



UL 1018

Underwriters Laboratories Inc.
Standard for Safety

Electric Aquarium Equipment



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UL Standard for Safety for Electric Aquarium Equipment, UL 1018

Fifth Edition, Dated March 12, 2001

Revisions: This Standard contains revisions through and including June 16, 2008.

Summary of Topics

These revisions to UL 1018 are being issued:

- 1. To add requirements for evaluating fittings integral to aquarium base;***
- 2. To add requirements for evaluating aquarium equipment provided with Tungsten-Halogen or High Intensity Discharge Lamps;***
- 3. To add requirements for dual power supply cords; and***
- 4. To address universal upkeep of the standard. These revisions are considered to be non-substantive and not subject to UL's STP process.***

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
January 31, 2010	Paragraphs 1.2, 1.4, 59.7, 60.1.10, 60.1.11, 62.1.2 and 63.1; Section 8.1A

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated December 7, 2007 and March 4, 2008.

The revisions dated June 16, 2008 include a reprinted title page (page1) for this Standard.

The revisions dated June 16, 2008 were also issued to delete references to "No." from "No. ____AWG" in Paragraphs 8.2.3.3, 8.2.3.5, 8.2.3.6, 8.2.3.10, and 36.9.2. These revisions are considered to be non-substantive and thus not subject to UL's STP process.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfonet.ul.com/ulforeword.html>.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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UL 1018

Standard for Electric Aquarium Equipment

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March 12, 2001

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. 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 <http://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.

Revised 1.2 effective January 31, 2010

1.3 Deleted April 29, 2003

1.4 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.

Added 1.4 effective January 31, 2010

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.4 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.

2.2 Units of measurement

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

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

2.3 Undated references

2.3.1 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.

3 Glossary

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

3.2 **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.

3.3 **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.

3.4 **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.

3.5 **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.

3.6 **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.

CONSTRUCTION

4 Frame and Enclosure

4.1 General

4.1.1 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.

4.1.2 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 54, 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 33, shall be used to determine whether water has contacted any live part.

4.2 Thickness of metal

4.2.1 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.

4.2.2 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.

4.2.3 The thickness of sheet metal in an aquarium hood or reflector shall not be less than indicated in Table 4.1.

4.2.4 The maximum dimension specified in Table 4.1 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 4.1
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 4.2.4.					

4.2.5 Table 4.1 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.

4.2.6 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.

4.2.7 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 55.1 – 55.3.

4.3 Barriers

4.3.1 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.

4.3.2 The requirement in 4.3.1 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.

4.3.3 The requirement in 4.3.1 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.

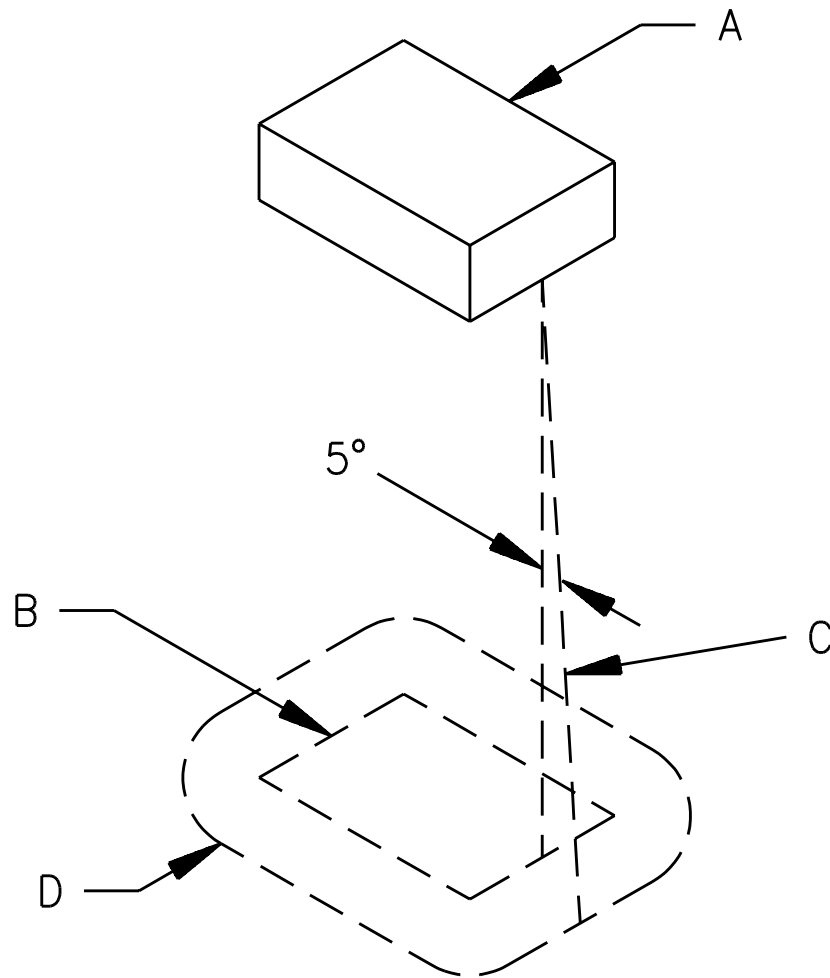
4.3.4 The barrier mentioned in 4.3.2 shall be horizontal, shall be located as indicated in Figure 4.1, and shall have an area not less than that shown in the figure. Openings for drainage, ventilation, and similar needs may be provided in the barrier if they do not permit molten metal, burning insulation, or like materials to fall on combustible material.

4.4 Polymeric material

4.4.1 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.

4.4.2 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.

Figure 4.1
Location and extent of barrier



EB120A

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.

4.4.3 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 Mechanical Assembly

5.1 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.

5.2 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.

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

5.4 An aquarium appliance intended to be installed on a tank shall be tested as described in 51.1, and provided with instructions in accordance with 62.3.3.

Exception: The test described in 51.1 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.

5.5 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.

6 Accessibility of Live Parts

6.1 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 6.2 – 6.6.

6.2 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 6.1, when inserted into the opening, does not touch any part that involves electric shock to earth ground.

6.3 Regarding the application of 6.2, 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.

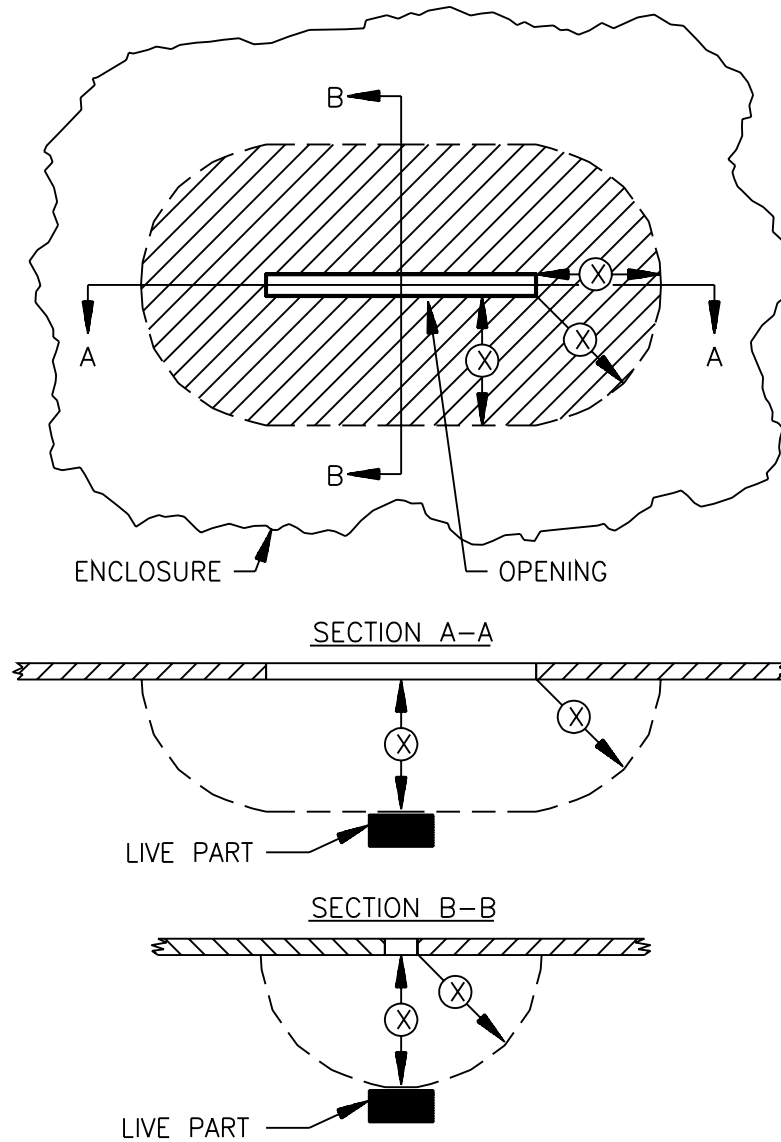
6.4 If any part of the enclosure must be opened or removed for user servicing with or without the use of tools, or can be opened or removed without the use of tools, the probe is to be applied without the part in place.

6.5 If an appliance is supported directly by the floor, the probe illustrated in Figure 6.1 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.

6.6 An opening that permits entrance of a 1-inch (25.4-mm) diameter rod can be used under the conditions described in Figure 6.2.

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

Figure 6.2
Opening in enclosure



EC100A

(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).

7 Protection Against Corrosion

7.1 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.

7.2 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.

8 Supply Connections

8.1 Cord-connected appliances

8.1.1 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.

8.1.2 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 mm²).

8.1.3 A flexible cord shall terminate in a grounding-type attachment plug or in a polarized attachment plug. Figure 8.1 illustrates attachment plug connections, and Table 8.1 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.

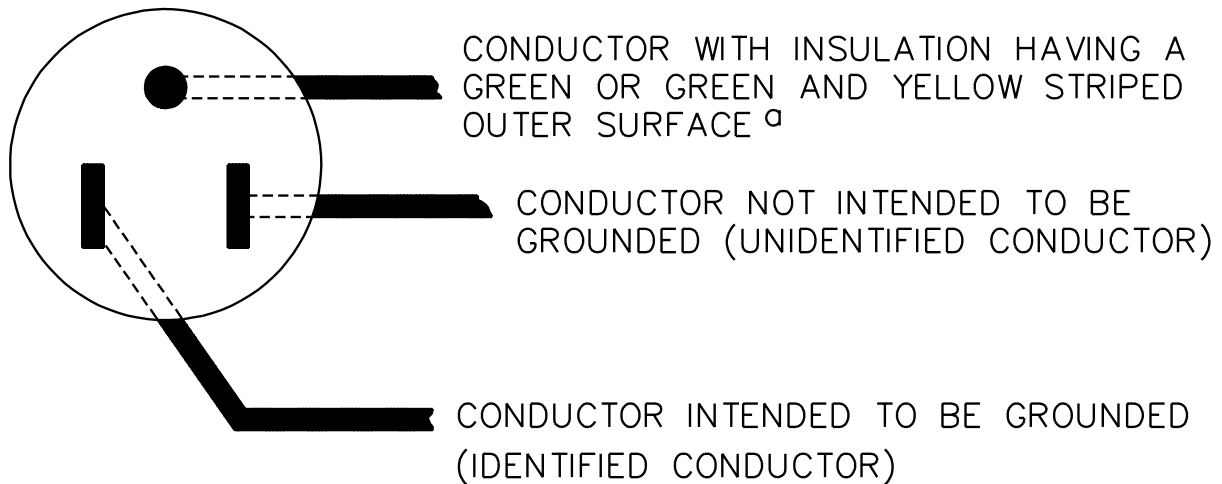
8.1.4 If the flexible cord includes an equipment grounding conductor, that conductor shall comply with 11.2.

8.1.5 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.

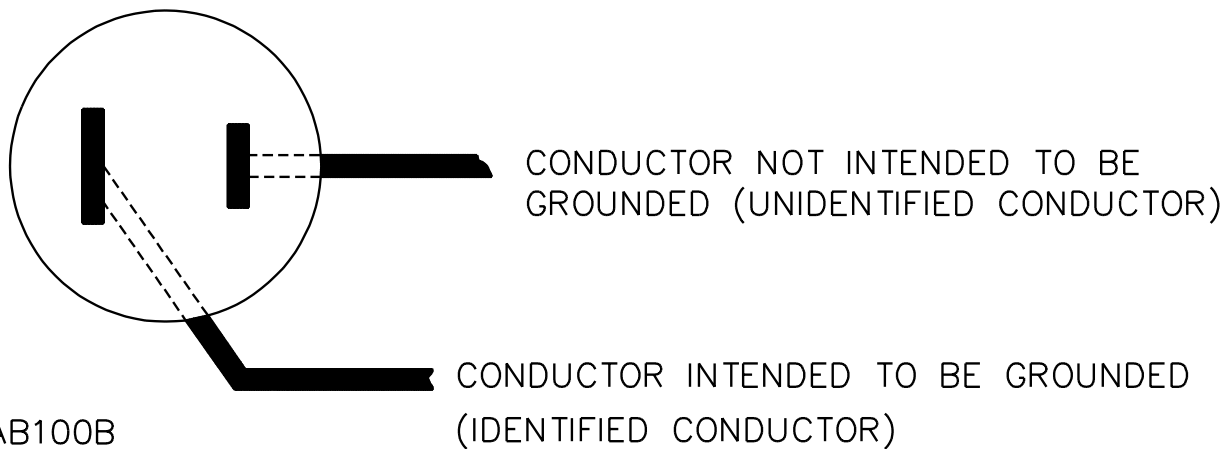
8.1.6 A flexible cord shall be permanently attached to the appliance.

Figure 8.1
Connections to attachment plug

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



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



AB100B

^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.

8.1.7 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 8.2.1.2.

The flexible cord of all other appliances intended for household use and marked in accordance with 60.1.8 shall be Type SP-1, SPE-1, SPT-1, or heavier cord.

Table 8.1
Polarity identification of flexible cords

Table 8.1 revised April 29, 2003

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 11.2 and Figure 8.1. ^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.		

8.1.8 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.

8.1.8 revised August 1, 2006

8.1.9 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 grounding type receptacle may be used on an integral aquarium system (more than one appliance mounted together in one complete unit) when the receptacle is enclosed within the overall enclosure.

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8.1.10 The face of a receptacle as described in 8.1.9 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.

8.1.11 An aquarium reflector employing an in-line ballast shall be supplied with a cord as specified in 8.1.1 such that there is a minimum of 5 feet (1.52 m) between the ballast and the point where the cord enters the reflector.

8.1A Multiple power supply cords

Added 8.1A effective January 31, 2010

8.1A.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 8.1.5;
- d) The total current input per Power Input Test, Section 35, 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 60.1.10.*

Note: The disconnect means may be considered the supply cord. In this case the marking of 60.1.10 should be located near the cord entries into the appliance.

- f) The appliance is rated in accordance with 59.7;

- g) The appliance contains the markings in 60.1.11;
- h) The appliance is provided with instructions as indicated in 62.1.2;
- 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.

Added 8.1A.1 effective January 31, 2010

8.2 Permanently-connected appliances

8.2.1 General

8.2.1.1 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.

8.2.1.2 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 8.1.7 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.*

8.2.1.3 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.

8.2.1.4 The diameter of a knockout shall accommodate conduit of the trade size for which the knockout is intended as specified in Table 8.2.

Table 8.2
Dimensions associated with knockouts for conduit

Trade size of conduit, inch (mm)		Unthreaded openings			
		Nominal knockout diameter, inches (mm)		Minimum diameter of flat surface at knockout, 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

8.2.1.5 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 8.2.

8.2.2 Field-wiring compartment

8.2.2.1 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.

8.2.2.2 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.

8.2.2.3 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 8.3.

Exception: A motor containing an integral wiring compartment that complies with the Standard for Electric Motors, UL 1004, is not required to comply with this requirement.

8.2.2.4 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.