accordance with the requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, shall not be provided with a means for grounding.

13.1.2 When a grounding means is supplied, whether required or not, it shall be in accordance with 13.1.3 and, when the appliance is cord-connected, shall comply with the requirements in 13.1.4. All

exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any user servicing operation and are likely to become energized shall be reliably connected to the means for grounding.

13.1.3 The following may be used as means for grounding:

a) In an appliance intended to be permanently connected by a metal-enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the appliance.

b) In an appliance intended to be permanently connected by a nonmetal-enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead. See 13.1.8 and 68.2.3.

c) In a cord-connected appliance, an equipment grounding conductor in the cord.

13.1.4 The grounding conductor of a supply cord shall be secured to the frame or enclosure of the appliance by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by another means that has been determined to be equivalent. The screw shall be of a corrosion-resistant material or made resistant to corrosion by a means that will not inhibit electrical conductivity between the screw and any other conductor. A lock washer shall be employed so that the screw is not subject to loosening if vibration is likely. Solder alone shall not be used for securing the grounding conductor. Servicing includes repair of the appliance by qualified service personnel.

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

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

Exception: Interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken is not required to comply with this requirement.

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

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

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

13.1.10 A small metal part such as an adhesive attached foil marking, a screw other than the grounding screw, a handle or the like that is on the exterior of the enclosure and separated from all electrical components is not considered likely to become energized, and is not required to comply with 13.1.1.

13.2 Identification

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

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

13.2.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified. A marking such as "G ," "GR ," "Ground ," "Grounding ," or a marking on a wiring diagram provided on the appliance shall be used.

14 Internal Wiring

14.1 General

14.1.1 The internal wiring of an appliance shall consist of wires of a size and type for the intended use when considered with regard to temperature, voltage, exposure to oil and grease, and other conditions of service likely to be encountered.

14.1.2 There is no temperature limit applicable to beads of inorganic material or the equivalent used as conductor insulation.

14.2 Aluminum conductors – termination

14.2.1 An aluminum conductor, insulated or uninsulated, used as internal wiring, such as for interconnection of current carrying parts or as a motor winding, shall be terminated at each end by a method determined to be acceptable for the combination of metals involved at the point of connection.

14.2.2 When a wire binding screw or a pressure wire connector is used as a terminating device for an aluminum conductor, it shall be for use with aluminum under the conditions involved (for example, temperature, heat cycling, and vibration).

14.3 Protection of wiring

14.3.1 The wiring and connections between parts of an appliance shall be protected or enclosed. An uninsulated conductor or one with beads for insulation shall not be used outside an enclosure. If the flexibility of flexible cord is essential, a length of such may be employed for:

a) External connections,

b) Internal connections that may be employed for external connections, or

c) Internal connections that may be exposed during servicing.

14.3.2 Internal wiring that is exposed through an opening in the enclosure of an appliance is considered to be protected as required in 14.3.1 if it is evaluated as enamel-insulated and complies with 8.2 and 8.3. Internal wiring not so protected complies if it is secured within the enclosure in such a manner that it:

a) Closely follows the main structure of the appliance and

b) Is securely held in place so that it is unlikely to be subjected to stress or mechanical abuse.

14.3.3 An internal terminal or wiring of an aquarium appliance shall not be adversely affected by splashing or overflow due to careless filling of the aquarium tank.

14.3.4 If the wiring of an appliance is located so that it may be in proximity to combustible material or may be subjected to mechanical abuse, it shall be:

a) Electric metallic tubing,

b) Constructed of armored cable,

c) Housed in rigid metal conduit,

d) Other metal raceway, or

e) Constructed of, or housed in, another material that has been determined to be equivalent.

14.3.5 Wiring within an enclosure, compartment, raceway, or similar area shall be located or guarded so as to reduce the risk of contact with any sharp edge, burr, fin, moving part, or similar parts that can damage the conductor insulation.

14.3.6 A hole by means of which insulated wires pass through a sheet metal wall within the overall enclosure of an appliance shall be supplied with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires bear to reduce the risk of insulation abrasion. A flexible cord used for external interconnection as mentioned in 19.1 and 19.2 shall be supplied with strain relief and bushings as specified in Strain Relief, Section 11, unless the construction is such that the cord will not be subject to mechanical stress or motion.

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

14.3.8 Type SPT-1, SP-1, and SPE-1 cord shall be split a maximum of 3 inches for internal connections.

14.4 Polarity

14.4.1 The following shall be connected to the grounded (neutral) conductor of the supply cord:

a) Any lampholder screw shell and

b) On any polarized receptacle, the terminal or lead intended to be grounded.

The method of identification of the supply cord conductor intended to be grounded shall be in accordance with Table 10.1 for cord-connected appliances and 10.3.3.2 and 10.3.3.3 for permanently-connected appliances.

14.4.2 A single pole switch shall be connected so as to interrupt the ungrounded side of the supply circuit.

14.4.3 A fuse or similar device shall be connected so as to interrupt the ungrounded side of the supply circuit.

15 Splices

15.1 A splice or connection shall be mechanically secure and shall provide continuity of electrical contact. A soldered connection shall be made mechanically secure before soldering if breaking or loosening of the connection could result in an increase in the risk of fire or electric shock.

15.2 For an aquarium appliance such as a pump in which a significant amount of vibration is likely, the requirement of 15.1 specifies the use of lock washers or other means so that wire binding screws and nuts will not loosen.

15.3 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape can be used on a splice if the voltage involved is not more than 250 volts. In determining whether splice insulation consisting of coated fabric, thermoplastic, or other types of tubing is acceptable, consideration is to be given to such factors as dielectric properties, heat and moisture resistance, and similar conditions. Thermoplastic tape shall not be used to wrap a sharp edge.

15.4 Where stranded internal wiring is connected to a wire binding screw, loose strands of wire shall not contact any other uninsulated live part that is not always of the same polarity as the wire nor any dead metal part. Separation may be accomplished by the use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of wire together, or a means determined to be equivalent.

15.5 A splice, tap, or exposed terminal shall be enclosed in metal, glass, marble, ceramic, phenolic, or suitable thermoplastic material.

16 Current-Carrying Parts

16.1 A current-carrying part shall be of silver, cooper alloy, stainless stell or other similar metal.

16.2 Ordinary iron or steel shall not be used for a current-carrying part.

Exception: Ordinary iron or steel provided with a corrosion resistant coating, may be used for a current-carrying part if acceptable in accordance with 6.2 – 6.25 or within a motor or associated governor.

17 Separation of Circuits

17.1 General

17.1.1 Unless supplied with insulation rated for the highest voltage involved, insulated conductors of circuits connected to separate sources of supply shall be separated by barriers or other means. An insulated conductor of one circuit shall be separated from any uninsulated live part of a different circuit.

17.1.2 Separation of insulated conductors may be accomplished by clamping, routing, or a means determined to be equivalent that maintains permanent separation from insulated or uninsulated live parts of a different circuit.

17.2 Barriers

17.2.1 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of insulating material (not fiber), shall have the required mechanical strength if exposed or otherwise likely to be subjected to mechanical abuse, and shall be securely held in place. Unclosed openings in a barrier for the passage of conductors shall not be larger than 1/4 inch (6.4 mm) and shall not exceed in number the total number of wires that pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may contact it, and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the required wires.

17.2.2 A metal barrier shall have a thickness at least as large as the minimum required thickness of the enclosure material. A barrier of insulating material shall be at least 0.028 inch (0.71 mm) thick. A barrier shall be to able withstand mechanical abuse that could otherwise defeat its purpose.

18 Insulating Material

18.1 Material for mounting an uninsulated live part shall be porcelain, or constructed of a similar composition that has been determined equivalent. Moisture absorptive material shall not be used for electrical insulation.

Exception: Moisture absorptive material may be used if it is sealed in areas where moisture will not enter and where it is inaccessible to the user.

18.2 A thermoplastic material generally is not considered acceptable for the sole support of an uninsulated live part, but may be employed if determined to have the necessary mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric properties, and other applicable characteristics.

18.3 A small, molded part such as a brush cap shall be constructed to have the mechanical strength and rigidity required to withstand the stress of actual service. A brush cap shall be secured or located so that it will not be subjected to mechanical abuse under conditions of intended use.

19 Interconnecting Cords and Cables

19.1 A flexible cord or cable assembly used for external connection between sections of an appliance or between an appliance and an accessory intended for use with that appliance shall be of a type determined to be equivalent to or heavier than the supply cord of the appliance.

19.2 An interconnecting cable or flexible cord as described in 14.3.1 shall be permanently connected at the accessory or additional appliance end at the factory, and shall not be constructed, intended, or readily adaptable for field disconnection at that end.

Exception: For household indoor aquarium equipment, detachable low voltage non-immersed output connections of isolated power supply are allowed when the voltage does not exceed Class 2 wet limits in Table 71.1. When the voltage of these connections exceeds limits in Table 71.1 but within Class 2 limits, the detachable connection of power unit shall have:

a) Minimum of 5 feet (1.52 m) from the point where the cord enters the non submersible aquarium appliance; and

b) Minimum of 6 feet (1.83 m) from the point where the cord enters the submersible aquarium appliances.

19.3 A plug shall be factory installed on the free end of the flexible cord specified in 19.2. This plug shall not fit into a parallel blade attachment receptacle or wall outlet.

20 Motors

20.1 General

20.1.1 A motor shall be capable of handling the maximum load imposed by the appliance without introducing a risk of fire, electric shock, or injury to persons.

20.1.2 A motor winding shall resist the absorption of moisture. Enameled wire is not required to be additionally treated to reduce the absorption of moisture. However, fiber slot liners, cloth coil wrap, and moisture absorptive materials determined to be equivalent shall be impregnated or otherwise treated to reduce such absorption.

20.1.3 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 are retained to the degree required to keep:

a) Accessible dead metal parts from becoming energized and

b) Live parts from becoming accessible.

20.2 Overload protection

20.2.1 An appliance using a motor with a frame diameter of 7 inches (178 mm) or less, rated at 1 horsepower (746 W) or less, that is intended to be remotely or automatically controlled or that may be operated while unattended, shall incorporate thermal or overcurrent protection so that it will not attain temperatures higher than those indicated in 46.4.1.1 and 46.4.1.2. The motor shall not burn out, and there shall not be evidence of a risk of fire as a result of testing.

Exception: An impedance-protected motor is not required to have additional thermal or overcurrent protection.

20.2.2 For a multispeed motor of any of the types mentioned in 20.2.1 that employs a separate overcurrent protective device to provide running overcurrent protection, the requirement applies at all speeds at which the motor is intended to operate.

20.2.3 A motor provided with inherent over-temperature protection complying with 6.16.3.1 or an impedance protected motor complying with 6.16.3.2 (unless the impedance-protected motor is subjected in the appliance to a condition such as restricted ventilation, proximity to an external heat source, and the like), is considered to comply with the requirements in 20.2.1 – 20.2.6 without further testing.

20.2.4 The motor of an appliance shall incorporate thermal or overload protection that complies with the requirements in 46.4.1.1 – 46.4.1.4.

20.2.5 A thermal or overcurrent protective device shall not open the circuit during the temperature test in the Normal Temperature Test, Section 41.

20.2.6 The functioning of any motor protective device provided as part of an appliance shall not result in any increase in the risk of fire or electric shock.

20.3 Insulation systems

20.3.1 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 Primary Class A insulating materials and minimum thickness, Table 20.1 at the thicknesses specified are permitted to be used without further evaluation.

20.3.2 For Class A insulation systems employing other materials or thinner materials than those indicated in Primary Class A insulating materials and minimum thickness, Table 20.1 or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements in 20.3.3.

Table 20.1
Primary Class A insulating materials and minimum thicknesses

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

20.3.3 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 63.

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

20.3.4 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.

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

21 Overcurrent Protective Devices

21.1 A protective device such as a fuse, whose normal function requires removal or replacement, shall be in an accessible location. However, such a device shall be inaccessible from outside the appliance unless a door or cover is opened. The use of a tool shall be required in order to open such a door or cover.

Exception No. 1: The protective device is not required to be accessible when the appliance, with the device shunted out of the circuit, complies with all requirements.

Exception No. 2: The operating handle of a circuit breaker, the operating button of a manually resettable motor protector, and similar parts, but not including the knob of an extractor type fuseholder, may project outside the appliance enclosure.

21.2 No uninsulated live part other than the screw shell or clips of a fuseholder shall be exposed to contact by persons removing or replacing the fuse.

21.3 A fuseholder or other overcurrent protective device shall be connected in the unidentified power supply conductor. The screw shell of a plug type fuseholder shall be connected toward the load.

22 Spacings

22.1 An uninsulated live part shall be spaced from another such part connected to a different circuit (line or low voltage) as though they were parts of opposite polarity as described in 22.2 – 22.4.

22.2 The spacing between uninsulated live parts of opposite polarity and between such a part and dead metal that may be grounded in service shall not be specified for parts of circuits classified as low voltage.

22.3 The spacing between field-wiring terminals of opposite polarity and between a field-wiring terminal and any other uninsulated electrically conductive part not of the same polarity shall not be less than indicated in Table 22.1.

Table 22.1
Spacings at field-wiring terminals

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

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

[b] A spacing of not less than 3/8 inch (9.5 mm) through air or over surface is acceptable at wiring terminals in a wiring compartment or terminal box if it is integral with the motor.

22.4 The spacing between an uninsulated live part and a dead metal part that is exposed to contact by persons or that may be grounded shall not be less than indicated in Table 22.2. If an uninsulated live part is not rigidly fixed in position by means of other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing is maintained.

Exception No. 1: The spacing may not be less than 3/64 inch (1.2 mm) between an isolated dead metal part interposed between or in close proximity to:

a) Live parts of opposite polarity,

b) A live part and an exposed dead metal part, or

c) A live part and a dead metal part that may be grounded.

However, the total spacing between the isolated dead metal part and the two other parts shall total at least the value indicated in Table 22.2.

Exception No. 2: At a terminal screw or stud to which connection may be made in the field by means of wire connectors, eyelets, and similar parts, spacings shall not be less than those specified in Table 22.1. However, the connectors, eyelets, and similar parts shall be in such position that the smallest spacings to opposite polarity and to dead metal are present at the screw or stud.

Table 22.2
Spacings at other than field-wiring terminals[a]

Potential involved in volts	Parts involved	Minimum spacings							
		Motor diameter 7 inches (178 mm) or less[b]				Motor diameter greater than 7 inches (178 mm)[b]			
		Over surface,		Through air,		Over surface,		Through air,	
		inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 125	Commutator or collector rings of a motor	1/16	1.6	1/16	1.6	3/16[c]	4.8	1/8[c]	3.2
	Elsewhere in the appliance	3/32[d]	2.4	3/32[d]	2.4	1/4[c,e]	6.4	1/8[c,e]	3.2
126 – 250	Commutator or collector rings of a motor	1/16	1.6	1/16	1.6	3/16[c]	4.8	3/16[c]	4.8
	Elsewhere in the appliance	3/32	2.4	3/32	2.4	1/4[c,e]	6.4	1/4[c,e]	6.4
251 – 600	Commutator or collector rings and live parts of the rigging of a motor	1/4	6.4	1/4[f]	6.4	3/8	9.5	1/4	6.4
	Elsewhere in the appliance	1/2[e,f]	12.7	3/8[e,f]	9.5	1/2[e]	12.7	3/8[e]	9.5

[a] Spacings of not less than 1/16 inch (1.6 mm) are acceptable at a heating element, and are acceptable throughout an aquarium heater rated 250 V or less.

[b] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes, and the like used solely for motor mounting, assembly, or connection.

[c] Spacings of not less than 3/32 inch (2.4 mm) are acceptable throughout a universal motor.

[d] For a motor rated at 1/3 horsepower (249 W) or less, these spacings may not be less than 1/16 inch (1.6 mm).

[e] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) (over surface and through air) between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

[f] Spacings inside a motor may not be less than 1/4 inch (6.4 mm), except a through-air spacing involving a collector ring may not be less than 1/8 inch (3.2 mm).

22.5 An insulating lining or barrier of insulating material employed where spacings would otherwise be insufficient shall be at least 0.028 inch (0.71 mm) thick and shall be so located or of such material that it will not be adversely affected by arcing. Insulating material not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception: Insulating material having a thickness less than that specified may be used if such a material is determined to be acceptable for the intended use.

22.6 The spacing requirements in this section do not apply to the inherent spacings of a component, such as a snap switch. These components are to be evaluated under the individual requirements for the particular component. For a repulsion motor, a repulsion induction motor, or a repulsion start induction motor, the spacing requirements do not apply to the commutator, the brush assembly, and the jumpers that short circuit the brushes. Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with regard to the stator circuits, and the appropriate spacing is required between uninsulated stator and rotor conductors.

22.7 In applying Table 22.2 to an appliance incorporating two or more motors of different sizes, the spacings inside each motor are to be evaluated using the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1. The spacings elsewhere in the appliance are to be evaluated on the basis of the size of the largest motor in the appliance.

23 Alternate Spacings – Clearances and Creepage Distances

23.1 As an alternative to the specified spacing requirements of this Standard, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are able to be used for spacings on printed wiring boards. The spacing requirements in UL 840 are not to be used for field wiring terminals and spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be identified and is to modify those characteristics given in 23.2 – 23.3, as appropriate.

23.2 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the degree of pollution expected or controlled will be as indicated in Table 23.1.

Table 23.1
Degrees of pollution

Equipment pollution degree	Equipment pollution degree
Hermetically sealed or encapsulated equipment without contaminating influences or printed wiring boards with a protective coating.	1
Totally enclosed equipment for use in a clean environment.	2
Open equipment for use in a clean environment.	3

23.3 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the equipment will be identified by overvoltage categories as indicated in Table 23.2.

Table 23.2
Overvoltage categories

Equipment overvoltage category	Equipment overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected.	II
Power-limited and safety low voltage.	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.	

23.4 Printed-wiring boards constructed of Types XXXP, XXXPC, G-10, FR-2, FR-3, FR-4, FR-5, CEM-1, CEM-3, GPO-2, or GPO-3 industrial laminates in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed-Wiring Boards, UL 746E, are determined to have a minimum comparative tracking index of 100 without further investigation.

24 Antisiphoning

24.1 An aquarium air pump provided with a power supply cord shall also be supplied with a check valve, or other means determined to be equivalent, to reduce the risk of backflow of liquid that may result in a risk of electric shock. This check valve may be provided as part of the air hose if applicable installation instructions are provided. The means of backflow prevention shall be investigated by testing in accordance with 52.1. In lieu of the backflow prevention, a pump may be marked as shown in 68.1.4.

Exception: An aquarium air pump intended for direct connection to an outlet receptacle by means of integral attachment plug blades, with no power supply cord provided shall not be marked as described in 68.1.4. Such a pump shall be provided with a check valve or other means determined to be equivalent to reduce the risk of liquid backflow.

25 Reduction of Risk of Injury to Persons

25.1 General

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

25.2 Sharp edges

25.2.1 A material (including glass) that is used as a portion of an appliance other than on an immersible heater shall be such that no sharp edges are exposed to contact by the user when the appliance is subjected to a mechanical abuse test as outlined in 53.1 and 53.2.

25.2.2 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 shall not cause lacerations or cuts during intended use or user maintenance.

25.3 Switches, controls, interlocks

25.3.1 The details of guards, safety releases, interlocks, and the like are not specified, but the need for such accessory protection and its acceptability shall be determined from a study of the complete appliance, its operating characteristics, and the likelihood of injury occurring from other than gross negligence.

25.3.2 A motor control switch on the appliance (other than a momentary contact switch) shall have a plainly marked off position.

Exception: A switch is not required to be marked if energization of the appliance cannot result in a risk of injury to persons.

25.3.3 If an automatic reset protective device is employed in an appliance, the automatic restarting of the motor shall not result in the risk of injury to persons.

25.3.4 The requirement in 25.3.3 specifies the use of an electrical interlock in the appliance when moving parts or the like can cause injury to persons upon the automatic restarting of the motor.

25.4 Materials

25.4.1 The material of a part (such as an enclosure, a frame, a guard, or similar parts), the breakage or deterioration of which might result in the risk of injury to persons, shall have such properties as to meet the demand of expected loading conditions.

25.4.2 The requirement in 25.4.1 applies to those portions of a part adjacent to a moving part considered to be capable of causing an injury.

25.5 Rotating or moving members

25.5.1 A rotating member, the breakage of which might result in a risk of injury to persons, shall be constructed so as to reduce that risk of breakage or the release or loosening of a part that could become a hazard.

25.5.2 An appliance employing a series motor shall be tested as described in 46.4.2.1 to determine whether it complies with the requirement in 25.5.1.

25.5.3 A rotating or moving part shall be provided with a means to retain a part in place under conditions of use if that part has a tendency to become disengaged or cause a risk of injury to persons.

26 Switches and Controllers

26.1 A switch or other control device shall be of a type for the intended use and shall not have a rating less than that of the load it controls. An aquarium appliance shall not employ a through-cord switch.

26.2 With reference to the requirement in 26.1, the current rating of the switch that controls an inductive load other than a motor, such as a transformer or an electric discharge lamp ballast, shall be at least twice the full load current of the inductive load unless the switch has been evaluated for the intended use.

26.3 A switch or other device that controls a solenoid, relay, coil, or similar part, and that has not been previously evaluated shall be subjected to an overload test as described in 54.1.1.

26.4 A manually operated motor control switch shall be provided in a cord-connected appliance that employs a motor rated greater than 1/3 horsepower (249 W).

26.5 A switch that controls a lampholder for an incandescent lamp, other than a 15 watt or smaller pilot or indicating lamp, shall be for use with tungsten filament lamps or shall have a current rating at least equivalent to six times the steady state tungsten load for alternating current, or ten times the steady state load for direct current.

26.6 A switch of the single-pole type shall not be connected in the conductor intended to be grounded as described in 10.3.3.2 and 10.3.3.3.

27 Controls – End Product Test Parameters

27.1 General

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

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

27.2 Auxiliary controls

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

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

Exception: An auxiliary control that complies with a component standard(s) specified in Controls, 6.6, is considered to fulfill this requirement

27.3 Operating controls (regulating controls)

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

a) Control action Types 1 or 2;

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

c) Installation Class 2 per Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test, IEC 61000-4-5;

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

e) For the applicable Material Group, see Table 27.2;

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

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

a) Control action Types 1 or 2;

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

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

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

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

Table 27.1
Overvoltage categories

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

Table 27.2
Material group

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

Table 27.3
Pollution degrees

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

27.4 Protective controls (limiting controls)

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

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

a) Failure-Mode and Effect Analysis (FMEA) or equivalent Risk Analysis method;

b) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 10°C and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section 41;

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 of UL 60730-1 shall be conducted at ambient temperatures of 10.0+2°C and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section 41. The test shall be conducted for 14 days; and

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test; see Section 41

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

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

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

b) A field strength of 3 V 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 (0°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 equipment 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; and

j) Conduct a failure-mode and effect analysis (FMEA).

k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

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

27.5 Controls using a temperature sensing device

27.5.1 A temperature sensing positive temperature coefficient (PTC) or 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.

28 Lampholders

28.1 The screw shell metal of a lampholder shall be stainless steel, nickel-plated aluminum, or nickel-plated copper alloy unless the lampholder is located so that it is unlikely to be exposed to moisture.

28.2 The spacing between an uninsulated live part, such as a screw shell or lamp envelope, and water in an aquarium tank shall not be less than 1/2 inch (12.7 mm). In measuring the distance between the water and a lamp envelope, it is to be assumed that the lamp envelope is symmetrical about the screw shell axis. The spacing shall be evaluated with the appliance installed as discussed in the instruction manual, on an aquarium tank having the dimensions specified in the instruction manual. The aquarium tank is to be filled with the maximum quantity of water it can hold. Any accessory or part of the appliance that is removable without the use of a tool is to be removed for the purpose of this requirement.

28.3 A lampholder shall be constructed of porcelain, cold-molded phenolic, urea, or other moisture-resistant material determined to be equivalent.

28.4 The requirements in 28.3 preclude the use of fiber as electrical insulation in lampholders.

29 Capacitors

29.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line (such as for radio interference elimination or power factor correction) shall be housed within an enclosure or container so that the plates will not be subject to mechanical abuse, and there will not be emission of flame or molten metal resulting from failure of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm). Sheet metal less than 0.026 inch (0.66 mm) thick is not recommended.

Exception: The individual container of a capacitor may be of sheet metal thinner than specified or of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance, provided that such a box, case, and similar housing is acceptable for the enclosure of current-carrying parts.

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

30 Electronic Control Equipment

30.1 Electronic control components or devices shall have a performance level determined to be equivalent to other such controls or devices.

30.2 Electronic control equipment shall be investigated as a system in addition to the investigation of individual components.

30.3 Breakdown of any electronic component shall not result in a risk of fire, electric shock, or injury to persons within the unit or in the equipment controlled.

30.4 Compliance with 30.3 requires analysis of the circuit and may require the opening and shorting of each component in turn while observing the ultimate operating condition. If the circuit opening or shorting of a component may result in a risk of fire, injury to persons, or electric shock, the reliability of the component (the probability that the component will perform its intended function under a specified set of environmental conditions and over a specified period of time) shall be investigated.

30.5 Environmental and field conditions such as ambient temperature, vibration, thermal shock, electrical transients, moisture, and the like shall be considered in investigating electronic control systems.

31 Printed Wiring Boards

31.1 General

31.1.1 A resistor, capacitor, inductor, transformer, transistor, diode, or other component or part that is mounted on a printed wiring board to form a printed wiring assembly shall be securely held in place.

31.1.2 Consideration is to be given to the mechanical protection and electrical insulation afforded to a component or part by the presence of a barrier or partition.

31.2 Spacings on printed wiring boards

31.2.1 As an alternative to the spacing requirements of Spacings at other than field-wiring terminals, Table 22.2, 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.

31.2.2 The following end use factors from this Standard shall be applied:

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

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

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

31.2.3 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.

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

32 Thermostats

32.1 A thermostat shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, and shall be subjected to the test described in 55.1.1. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception: A thermostat is not required to be subjected to the test specified in 55.1.1 if:

a) The heater does not exceed the maximum allowable temperature when the thermostat is bypassed (shorted out) and

b) The thermostat is not likely to be defeated by the user.

33 Fusible Links

33.1 A fusible link shall comply with the requirements for such a component. It shall be capable of opening the circuit in the intended manner. It shall not cause the short circuiting of live parts nor cause them to be grounded to the enclosure when the appliance is connected to a voltage circuit as specified in 37.2 and operated to cause abnormal heating. Such a fusible link shall comply with the test requirements in 55.2.1.

34 Rectifiers

34.1 When an appliance uses a combination of a rectifier and an electrolytic capacitor, no increase in the risk of fire, electric shock, or injury to persons shall result when either component is short circuited.

35 Heating Elements

35.1 A heating element shall be supported and shall be guarded against mechanical damage and contact with outside objects. In the investigation of an element supporting means, consideration is to be given to sagging, loosening, and other adverse results of continuous heating.

35.2 Any heating element that may be contacted by the user during intended use or cleaning shall not be of the open wire type.

35.3 An appliance in which the heating element is intended for operation only when provided with a cooling air blast shall be wired or constructed so that the element can be operated only when the cooling effect of the air blast is provided. An appliance in which the cooling effect of the motion of a part is required to preclude excessive temperatures shall be wired or constructed so that the element cannot be operated without such motion.

36 Attachments

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

36.2 The literature accompanying a package containing a basic appliance and attachments intended to be marketed as a complete unit shall indicate what attachments are intended for use with the basic appliance if use of such attachments exposes the user to the likelihood of injury.

36.3 An attachment that is packaged and marketed separately from the basic appliance and recommended by the manufacturer for use on the basic appliance shall be marked in a manner that identifies the basic appliance with which it is intended to be used. The identification shall appear in at least one of the following locations:

a) On the attachment,

b) On the package housing the attachment,

c) In the instruction book for the basic appliance, or

d) In information furnished with the attachment.

PERFORMANCE

37 General

37.1 The tests outlined in these requirements are to be conducted, if possible, in the order in which they are presented.

37.2 Unless otherwise specified, test voltages used in all tests are to be as shown in Table 37.1.

Table 37.1
Test voltages

Voltage rating of appliance	Test voltage
Appliances rated with a single voltage within the ranges 110 – 120 (inclusive) or 240 – 250 (inclusive)	Highest voltage of range
Appliances rated with a single voltage not within one of the ranges given above	Rated single voltage
Appliances rated with a range of voltages that may or may not coincide with one of the ranges given above	Highest voltage of rated range

38 Leakage Current Test

38.1 The leakage current of a cord-connected aquarium appliance (including any accessory intended for use with the appliance) when tested in accordance with 38.3 – 38.7 shall not exceed:

a) 0.5 milliampere for an ungrounded 2-wire product,

b) 0.5 milliampere for a grounded 3-wire portable product, and

c) 0.75 milliampere for a grounded 3-wire product:

1) Employing a standard attachment plug rated 20 amperes or less and

2) Intended to be fastened in place or located in a dedicated space.

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

38.3 Any exposed conductive surface is to be tested for leakage current. The leakage current from such a surface is to be measured to the grounded supply conductor individually as well as collectively where more than one surface is simultaneously accessible, and from one such surface to another. A surface is considered accessible unless protected against inadvertent contact by an enclosure or equivalent that meets the requirements of Accessibility of Live Parts, 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 that are considered not to present a risk of injury.

38.4 If part or all of an enclosure is of a material other than metal, a piece of metal foil measuring 4 by 8 inches (100 by 200 mm) is to be placed on the enclosure so that all of the foil is in close contact with the

surface of the appliance. Leakage current is then to be measured from the foil to the grounded supply conductor, and from the foil to exposed conductive surfaces of the appliance. The foil is not to be left in place long enough to affect the temperature of the appliance.

Exception: For a surface smaller than 4 by 8 inches, the piece of metal foil is to be the same size as the surface.

38.5 The measurement circuit for leakage current is to be as shown in Figure 38.1. The ideal measuring instrument is defined in (a) – (d) below. The meter that is actually used for a measurement need only indicate the same electrical value for a particular measurement as would the ideal instrument; it need not have all the attributes of the ideal instrument.

a) The ideal meter has an input impedance of 1500 ohms resistivity shunted by a capacitance of 0.15 microfarad.

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

c) The ideal meter, over a frequency range of 0 – 100 kilohertz, has a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of a 1500 ohm resistance shunted by a 0.15 microfarad capacitance of 1500 ohms. At an indication of 0.5 or 0.75 milliampere the measurement is to have an error of not more than 5 percent at 60 hertz.

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

38.6 A sample of the appliance is to be tested for leakage current starting with the as-received condition but with its grounding conductor (if any) open at the attachment plug. In the as-received condition, the appliance shall not have been previously energized except as may have occurred during production-line testing. The supply voltage sequence with reference to the measuring circuits shown in Figure 38.1 is to be as follows:

a) With switch S1 open, the appliance is to be connected to the measuring circuit, and the leakage current is to be measured using both positions of switch S2 with the appliance switching device in all intended operating positions.

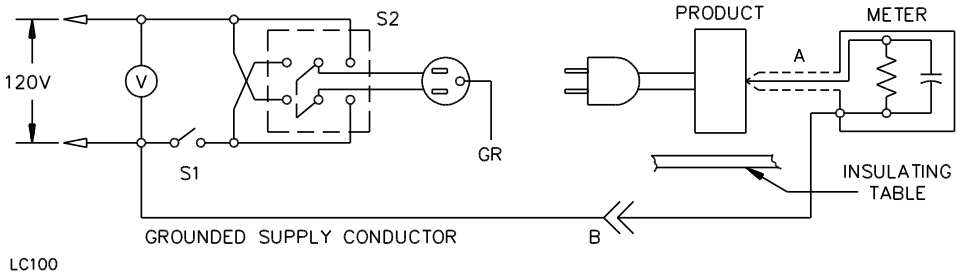
b) Switch S1 is then to be closed, energizing the appliance, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2 with the appliance switching devices in all intended positions.

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

38.7 A sample is to be carried through the complete leakage current test program without interruption for other tests. However, with the concurrence of all concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive testing.

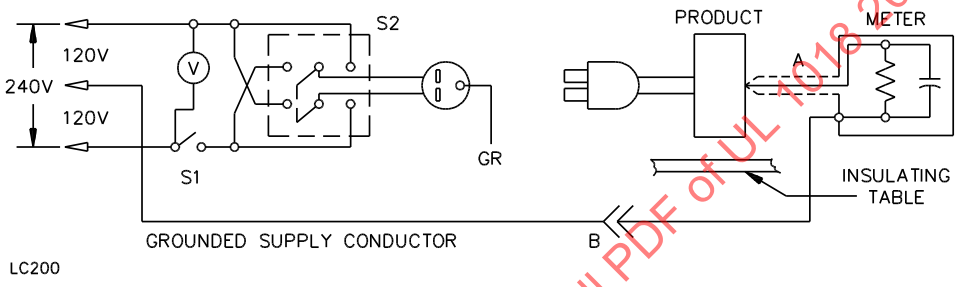
Figure 38.1

Leakage current measuring circuits



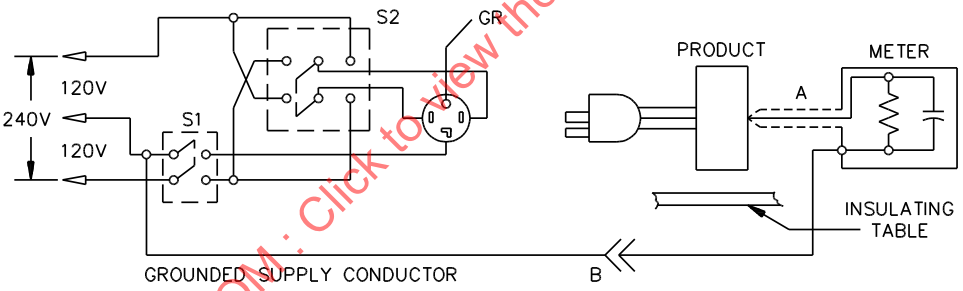
LC100

Appliance intended for connection to a 120-volt power supply.



LC200

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



LC300

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

A – Probe with shielded lead.

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

39 Insulation Resistance Test

39.1 Where measurement of the insulation resistance is required (for permanently-connected appliances), a DC voltage of approximately 250 volts is to be applied between exposed dead-metal parts of the appliance and the appliance supply conductors connected together. A voltmeter, having an internal resistance of at least 30,000 ohms, is to be connected in series with the DC voltage source and the supply conductors. The DC line voltage is to be measured using a separate AC-DC voltmeter. See Figure 39.1. The insulation is to be calculated using the following circuit equation:

$$R_i = \left(\frac{V_1 - V_S}{V_S} \right) R_S$$

in which:

R_i is the insulation resistance of the test sample,

V_1 is the DC line voltage (reading given on AC - DC voltmeter),

V_s is the voltage across series voltmeter (reading given on series voltmeter), and

R_s is the resistance of series voltmeter using the following equation:

$$R_S = M_S V_m$$

in which:

M_s is the deflection sensitivity of the series voltmeter in ohms/volts and

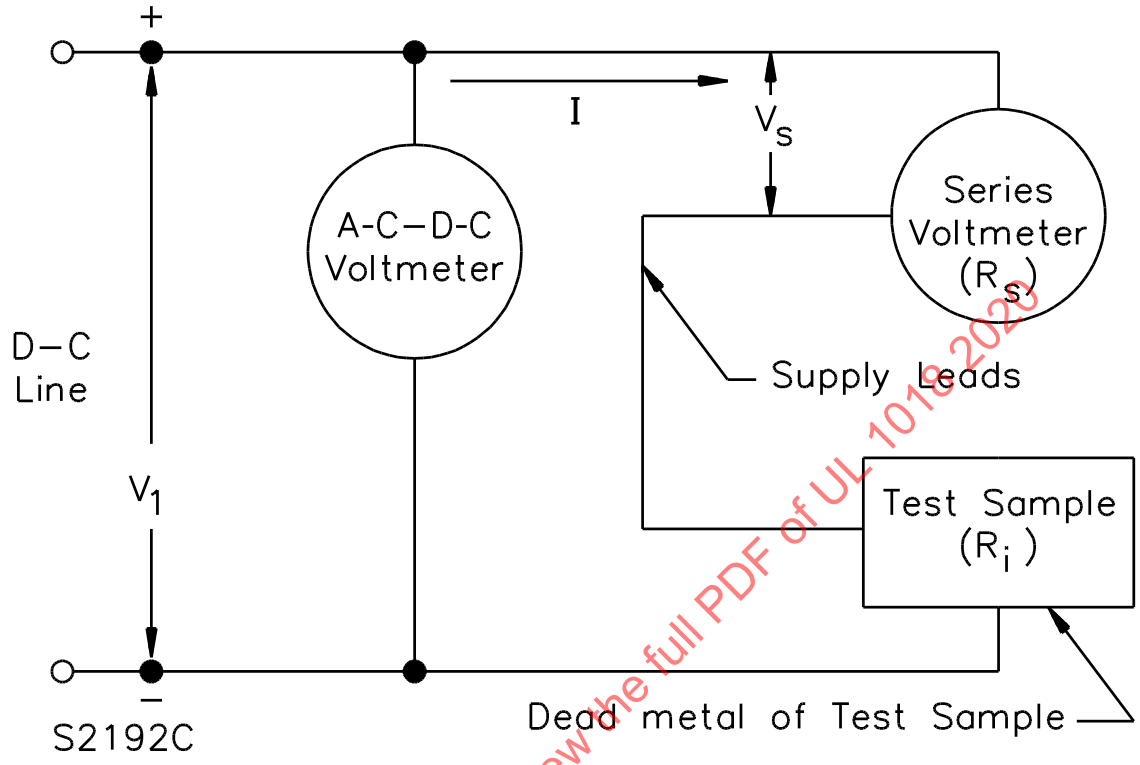
V_m is the maximum voltage which can be read on the scale being used.

The calculated insulation resistance shall not be less than 50,000 ohms.

Exception: It is acceptable for self-contained laboratory grade instrumentation that produces equivalent results, such as a megohmmeter with an open circuit output of 500 volts, to be used in place of the two-voltmeter circuit shown in Figure 39.1.

Figure 39.1

Two-voltmeter method of measuring insulation resistance



40 Input Test

40.1 The current or wattage input to an appliance is to be measured when an appliance is operated under the conditions of maximum intended load as described in 41.2.1– 41.7.1 and when connected to a supply circuit of maximum rated voltage and rated frequency. The test voltage is to be as specified in Table 37.1. The measured current or wattage input shall not be more than 105 percent of the marked electrical rating on the appliance.

41 Normal Temperature Test

41.1 General

41.1.1 An appliance is to be tested under conditions of maximum intended load as described in 41.2.1 – 41.2.3. A temperature shall not be recorded at any point that is sufficiently high to cause a fire or to damage any material used in the appliance. There shall not be temperature rises at specific points greater than those indicated in Table 41.1.

41.1.2 The temperature rise values in Table 41.1 are based on an ambient temperature of 25°C (77°F), but the tests may be conducted at ambient temperatures of 10 – 40°C (50 – 104°F).

Table 41.1
Maximum temperature rises

Materials and component parts	Degrees, °C	Degrees, (°F)
1. Varnished-cloth insulation	60	108
2. Fuses	65	117
3. Wood and other similar material	65	117
4. Unimpregnated glass fiber	225	405
5. A surface upon which a cord-connected or permanently wired appliance is likely to be mounted in service, and surfaces that are likely to be adjacent to the appliance when it is so mounted	65	117
6. Class A insulation systems on coil windings of AC motors having a frame diameter (see note a to Table 22.2) of more than 7 inches (178 mm) and of DC and universal motors:		
a) In open motors:		
Thermocouple method	65	117
Resistance method	75	135
b) In totally enclosed motors:		
Thermocouple method	70	126
Resistance method	80	144
7. Class A insulation systems on coil windings of AC motors having a frame diameter (see note a to Table 22.2) of 7 inches (178 mm) or less (not including universal motors):		
a) In open motors (thermocouple or resistance method)	75	135
b) In totally enclosed motors (thermocouple or resistance method)	80	144
8. Class 105 insulation systems on vibrator coils (thermocouple or resistance method	75	135
9. Class 105 insulation systems on windings of relays, solenoids, magnets, and the like:		
Thermocouple method	65	117
Resistance method	85	153
10. Class B insulation systems on coil windings of AC motors having a frame diameter (see note a to Table 22.2) of more than 7 inches (178 mm) and of DC and universal motors:		
a) In open motors:		
Thermocouple method	85	153
Resistance method	85	153
b) In totally enclosed motors:		
Thermocouple method	90	162
Resistance method	100	180
11. Class B insulation systems on coil windings of AC motors having a frame diameter (see note a to Table 22.2) of 7 inches (178 mm) or less (not including universal motors):		
a) In open motors (thermocouple or resistance method)	95	171
b) In totally enclosed motors (thermocouple or resistance method)	100	180
12. Class E system on coil windings of an ac motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor.		
a) In open motors (thermocouple or resistance method)	85[a]	153[a]
b) In totally enclosed motors (thermocouple or resistance method)	90	162
13. Class E system on coil windings of an ac motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor.		
a) In open motors		
Thermocouple method	75[a]	135[a]

Table 41.1 Continued on Next Page

Table 41.1 Continued

Materials and component parts	Degrees, °C	Degrees, (°F)
Resistance method	85	153
a) In totally enclosed motors		
Thermocouple or resistance method	80	144
Resistance method	90	162
14. 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 open motors		
Thermocouple method	110	198
Resistance method	120	216
b) In totally enclosed motors		
Thermocouple method	115	207
Resistance method	125	225
15. 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 open motors:		
Thermocouple or Resistance method	120	216
b) In totally enclosed motors:		
Thermocouple or Resistance method	125	225
16. Class 130 insulation systems on vibrator coils (thermocouple or resistance method)	95	171
17. Class 130 insulation systems on windings of relays, solenoids, magnets, and the like		
Thermocouple method	85	153
Resistance method	105	189
18. Phenolic composition employed as electrical insulation or as a part whose failure is likely to result in a risk of fire, electric shock, or injury to persons	125[a]	225[a]
19. Rubber- or thermoplastic-insulated wires and cords	35[a,b]	63[a,b]
20. On the surface of a capacitor rating:		
Electrolytic	40[c]	72[c]
Other types	65[d]	117[d]
21. Transformers with Class 105 insulation systems:		
Thermocouple method	65	117
Resistance method	75	135
22. At any point within a terminal box or wiring compartment of a permanently-connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 68.2.1	35	63

[a] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and determined to have heat-resistant properties.

[b] Rubber-insulated conductors within a Class A insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor are likely to be subjected to a temperature rise of more than 35°C (63°F) if a braid is used on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[c] An electrolytic capacitor operating at a temperature (not temperature rise) higher than 40°C (72°F) may be evaluated on the basis of its marked temperature rating. If not marked with a temperature rating, it may be investigated to determine its compliance at the higher temperature.

[d] A capacitor operating at a temperature (not temperature rise) higher than 65°C (117°F) may be evaluated on the basis of its marked temperature rating. If not marked with a temperature rating, it may be investigated to determine its acceptability at the higher temperature.

41.2 Maximum normal load

41.2.1 In testing an appliance, maximum normal load is considered to be that load that approximates the most severe conditions of use during intended operation. It is not a deliberate overload; however the conditions of actual use may be somewhat more severe than the maximum load conditions recommended by the manufacturer. Test loads that have been found to be close approximations of the most severe conditions of intended use are described in 41.3.1 – 41.7.1 for some of the common forms of aquarium equipment.

41.2.2 If an appliance is not intended for continuous operation, the normal temperature test may be conducted in such a manner that it will take into consideration the probable intermittent or short term operation of the particular appliance.

41.2.3 For the tests described in this section, the appliance is to be mounted or supported as in service and tested under conditions approximating those of intended operation. Installation against a wall, in a right angle corner of a room, or in an alcove is to be simulated for an appliance that lends itself to such placement and when 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 feet (0.61 m) beyond the physical limits of the appliance. Temperatures are to be observed on nearby surfaces, on the supporting surface, at points of support, on any attachment plug, and at other points determined to be appropriate for the particular appliance.

41.3 Immersible heaters

41.3.1 For the normal temperature test, an immersion type aquarium heater is to be immersed in water to the water level marked on the product. It is then to be operated until temperature equilibrium has been reached. The test may be conducted in any convenient size container of water, but in the event of results that do not comply, it is to be repeated in both the minimum and maximum size tanks in which it is intended to be used as indicated in the instruction manual.

41.3.2 During the test specified in 41.3.1, a small water circulation is permitted to prevent more than 2°C (3.6°F) difference between the water temperature in the upper part of the tank and the water temperature in the bottom part of the tank. To accomplish this, a 26.5 gallons (100 L) per hour water pump should be used and located at the bottom of the tank, at least 19.5 inches (50 cm) from the heater, for an aquarium of 40 gallons (150 L) or less. For an aquarium of greater than 40 gallons (150 L), a 53 gallons (200 L) per hour water pump should be used and located at the bottom of the tank, at least 39 inches (100 cm) from the heater. If the difference in water temperature cannot be limited to 2° C (3.6° F) using the above configuration, the flow rate of the pump and/or the distance between the water pump and the heater can be adjusted as necessary until the desired condition is reached.

41.4 Water pumps

41.4.1 An aquarium water pump or motor-driven filter incorporating such a pump is to be operated as follows with the pump outlet open:

a) Under zero head of water for a centrifugal pump and

b) Under a 3-foot (0.91-m) head of water for all other type pumps.

41.5 Air pumps

41.5.1 An air pump is to be operated with its outlet open until thermal equilibrium is reached. The test is then to be repeated with the pump outlet blocked.

41.6 Aquarium stands

41.6.1 An aquarium stand, with or without heater elements, built-in tank illumination, and similar accessories is to be operated once while supporting the largest size aquarium permitted by its dimensions and once with the tank removed. The aquarium tank is to be filled to capacity. Each test is to be conducted until thermal equilibrium has been attained. All thermostats are to be adjusted for maximum temperature during both tests.

41.7 Reflectors

41.7.1 An aquarium reflector is to be operated while containing the maximum size and wattage lamp(s) specified by the manufacturer until thermal equilibrium is reached. The test is to be carried out with the reflector placed on a softwood board covered with a double layer of tissue paper.

41.8 Test voltages

41.8.1 Unless otherwise specified in 41.8.2 or 41.8.3, the test voltage is to be as specified in Table 37.1.

41.8.2 For an appliance containing a heater or incandescent lamp, the voltage specified in Table 37.1 is to be adjusted so that the wattage is equal to its marked wattage rating. However, in no case is the test voltage to be less than that indicated in the table.

41.8.3 When an appliance uses a motor in addition to a heating element, the voltage applied to an integrally connected motor is to be the test voltage specified in Table 37.1. A motor supplied from a separate circuit is to be connected to a test voltage derived from its marked voltage rating in accordance with Table 37.1.

41.9 Other test requirements

41.9.1 The temperature test on an appliance intended to be operated with a constant (noncycling) load is to be continued until temperatures become constant; that is, when three successive readings taken at intervals of 10 percent of the previously elapsed total duration of the test, but not less than 5 minute intervals, show no change in temperature. If ventilation of the appliance may be affected by opening doors, the test is to be repeated with any such doors opened.

41.9.2 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer type instrument; such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouples and related instruments are to be accurate and calibrated in accordance with laboratory practice. The thermocouple wire is to comply with the requirements for special tolerances thermocouples as listed in the Tolerances on Initial Values of EMF Versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M. A temperature is considered to be constant 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.

Exception: Temperatures may be determined by the change-of-resistance method for a coil that is inaccessible for mounting thermocouples (for example, a coil immersed in sealing compound) or if the coil wrap includes thermal insulation or more than two layers (1/32 inch or 0.8 mm maximum thickness) of cotton, paper, rayon, or similar material.

41.9.3 A thermocouple junction and the adjacent thermocouple lead wire are to be held securely in thermal contact with the surface being measured.

41.9.4 The temperature of a coil winding may be determined by the change-of-resistance method in accordance with the exception to 41.9.2 by comparing the resistance of the winding at the temperature to be measured with its resistance at a known temperature. The following formula is to be used to make such temperature determinations:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise,

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

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

k is 234.5 for copper or 225.0 for electrical conductor grade (EC) aluminum,

t_1 is the room temperature in degrees C at the end of the test, and

t_2 is the room temperature in degrees C at the beginning of the test.

41.9.5 For a thermocouple-measured temperature on the coil of a fractional horsepower alternating current motor other than a universal motor, the thermocouple is to be applied to the magnet wire, or it is to be separated from that wire by not more than the insulation on the conductor itself. For a thermocouple-measured temperature of a coil of any other motor, the thermocouple is to be mounted as described or it may be separated from the conductor by not more than the insulation on the conductor itself and the coil wrap.

41.9.6 The maximum acceptable sealing compound temperature, when corrected to a 25° C (77° F) ambient, shall be 15°C (27°F) less than the softening point of the compound as determined by the Test for Softening Point by Ring and Ball Apparatus, ASTM Designation E28-92. It should be noted that the temperatures given in this paragraph are absolute values, not temperature rises.

41.9.7 There is no temperature limit specified for beads of inorganic material, or similar materials used as conductor insulation. Copper conductors are limited to a maximum of 200°C (392°F).

41.9.8 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, can be used. However, supplementary heat resistant insulation with the required dielectric voltage-withstand properties is to be used on the individual conductors of the cord to protect the appliance against deterioration of the conductor insulation.

42 Dielectric Voltage-Withstand Test

42.1 General

42.1.1 An appliance is to be subjected to the application of a 2500 volt, 60 hertz, essentially sinusoidal potential for 1 minute, between:

a) Live parts and exposed dead metal parts,

b) Live parts of opposite polarity of a capacitor used for radio interference suppression or arc suppression, and

c) Any live parts of the primary circuit and live parts of the secondary circuit, with the appliance at the maximum operating temperature reached during intended use.

There shall not be a dielectric breakdown.

42.1.2 An aquarium heater that is either partially or completely immersed in water during use shall be tested once by applying the potential between live parts and exposed dead metal and once between live parts and water in which the heater is immersed to the level intended in use.

42.1.3 To determine whether an appliance complies with the requirements in 42.1.1, the appliance is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which can be varied and is essentially sinusoidal. The applied potential is to be increased from zero until the required test level is reached with the rate of increase as rapid as is consistent with correct indication of the test potential on a voltmeter. After the required test potential has been reached, it is to be maintained for 1 minute.

42.1.4 The following requirement is for a capacitor that is connected across the line or from line to ground where the strength of the charging current makes it impossible to maintain the required alternating current potential. The capacitor is to be subjected for 1 minute to a direct current potential of:

a) 1414 volts for equipment rated 250 volts or

b) 1414 volts plus 2.828 times the alternating current rated voltage (as determined in accordance with 37.2 and Table 37.1) for an appliance rated more than 250 volts.

The result complies if there is no evidence of dielectric breakdown.

42.2 Secondary circuits

42.2.1 A secondary circuit of an appliance shall withstand for 1 minute the application of a test potential:

a) Between primary and secondary circuits,

b) Between secondary circuits and grounded metal with all chassis-connected components disconnected at the chassis, and

c) Between secondary circuits supplied from separate transformer windings with common connections disconnected. If the secondary winding being tested is grounded, it is to remain grounded during the test.

The appliance is to be at its maximum normal operating temperature during the test. The test potential is to be as indicated in Table 42.1. While at its maximum normal operating temperature, each power transformer shall operate without breakdown while the potential indicated in Table 42.1 is induced for 1 minute in each secondary winding that normally operates at a higher potential than the primary.

Table 42.1
Dielectric voltage-withstand test potentials

Maximum voltage in circuit	Test potential
1000 or less	Three times maximum voltage, but not less than 500 volts
More than 1000	1750 volts plus 1.25 times the maximum voltage in the circuit

42.2.2 To determine whether an appliance complies with the requirements in 42.2.1, it is to be tested by means of a 500 volt-ampere or larger capacity supply, the output voltage of which can be varied. The

applied potential is to be increased from zero until the required test level is reached, and then maintained at that level for 1 minute. The increase in applied potential is to be at a substantially uniform rate, and is to be as rapid as is consistent with its value being correctly indicated by a voltmeter.

42.2.3 With reference to the applied potential mentioned in 42.2.2:

a) A 60 hertz essentially sinusoidal voltage is to be used for testing alternating current circuits.

b) An essentially sinusoidal source is to be used for the induced test potential to transformers. The frequency of the source may be in the range of 180 – 1000 hertz if necessary to prevent saturation of the core.

c) A direct current source is to be used for a direct current circuit.

43 Grounding Continuity Test

43.1 The resistance between the point of connection of the equipment grounding means, at or within the unit, and any other part of the grounding circuit is to be measured. The result complies if the resistance is not more than 0.1 ohm.

43.2 Any indicating instrument may be used to determine compliance with 43.1. However, if results do not comply, an alternating current of at least 25 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit. The resulting voltage drop is to be measured between the two points. Then, the resistance in ohms may be calculated by dividing the drop in potential (in volts) by the current (in amperes). The grounding conductor of a power supply cord is not to be tested by this method.

44 Repeated Leakage Test and Dielectric Test (After Conditioning)

44.1 A cord-connected aquarium appliance is to be exposed to air having a relative humidity of 93 ±2 percent at a temperature of 32.0 ±2°C (89.6 ±3.6°F) for 48 hours.

44.2 Following the initial leakage current measurement, the sample is to be cooled or heated to just above the test chamber temperature. Then, the sample is to be placed in a humidity chamber for 48 hours in accordance with 44.1.

44.3 Following the exposure and while still in the test chamber, the sample is to be subjected to a repeated leakage current test in accordance with the Leakage Current Test, Section 38. Results shall comply with Section 38.

Exception: The test is to be discontinued when the leakage current stabilizes or decreases.

44.4 While at the temperature specified in 44.1, the sample shall be subjected to the Dielectric Voltage-Withstand Test, Section 42. Results shall comply with Section 42.

45 Repeated Leakage Measurement Test – Heaters

45.1 An immersible aquarium heater is to be immersed in water 12 inches (305 mm) deep in a metal container filled with a standard test solution of hard water, as specified in 46.1.7. If the product floats, it is not to be forcibly submerged below the normal floating level. Leakage current is to be measured between the metal container and earth in accordance with the Leakage Current Test, Section 38, for a duration of 7 hours. The result complies if the leakage current does not exceed 5 milliamperes.

46 Abnormal Operation Test

46.1 General

46.1.1 It is possible that the intended operating conditions of an appliance are not representative of abnormal conditions likely to be encountered during actual service. An example is the operation of an immersible heater in a dry tank or while lying on a surface outside a tank. Therefore, an appliance is to be operated so that it can be determined whether an increase in the risk of fire, electric shock, or injury to persons exists under abnormal conditions.

46.1.2 Abnormal operation as described in 46.1.1 is not required to be limited to the tests described in this Section; additional testing may be conducted as required for the particular type of appliance.

46.1.3 To determine that a risk of fire, electric shock, or injury to persons is unlikely under abnormal conditions, a separate burnout or abnormal test is to be conducted with the appliance operating continuously until the ultimate result is observed. Such a test is to be conducted with the voltage specified in Table 37.1 and with the appliance mounted or supported as intended.

Exception: A cord-connected appliance intended to be installed in or attached to an aquarium tank is to be tested while resting on white tissue paper covering a softwood surface as well as while installed as intended on or in a dry aquarium tank.

46.1.4 Ultimate results usually occur in a 7-hour period following energization. Unless there is evidence that such results have not been observed, an abnormal test is normally discontinued after 7 hours.

46.1.5 When operated under the abnormal conditions specified, an appliance is considered to cause a fire when:

a) There is any emission of flame or molten metal (other than drops of melted solder) or

b) The operation of the appliance results in the glowing or flaming of combustible material upon which the appliance is resting or that may be in proximity to the appliance when installed as intended.

46.1.6 Risk of electric shock is considered to exist if:

a) For a cord-connected appliance, leakage current measured in accordance with the Leakage Current Test, Section 38, exceeds 5 milliamperes between any accessible part and ground or

b) For a permanently-connected appliance, the insulation resistance measured in accordance with the Insulation Resistance Test, Section 39, is less than 50,000 ohms.

Leakage current is not required to be measured at terminals operating at voltage levels considered to be nonhazardous. In the case of an appliance that uses a liquid in its operation, the liquid container is to be filled with the hard water solution described in 46.1.7 in the intended manner prior to the leakage current or insulation resistance measurement. Liquid need not be added if it is obvious that the appliance does not hold liquid. Otherwise, water in an amount equal to the capacity of the container is to be poured into the container, and the current (or voltage for insulation resistance) is to be measured as quickly as possible thereafter. Submersible or immersible aquarium equipment is to be submerged in the intended manner.

46.1.7 The hard water solution specified in 45.1 and 46.1.6 is to consist of 1/2 gram of calcium sulfate ($CaSO_4 \cdot 2H_2 0$) per liter of distilled water.

46.1.8 Standardized abnormal test conditions for most of the common types of aquarium appliances are described in 46.2.1 – 46.4.2.1.

46.2 Heater-motor combinations

46.2.1 An appliance using a motor that is connected across a portion of a resistive type heating element shall be subjected to an open circuit in the portion of the element that is shunting the motor. There shall be no risk of fire, electric shock, or injury to persons.

46.3 Immersible heaters

46.3.1 An immersible heater with its controls set for maximum heating is to operate in free air until it is well heated and then suddenly dipped into water at room temperature. After this test has been repeated five times, the result complies with the requirements if:

a) A dielectric voltage-withstand test shows no evidence of dielectric breakdown,

b) There are no adverse effects on the heater unit or its operation, and

c) There is no increased risk of fire, electric shock, or injury to persons.

46.3.2 A new sample of the immersible heater is to be tested by placing it on a softwood board covered with two layers of tissue paper. The heater is then to be covered with one layer of cheesecloth, and connected to a 60 hertz supply source in accordance with Table 37.1. All temperature-regulating devices are to be set to maximum heat, and the heater is to be operated for 7 hours or until ultimate results are observed. The result complies if:

a) There is no glowing or flaming of the cheesecloth or tissue paper,

b) The sample remains operable throughout the test, and

c) There is no indication of a dielectric breakdown during a repeat dielectric voltage-withstand test.

46.4 Motors and protectors

46.4.1 General

46.4.1.1 When the motor is operating with the maximum load that it is able to carry without causing a protective device to operate, the temperature on a Class A insulated motor winding shall not exceed 140°C (284°F). On a Class B insulated motor winding, the temperatures shall not exceed 165°C (329°F). The motor shall not burn out, and there shall not be evidence of a risk of fire as a result of the tests.

Exception: This requirement does not apply to the motor of a pump, fan, or blower intended to move air only.

46.4.1.2 When the rotor of a motor is locked, the temperature on the windings of the motor shall not exceed the value specified in Table 46.1. The average temperature is to be determined as follows. A graph of the motor temperature plotted against time is to be obtained for the second hour and the seventy-second hour of operation. For each of these periods, the average temperature is to be determined by taking:

a) The arithmetic mean of the maximum temperatures and

b) The arithmetic mean of the minimum temperatures.

The motor shall not burn out, and there shall not be evidence of a risk of fire as a result of the test.

Table 46.1
Maximum temperatures during locked-rotor test

	Maximum				Average			
	Class A insulation,		Class B insulation,		Class A insulation,		Class B insulation,	
	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
During first hour of operation	200	392	225	437	–	–	–	–
After first hour of operation	175	347	200	392	150	302	175	347

46.4.1.3 During the test described in 46.4.1.2, temperatures are to be measured by thermocouples on the surface of coils of the motor. The test on a manually reset protective device is to be continued for four operations of the protective device with the device being reset as quickly as possible after it opens. For an automatically reset device, the locked rotor test is to be continued for 72 hours unless the appliance includes other controls (such as a timer) that positively limit the duration of operation to a shorter period. During the test, the motor is to be connected to a supply circuit as specified in Table 37.1.

46.4.1.4 An automatically reset thermal protector of a motor shall perform as intended when operated for 15 days (unless the appliance includes other controls, such as a timer that positively limits operation to a shorter period or the device permanently opens the circuit before the 15 days has elapsed). The rotor of the motor is to be locked, and the motor is to be connected to a supply circuit of between 100 and 110 percent of the test voltage shown in Table 37.1. The result complies when:

a) There is no permanent damage to the motor, including significant deterioration of the insulation and

b) The device permanently opens the circuit and it does so without grounding to the motor frame, damaging the motor, or introducing any hazardous condition. A manual reset protector of a motor can be used if it is capable of interrupting the locked rotor current for 50 operations without damage to itself. The 15 days and 50 operations mentioned in this paragraph are in addition to the 72 hours and four operations required in 46.4.1.3.

46.4.1.5 Submersible/immersible water pumps are to be submerged and tested in the intended manner. The rotor of the motor is to be locked. Non-submersible/immersible water pumps are to be tested with the hydraulic circuit filled with the liquid in the intended manner prior to locking the rotor of the motor.

46.4.2 Series motor – overspeed

46.4.2.1 A series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times rated voltage. An appliance in which the rotating load may be varied is to be tested for each condition of loading that can occur. No parts that can create a hazard shall become loose.

46.5 Electronic components

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

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

46.5.2 The Dielectric Voltage-Withstand Test, Section 42 need be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

47 Mechanical Abuse Test – Immersible Heaters

47.1 General

47.1.1 Six samples of an immersible heater, three of which are in the as-received condition and three that have been conditioned at 70°C (158°F), or 10°C (18°F) higher than the temperature recorded on the enclosure during the temperature test (whichever is greater), are to be dropped three times each from a height of 3 feet (0.91 m) onto a hardwood surface. For each drop, each sample is to strike the hardwood floor in a different position. Following this test, the samples shall comply with 47.2.1.

47.2 Results

47.2.1 After testing in accordance with 47.1.1, the results comply when:

a) The samples comply with the criteria for insulation resistance as described in 48.1 with a cycling period of 3 days;

b) There is no breakage of the enclosure;

c) While immersed to their intended level in a standard hard water solution as described in 46.1.7, the samples comply with the criteria for leakage current in the Leakage Current Test, Section 38;

d) The probe illustrated in Figure 8.1 does not contact any uninsulated live part; and

e) Spacings are not reduced below the minimum values.

47.3 Pull and torque

47.3.1 Three samples of the heater are to be placed in an air oven maintained at 70°C (158°F), or 10°C (18°F) higher than the temperature measured on the enclosure during the temperature test, whichever is greater, for 30 days. The samples are then to be allowed to cool to room temperature before conducting pull torque tests. The pull test is intended to determine the force required to separate enclosure parts from the remainder of the assembly, while the torque test determines the force required to free parts that use torque to secure them to the unit. The values obtained in these tests are to be compared to those recorded for three different samples tested in the as-received condition. The results comply when:

a) For the as-received samples, there is no lessening of the forces required to achieve separation greater than 50 percent of the values observed;

b) With 50 percent of the pull and torque forces applied to the conditioned samples, there is no motion of parts likely to be pulled or torque in service; and

c) After the test, the dielectric voltage-withstand test shows no evidence of dielectric breakdown.

Exception: This requirement does not apply to parts that do not rely upon torque to secure them in position, nor to parts unlikely to be subjected to pulling or torque forces in actual service.

48 Immersion Test

48.1 Three new samples of an immersible heater are to be mounted in their intended manner or immersed to their intended level. The samples are then to be operated for cycles of 6 hours on, 18 hours

off, for a period of 30 days. The insulation resistance or leakage current shall then be measured, and the units are to be subjected to a repeated dielectric voltage-withstand test. As a result:

a) The insulation resistance shall not be less than 2 megohms for permanently-connected equipment or,

b) The leakage current shall not exceed the values specified in 38.1 for cord- and plug- connected equipment, and

c) There shall be no indication of dielectric breakdown.

During the 30-day conditioning period, and during the three tests following conditioning, the relative humidity is to be maintained at 95 ±5 percent, and the temperature at 32 ±2°C (89.9 ±3.6°F).

48.2 A submersible aquarium pump is to be mounted in its maximum intended depth level, given on instruction manual. The sample is to be operated continuously for a period of 30 days at maximum normal load unless it is equipped with an automatic or manual switch. In this case the pump shall be operated for cycles of 6 hours on and 18 hours off. The insulation resistance or leakage current shall then be measured, and the units are to be subjected to a repeated dielectric voltage-withstand test. As a result:

a) The insulation resistance shall not be less than 2 megohms for permanently-connected equipment; or

b) The leakage current shall not exceed the values specified in 38.1 for cord- and plug connected equipment; and

c) There shall be no indication of dielectric breakdown.

49 Aquarium Stands or Shelves Test

49.1 Overflow (all types)

49.1.1 A free standing aquarium stand or a unit intended for attachment to a wall or ceiling is to be placed on a standard 1 inch (25.4 mm) thick piece of test felt. Any detachable legs are to be removed from the stand of the unit. An aquarium tank of the maximum size that can be used on the stand is to be in place and filled to capacity with water. An amount of water equal to 150 percent of the tank capacity is to be permitted to overflow from the tank onto the stand or shelf. The overflow test is to be followed by repeated leakage current measurement for cord- and plug-connected equipment, or insulation resistance measurement for permanently-connected equipment, and a dielectric voltage-withstand test. As a result:

a) The leakage current measured shall not exceed the values specified in 38.1,

b) There shall be no indication of dielectric breakdown,

c) The insulation resistance shall not be less than 2 megohms, and

d) Disassembly and inspection shall reveal no water inside the stand.

49.2 Glass breakage (all types)

49.2.1 An aquarium shelf or stand, under the conditions described in 49.1.1, is to be loaded with a glass aquarium tank filled with water. Then, the tank is to be broken by means of an impact. Following the resultant wetting of the stand:

a) The insulation resistance shall not be less than 50,000 ohms for permanently-connected equipment or,

b) The leakage current shall not exceed the values specified in 38.1 for cord- and plug-connected equipment,

c) There shall be no evidence of dielectric breakdown, and

d) Disassembly shall reveal no water inside the stand or shelf unit.

49.3 Stability (free standing units)

49.3.1 A free-standing, electrically-wired aquarium stand is to be investigated for stability. The stand shall not tip over when tilted 10 degrees from its intended upright standing position in any direction under two conditions:

a) When an empty tank of the maximum size specified for the stand is mounted on the stand and

b) When a tank of the maximum size specified for the stand is in place and filled with water.

49.3.2 In a test to determine compliance with 49.3.1, the tank and stand combination, first as described in (a), and then as described in (b), is to be placed on a level floor in the free standing position. A force is to be applied to the stand immediately beneath the tank so as to tip the entire configuration 10 degrees in the direction most likely to cause the unit to tip over.

49.4 Mounting means (units intended for wall or ceiling mounting)

49.4.1 An appliance intended to be wall or ceiling mounted is to be provided with installation instructions as described in 70.3.2. All hardware and other parts required for mounting the appliance as specified in those instructions shall also be provided.

49.4.2 The mounting means is to be subjected to a force of four times the combined weight of the stand or shelf and a full aquarium tank of the largest size and capacity that the stand or shelf is intended to support. However, in no case is the total load to be less than 100 pounds-force (445 N). The appliance mounting means shall sustain the test load for a period of 1 minute without failure of the unit or mounting means or any permanent distortion of any part.

49.4.3 To determine compliance with 49.4.2, the appliance is to be mounted in accordance with the manufacturer's instructions, using the hardware and construction recommended. If no wall construction is specified in the instructions, 3/8-inch trade size plasterboard (dry wall) on 2-by-4 inch trade size studs spaced on 16-inch (406-mm) centers is to be used as the supporting wall. The hardware is to be installed as specified, and when not otherwise indicated in the instructions, the securing screws are to be positioned between the studs and secured into the plasterboard. An adjustable appliance is to be adjusted to the position that gives the maximum projection from the wall. The force is to be applied through a 3-inch (76.2-mm) wide strap at the dimensional center of the appliance, and is to be increased in 5 – 10 second intervals until a load of four times the weight of the combined shelf and filled aquarium has been applied. The tank need not be in place on the stand or shelf; the weight may be applied directly to the appliance. The appliance mounting means shall sustain the test load for a period of 1 minute without failure of the unit or mounting means or any permanent distortion of any part.

50 Strain Relief Test

50.1 The strain relief means provided on the flexible cord of an aquarium appliance shall be subjected to a direct pull of 35 pounds-force (156 N) for 1 minute with the connections within the appliance severed. There shall not be movement of the cord at the point where the conductors are disconnected that would indicate that stress would have been transmitted to internal parts.

51 Flooding of Live Parts Test

51.1 For an appliance that uses water or other electrically conductive liquid in its operation, the failure of a timer switch, a float or pressure operated switch, or a boot or diaphragm of rubber or similar material shall not allow flooding of the electrical parts.

51.2 To determine whether an appliance complies with this requirement, a boot or diaphragm that flexes during intended operation is to be removed completely and the appliance operated through one complete cycle of operation. If flexing is not present, but the part is subjected to aquarium fluids, the material of the part is to be investigated to determine its acceptability if the failure of the part increases the risk of fire or electric shock. Consideration is to be given to the effects of heat, air pressure, aquarium solutions, and other factors that may contribute to deterioration of the material.

Exception: Infrequent motion of small amplitude, such as that experienced during operation of a diaphragm covering a pressure-sensitive switch, is not considered flexing for purposes of these requirements.

52 Air Pump Antisiphoning Test

52.1 To determine compliance with the requirements in Antisiphoning, Section 24, an aquarium air pump is to be operated at a level 3 feet (0.91 m) below the bottom plane of a tank containing water 26 inches (0.66 m) deep. An air hose of appropriate size is to be inserted into the tank water with its end at the lowest level possible in the tank. During the test, all hoses and diaphragms inside the pump are to be removed. The pump is to be operated until ultimate results are obtained. There shall not be evidence of wetting of any electrical component. There shall not be a dielectric breakdown.

53 Mechanical Abuse Test on Glass Used in Applications Other Than Immersible Heaters

53.1 Each of three samples of an appliance that has a glass part and is subject to user handling is to be dropped through a distance of 3 feet (0.91 m) to strike a hardwood surface in the position most likely to produce breakage of the glass. Each sample is to be dropped three different times so that it strikes the surface in a different position with each drop. There shall not be sharp edges of broken glass exposed after this test.

53.2 An appliance intended for use on a table, bench, counter, and similar structures and not likely to be moved from one position to another is to be subjected to an impact of 5 foot-pounds-force (6.8 J) on any surface that may be exposed to a blow during intended use. This impact is to be produced by dropping a steel sphere that is 2 inches (50.8 mm) in diameter having a mass of 1.18 pounds (0.535 kg) from the height required to produce the specified impact. For a surface other than the top of an enclosure, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum through the distance required to cause it to strike the surface with the specified impact. Each of three samples is to receive three impacts in different positions. There shall not be exposed sharp edges of broken glass.

54 Switches and Controls Test

54.1 Overload

54.1.1 In a test to determine compliance with 26.3, the appliance is to be connected to a supply circuit with a voltage 110 percent of that shown in Table 37.1 and with rated frequency. The load on the device is to be the same as that which it is intended to control. During the test, exposed dead metal parts are to be connected to ground through a 3-ampere fuse. The control device is to be operated through 50 complete cycles at a rate of not more than 10 cycles per minute. The fuse in the grounding circuit shall not rupture during the test, and there shall not be undue burning or pitting of the contacts.

Exception: A faster rate of cycling may be used if acceptable to all concerned.

54.2 Locked rotor motor overload

54.2.1 A switch or other device that controls a motor of an appliance (unless previously evaluated or interlocked so that it will never have to break the locked rotor current) is to be subjected to an overload test consisting of 50 cycles of operation while making and breaking the locked rotor current of the appliance. There shall not be electrical or mechanical failure of the device nor any significant pitting or burning of the contacts.

54.2.2 To determine compliance with 54.2.1, a switch or other device that controls a motor is to be tested by connecting the appliance to a grounded power supply circuit of rated frequency and voltage as shown in Table 37.1 with the rotor of the motor locked in position. During the test, exposed dead metal parts of the appliance are to be connected to ground through a 3-ampere plug fuse. 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 appliance is intended for use on direct current, or on direct current and alternating current, the exposed dead metal parts of the appliance are to be connected so as to be positive with regard to a single-pole current-rupturing device. The switch is to be operated at no more than 10 cycles per minute. Results do not comply if the plug fuse in the grounding circuit ruptures.

Exception: The rate of operation may be faster than 10 cycles per minute if agreeable to all concerned.

55 Thermostats, Fusible Links, and Protective Devices Tests

55.1 Thermostats

55.1.1 A thermostat is to be subjected to an endurance test as indicated in Table 55.1 at rated load and at a power factor of 100 percent. At the conclusion of the test, the thermostat shall be capable of performing its function, and there shall not be significant pitting or burning of the contacts.

Table 55.1
Number of cycles of operation for endurance test

Type of control	Automatically reset control	Manually reset control
Temperature-regulating	A number of cycles equivalent to 1000 hours of normal operation of the appliance, but not less than 30,000 cycles. However, the test may be omitted when, with the control short-circuited, no temperature higher than the limits specified in Table 41.1 is attained in a normal temperature test of the appliance.	To be made the subject of an investigation. No value is specified because of unlikely occurrence.
Temperature-limiting	A number of cycles equivalent to 100 hours of operation of the appliance under any condition that causes the control to function but not less than 6000 cycles.	1000 cycles under load and 5000 cycles without load.
Combination temperature-limiting and -regulating	100,000 cycles when, with the control short-circuited, there is evidence of a risk of fire. If there is no evidence of a risk of fire under this condition, the control is to be tested as described above for a temperature-regulating control.	To be made the subject of an investigation. No value is specified because of unlikely occurrence.

55.2 Fusible links

55.2.1 To determine compliance with 33.1, an appliance using one or more fusible links is to be operated five times with separate links while any other thermally-operated control device in the appliance is shunted out of the circuit. Each link is required to perform as intended. During the test, the enclosure is to be

connected to a supply conductor not containing the link. This connection is to be through a 3-ampere fuse. Results do not comply if the fuse ruptures.

55.3 Motor protectors – short circuit

55.3.1 Three samples of a thermal protector of a motor are to be subjected to limited short circuit currents with cotton surrounding the enclosure. For a motor rated 1/2 horsepower (373 W) or less and 250 volts or less, the current is to be 200 amperes. For a motor having other ratings, but not more than 1 horsepower (746 W) nor more than 600 volts, the current is to be 1000 amperes. The power factor of the test circuit is to be 90 to 100 percent, and the circuit capacity is to be measured without the device in the circuit. A nonrenewable cartridge fuse is to be connected in series with the device under test. The fuse rating is not to be less than four times the rated current of the appliance, and in no case is it to be less than 20 amperes for an appliance rated 150 volts or less, nor 15 amperes for a device rated more than 150 volts but not more than 600 volts. The test on one sample is to be made by closing the device on the short circuit. There shall not be ignition of cotton surrounding the enclosure of the thermal protectors.

56 Aquarium Appliance Pull Test

56.1 A cord-connected aquarium appliance is to be mounted on a filled tank as described in the instruction manual. A weight of 10 pounds (4.54 kg) is then to be freely suspended from the power supply cord. The test is to be repeated with the power supply cord placed in each position in which it is likely to be routed from the appliance. The result complies if the appliance does not contact the tank water.

Exception: In the case of a reflector marked as described in 68.1.9, the reflector is to be tested with the make and model aquarium tank specified in the marking.

57 Aging Test on Seal Materials

57.1 Neoprene or rubber compounds forming gaskets or flexible seals shall be placed in an air-circulating oven for 70 hours at 100°C ±2°C (212°F ±3.6°F). The results comply when the material has physical properties before and after the conditioning as indicated in Table 57.1, or – when not suited for these measurements – there is no visible cracking or material change in hardness or flexibility.

Table 57.1
Physical properties of seals and gaskets

Properties of material	Before conditioning	After conditioning
Recovery – Maximum set when 2-inch (50.8-mm) gauge marks are stretched to 5 inches (127 mm), held for 2 minutes, and measured 2 minutes after release.	1/2 inch (12.7 mm)	–
Elongation – Minimum increase in distance between 2-inch (50.8-mm) gauge marks at break.	250 percent (2 to 7 inches) (50.8 to 178 mm)	65 percent of original
Tensile strength – Minimum force at breaking point	850 pounds per square inch (5.86 kPa)	75 percent of original

58 Resistance to Salt Spray Test

58.1 Two samples of an appliance intended to be used with salt water aquariums are to be subjected to 24 hours of salt spray conditioning as outlined in 58.2 – 58.6. One sample is to be conditioned while operating and the other sample while not operating.

Exception: This test may be omitted if the appliance construction and intended location are as described in the exception of 68.1.6.

58.2 The apparatus used for a salt spray (fog) testing is to consist of:

a) A fog chamber, the inside of which has a minimum volume of 15 cubic inches (246 cm^3);

b) The salt solution reservoir;

c) A supply of compressed air maintained at a pressure and humidity as specified in 58.3;

d) A dispersion tower constructed in accordance with the Standard Practice for Operating Salt Spray (Fog) Apparatus ASTM B117-95;

e) Specimen supports; and

f) Provision for heating the chamber.

58.3 The dispersion tower for producing the salt fog is to be located in the center of the chamber and is to be supplied with air having a relative humidity between 94 – 98 percent at a pressure of 17 – 19 pounds per square inch (117 – 131 kPa) so that the salt solution is sprayed as a fine mist or fog into the chamber.

58.4 The salt solution is to have the following properties:

a) A 5 percent solution, by weight, of common salt (sodium chloride) in deionized water;

b) A pH value within the range of 6.5 – 7.2; and

c) A specific gravity within the range of 1.016 – 1.040 at 33°C (91°F).

58.5 The temperature in the chamber is to be maintained at 33 ±2°C (91 ±3.6°F) throughout the test period. Any drops of salt solution that accumulate on the ceiling or cover of the chamber are not to drop on the appliance, and any drops of solution that fall from the appliance are not to be recirculated but are to be removed by a drain in the bottom of the chamber.

58.6 The appliances are to be supported or suspended inside the fog chamber so as not to contact any other metal and then are to be subjected to the salt spray for 24 hours. The results comply with the requirements when:

a) The leakage current does not exceed the values specified in 38.1 for cord-connected appliances tested in accordance with the Leakage Current Test, Section 38; or

b) The insulation resistance is not less than 50,000 ohms for permanently-connected appliances tested in accordance with the Insulation Resistance Test, Section 39; and

c) There is no indication of dielectric breakdown when the unit is tested in accordance with the Dielectric Voltage-Withstand Test, Section 42.

59 Resistance to Overflow Test

59.1 In accordance with 5.1.2, one sample of an appliance shall be subjected to an overflow test. The appliance is to be connected to a supply circuit voltage as indicated in Table 37.1, and positioned or installed together with an aquarium tank in accordance with the instructions provided with the appliance.

59.2 While operating under the conditions described in 59.1 an overflow is to be caused by filling the aquarium tank to its top with a salt solution as described in 58.4. Then, an amount of salt solution equal to

25 percent of the tank capacity is to be added through a hose having a 3/8 inch (9.5 mm) diameter orifice at a rate of 4 gallons (15.1 L) per minute.

Exception: The test solution is to consist of 1/2 gram of calcium sulfate ($CaSO_4 \cdot 2H_2 0$) per liter of distilled water for an appliance marked for use only with fresh water in accordance with 68.1.6.

59.3 The results are in compliance with the requirements when:

a) In a cord-connected appliance, the leakage current, when tested in accordance with the Leakage Current Test, Section 38, does not exceed the limits specified in 38.1, and the unit does not show indication of dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 42.

b) In a permanently-connected appliance, the insulation resistance, when tested in accordance with the Insulation Resistance Test, Section 39, is not less than 50,000 ohms, and the unit does not show indication of dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 42.

60 Permanence of Adhesion Test

60.1 A reflective strip utilized as a heat sink for an aquarium reflector, as described in 5.2.7, shall be securely adhered to the frame of the reflector.

60.2 In order to determine compliance with 60.1, three samples of a strip and frame assembly are to be placed in a controlled atmosphere. The atmosphere is to be maintained at a temperature at least 10°C (18°F) higher than that encountered on the reflective strip during normal use, but in no case less than 70°C (158°F), with a relative humidity of 93 ±2 percent for 30 days.

60.3 Following this conditioning, the samples are to be tested by scraping a flat metal blade 1/32 inch (0.8 mm) thick held at right angles to the reflective strip surface with a force of 5 pounds (22.2 N), in such a manner as to most likely result in the strip being separated from the reflector frame. Reflective strip shall remain firmly secured to the reflector frame.

61 Solenoids

61.1 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 Induced potential, 63.4.

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 Induced potential, 63.4.

61.2 Where required in 61.1 (c) and/or (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, Section 41. 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.

61.3 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, Section 41 and with the plunger blocked in the de-energized position at the maximum stroke length specified for the assembly. For the test, the supply source to the appliance shall include appropriate branch circuit protection and grounded, if applicable. Following this test, the solenoid shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 42.

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

62 General Purpose Transformers

62.1 General

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

62.2 Voltage measurement test

62.2.1 For purposes of comparison with voltages measured as described in the Overload test, 62.3, each secondary open-circuit voltage shall be measured with the primary connected to a test voltage and frequency supply source as indicated in Performance, General, Section 37.

62.3 Overload test

62.3.1 A transformer shall be subjected to the test conditions described in 62.3.2. The stabilized surface or core temperature recorded on the transformer during the second 50 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, 62.2. As an option, a protective device, if provided, may be bypassed when conducting this test.

62.3.2 The transformer shall be operated as described in the Normal Temperature Test, Section 41, 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 62.3.1. Then, the secondary load shall be removed. With the primary energized, the secondary voltage(s) shall be measured and compared with the original output voltage measurements.

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

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

62.4 Repeated dielectric voltage-withstand test

62.4.1 Following the Overload test, 62.3, the transformer shall be subjected to a repeated dielectric voltage-withstand test. The test potential shall be 65 percent of the value originally specified. After this test, the transformer shall perform as intended.

63 Thermoplastic Motor Insulation Systems

63.1 General

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

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

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

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

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

63.2 Abnormal conditioning

63.2.1 The motor is to be subjected to the abnormal conditioning described in 63.2.2 and shall comply with all of the following conditions:

a) The 3 ampere fuse shall remain intact and

b) The material under test shall withstand without breakdown, the dielectric voltage-withstand potential specified in Section 42 immediately following the conditioning specified in 63.2.2 and with the 3 ampere fuse removed from the circuit.

63.2.2 The motor is to be operated with the armature locked until ultimate results have been determined or for 7 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

63.2.3 With reference to 63.2.2, when the length of the test is limited by an external factor – such as the functioning of a reliable, nonuser-serviceable device (such as a fuse or circuit breaker), or the functioning of the maximum-size branch-circuit protective device that the equipment is likely to be connected (but not