UL 676

STANDARD FOR SAFETY

Underwater Luminaires and Submersible Junction Boxes

UL Standard for Safety for Underwater Luminaires and Submersible Junction Boxes, UL 676

Ninth Edition, Dated August 10, 2015

Summary of Topics

This revision of ANSI/UL 676 dated October 22, 2019 includes the following changes in requirements.

Scope clarifications for non-metallic forming shells and junction boxes

Lens Guards

Installation instructions related to flexible cords

Electric shock test luminaire constant (N)

Gasket testing

Submersible luminaires – applicable clauses from part I

Cycling under water test

Number of required grounding connections for submersible junction boxes

Editorial corrections and adjustments

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 April 26, 2019.

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UL 676

Standard for Underwater Luminaires and Submersible Junction Boxes

The first edition was titled Standard for Underwater Lighting Fixtures and Junction Boxes for Swimming Pools. The second and third editions were titled Standard for Underwater Lighting Fixtures for Swimming Pools. The fourth, fifth, sixth, and seventh editions were titled Standard for Underwater Lighting Fixtures. The submersible luminaires now covered by this standard were originally covered by the Standard for Electric Lighting Fixtures, UL 57.

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Ninth Edition

August 10, 2015

This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through October 22, 2019.

TThe most recent designation of ANSI/UL 676 as an American National Standard (ANSI) occurred on October 14, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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CONTENTS

PERFORMANCE

MARKINGS

PART II – SUBMERSIBLE LUMINAIRES

CONSTRUCTION

PERFORMANCE

MARKINGS AND INSTALLATION INSTRUCTIONS

PART III – SUBMERSIBLE JUNCTION BOXES

CONSTRUCTION

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover electric luminaires for installation below the surface of the water in swimming pools, permanently installed spas, hot tubs, and similar water-containing vessels intended to accommodate the complete or partial immersion of persons, and for operation on supply circuits rated 150 volts or less, in accordance with the National Electrical Code, NFPA 70, Article 680.

1.2 These requirements also cover:

a) Luminaire housings (forming shells) for use with wet-niche luminaires intended for installation as described in 1.1;

b) Mounting brackets for use with no-niche luminaires intended for installation as described in 1.1; and

c) Electric luminaires and submersible junction boxes for installation in fountains and similar water-containing vessels not intended to accommodate the complete or partial immersion of persons.

1.3 These requirements do not cover junction boxes for use in the deck area around swimming pools, fountains, and spas, ground-fault circuit-interrupters, transformer enclosures, or transformers used for the supply of underwater luminaires.

1.4 *Revised and relocated as 5.4*

1.5 *Revised and relocated as 5.2*

1.6 *Revised and relocated as 5.3*

2 Components

2.1 Except as indicated in 2.2, 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 used in the products covered by this standard.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

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

4 References

4.1 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.

5 Glossary

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

5.2 LUMINAIRE, DRY-NICHE – intended to be permanently mounted and sealed in the wall of a swimming pool or fountain. It is equipped with provisions for conduit connection, and is designed to be serviced from the rear in a passageway or tunnel behind the wall or from the deck.

5.3 LUMINAIRE, NO-NICHE – intended for installation on a mounting bracket that is, in turn, mounted in or on the wall of a swimming pool or fountain where the luminaire will not extend behind the plane of the wall and will be surrounded by water. The luminaire is supplied by a flexible cord of a length that permits the luminaire to be removed from the mounting bracket and lifted to the deck for servicing.

5.4 LUMINAIRE, WET-NICHE – intended for installation in a luminaire housing (forming shell) mounted in or on the wall of a swimming pool or fountain where the luminaire will be surrounded by water. The luminaire is supplied by a flexible cord of sufficient length to permit the luminaire to be removed from the niche and lifted to the deck for servicing.

5.5 WATER, FRESH – Water of electrical resistivity well above that of sea water, generally drawn from lakes, streams, or underground sources and delivered by a private well or a municipality for industrial, commercial or household use. Fresh water treated with salt for chlorine generation, resulting in electrical resistivity that is typically 89 ohm-centimeters or higher (6000 ppm or less), is still considered fresh water for the purposes of this standard.

5.6 WATER, SEA – Water of electrical resistivity on the order of 22 ohm-centimeters, representative of water found in open seas and sometimes used (for therapeutic purposes) in swimming pools.

PART I – SWIMMING POOL LUMINAIRES

CONSTRUCTION – LUMINAIRES

6 General

6.1 A luminaire shall be constructed to provide mechanical strength appropriate for the stress it is likely to encounter during installation and use.

6.2 A luminaire shall be constructed to provide an enclosure for all electrical parts, including the lamp bulb.

Exception No. 1: The lens face of a PAR lamp is not required to be enclosed.

Exception No. 2: Flexible cord, attachment plugs, receptacles, and cord connectors are not required to be enclosed in an electrical enclosure when the luminaire and its installation complies with requirements for Flexible Cord and Connectors, Section 10.

6.3 A luminaire rated more than 15 volts and provided with a PAR lamp shall be provided with a guard, grid, or an outer lens.

6.4 A luminaire intended to be mounted facing upward shall have the lens guarded to prevent contact by any person or, in addition to the Impact Test (Section 40), shall additionally comply with the Static Load Test (Section 54) and Cylinder Impact Test (Section 55).

6.5 All metal parts of a luminaire, including assembly rivets, screws, and the like, shall be of a corrosion resistant metal. Copper alloy parts normally in contact with water shall have a zinc content not in excess of 15 percent. Aluminum and aluminum alloys shall not be used for any part of a luminaire normally in contact with water. Iron and steel parts made resistant to corrosion by plating, galvanizing, or equivalent means are permitted.

Exception No. 1: Metal parts that are completely encapsulated by a potting compound that complies with the Outline of Investigation for Potting Compounds for Swimming Pool, Fountain, and Spa Equipment, UL 676A, need not be corrosion resistant.

Exception No. 2: Metal parts whose deterioration from corrosion will not adversely affect compliance per (a) – (d) below need not be corrosion resistant:

a) Spacings requirements of Section 23, through migration or settling of particles to create a conductive path across insulating materials;

b) Bonding requirements of Section 26;

c) Temperature Test of Section 33, through loss of heatsinking or reflectance; or

d) Electric Shock Test of Section 41, through loss of current-collection capacity.

6.6 Paint, enamel, or other coatings that inhibit bonding of parts or reduce the electric-field shielding effect (where required) shall not be used on either the inside or the outside of a luminaire.

6.7 Tin-lead solder shall not be used for the fastening of seams or the assembly of parts of a luminaire.

6.8 Self-threading or sheet-metal screws shall not be used.

6.9 An external power unit or transformer for a low voltage swimming pool and spa luminaire shall comply with the Standard for Power Units for Fountain, Swimming Pool, and Spa Luminaires, UL 379.

7 Sheet Metal

7.1 The thickness of sheet metal in a luminaire enclosure shall be not less than 1 mm (0.040 inch) at any point where a conduit hub is secured, and not less than 0.5 mm (0.020 inch) at any other point on a drawn or spun luminaire. The thickness of sheet metal in a drawn or spun luminaire shall be such as to provide strength and rigidity at sealing points, or shall be reinforced to provide strength equivalent to that of sheet metal not thinner than 1 mm.

8 Cast Metal

8.1 Cast metal in a luminaire enclosure shall have a minimum thickness in accordance with Table 8.1.

Table 8.1
Minimum thickness of cast metal

Surface involved	Cast metal other than die-cast,		Die-cast metal,	
	mm	(inch)	mm	(inch)
Unreinforced flat surface	3.2	0.125	1.2	0.047
At base of threads, surface that is curved, ribbed, or otherwise reinforced, or surface of such size or shape that equivalent physical strength is provided	2.3	0.090	1.1	0.045

9 Mounting Means

9.1 A luminaire shall be provided with means for mounting as intended.

9.2 The means for mounting a wet-niche luminaire in its forming shell, and a no-niche luminaire to its mounting bracket, shall automatically bond the luminaire to the luminaire housing or mounting bracket as described in 26.1.1 and 26.2.1, and shall require the use of a tool for the removal of the luminaire. The bond shall comply with the bonding requirements in Bonding, Section 26.

10 Flexible Cord and Connectors

10.1 Flexible cord not enclosed within an enclosure shall be used only as described in this Section.

10.2 Flexible cord not enclosed within an enclosure shall be of the type suitable for hard usage (such as Type SJ, SJT, or SJTO) or the equivalent.

10.3 Flexible cord that is immersed in water shall be suitable for:

a) Hard usage (such as Type SJW, SJTW, or SJTOW) and not smaller than 3.3 mm^2 (12 AWG);

b) Extra-hard usage (such as Type SOW, STW, or STOW); or

c) Equivalent to the type specified in (a) or (b).

A grounding conductor shall not be smaller than the circuit conductors and, for flexible cords suitable for extra-hard usage, shall not be smaller than 1.3 mm^2 (16 AWG).

10.4 Flexible cord that is immersed in pool water, might rest in collected water outside a pool, or that is exposed to water such as rain, sprinkler, or water splashed from the pool, but that does not rest or become immersed in collected water shall be of the type suitable for immersion in water as indicated with the flexible cord type designation suffix “W”.

10.5 When the point where the flexible cord enters an enclosure is immersed, a watertight fitting or an equivalent method for reducing the risk of water entering the enclosure shall be used.

10.6 Flexible cord that is exposed to sunlight or another source of UV light shall be suitable for outdoor use as indicated by the presence of the flexible cord type designation suffix "W."

10.7 A luminaire is permitted to be provided with an attachment plug and mating receptacle or cord connector to facilitate the installation, maintenance, or servicing of the luminaire. When provided:

a) The luminaire shall include both the attachment plug and the mating receptacle or cord connector;

b) The luminaire shall require a tool to access or disconnect the attachment plug and mating receptacle or cord connector; and

c) The attachment plug and mating receptacle or cord connector shall not be exposed to sunlight, water, impact, strain, and other adverse conditions unless they have been found suitable for the conditions anticipated.

Exception: A luminaire intended only for use with a storable pool need not comply with this requirement.

10.8 An attachment plug and the mating receptacle or cord connector shall be polarized when polarization is required to comply with the requirements in Polarization and Identification, Section 20, or the Electric Shock Test, Section 41. When polarization is required and conductors are connected to the device during installation, the device shall have terminals marked to identify the intended connection of wiring.

10.9 A cord- and plug-connected luminaire shall be provided with a length of flexible cord that extends from the pool wall to the location remote from the pool wall. The flexible cord shall have a length of not less than 7.6 m (25 feet).

10.10 Flexible cord shall be accessible to contact only under conditions (a), (b), or (c) below:

a) During luminaire relamping or servicing;

b) When it is the flexible cord of the cord- and plug-connected luminaire that extends from the pool wall to the location remote from the pool wall as specified in 10.9; or

c) No more than 1.52 m (5 ft) of flexible cord may be accessible when the installation instructions include guidance for reliably routing and securing the cord to suitably rigid structural members of the pool, the luminaire, or other objects installed for the purpose in accordance with 44.11. If the instructions require the use of a guard and/or related structural support parts, those parts shall be provided and the assembly shall comply with the Flexible Cord Guard and Support Test, Section 43.

10.11 A strain relief device shall be provided and comply with the Strain Relief Test, Section 37.

11 Power Supply Connections

11.1 General

11.1.1 A dry-niche luminaire and the luminaire housing for a wet-niche luminaire, and the mounting bracket for a no-niche luminaire, shall have provision for the connection of rigid metal or nonmetallic conduit.

11.1.2 Holes for the connection of conduit shall be threaded. When the threads are tapped all the way through a hole in an enclosure wall, or when an equivalent construction is used, there shall not be fewer than 3-1/2 nor more than five threads in the metal and the construction shall be such that a conduit bushing can be attached as intended. When the threads are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be fewer than five threads in the metal and there shall be a smooth, rounded inlet hole for the conductors equivalent to that provided by a standard conduit bushing. The internal diameter of the inlet hole shall be the same as that of the corresponding trade size of rigid conduit.

11.1.3 A conduit hub shall be threaded and shall have a wall thickness before threading not less than that of the corresponding trade size of conduit. A conduit hub that is not cast integrally with an enclosure

shall not depend upon friction alone to prevent its turning, and shall comply with the Conduit Hub Torque Test, Section 43A.

11.1.4 The termination means for a field-connected conductor shall consist of a pigtail lead, a pressure terminal connector, a wire-binding screw, or a stud with nut. A pressure terminal connector shall be of a type that can be applied by means of an ordinary tool (such as a screwdriver, nut driver, or pliers).

11.1.5 A pigtail lead for connection of field wiring shall not be more than two standard (AWG) sizes smaller than the field-connected conductor to which it will be connected, and shall not be smaller than a 0.82 mm^2 (18 AWG) copper conductor in any case.

11.1.6 A pigtail lead shall have a free length in a splice compartment of at least 15.2 cm (6 inches).

11.1.7 A field-wiring terminal shall be provided with a pressure terminal connector securely fastened in place by being brazed, bolted, held by a screw, or the equivalent. A single rivet shall not be used.

Exception: A wire-binding screw is not prohibited from being used at a field-wiring terminal intended to accommodate a 5.3 mm^2 (10 AWG) or smaller conductor.

11.1.8 A field-wiring terminal shall be prevented from turning or shifting in position by means other than friction alone. Acceptable means of complying with this requirement include use of two screws or rivets, square shoulders or mortises, dowel pins, lugs, offsets, or connecting straps or clips fitted into an adjacent part, or by an equivalent method.

11.1.9 A wire-binding screw at a field-wiring terminal shall not be smaller than 4.8 mm (No. 10 major diameter).

Exception: A 4.2 mm (No. 8) screw is not prohibited from being used for the connection of a 2.1 mm^2 (14 AWG) conductor. A 3.5 mm (No. 6) screw is not prohibited from being used for the connection of 1.3 mm^2 (16 AWG) and smaller conductors.

11.1.10 A wire-binding screw shall thread into metal at least 1.3 mm (0.050 inch) thick.

Exception: Metal not less than 0.8 mm (0.030 inch) thick is not prohibited from being used when the threaded joint withstands a tightening torque applied to the wire-binding screw without stripping the screw threads or the terminal plate threads when tested with a solid copper conductor of the size intended and placed under the screw head and wrapped 2/3 – 3/4 turn around the screw. The tightening torque shall be 1.4 N·m (12 pound-inches), 1.8 N·m (16 pound-inches), and 2.3 N·m (20 pound-inches) for screw sizes No. 6, No. 8, and No. 10 or larger, respectively.

11.1.11 Upturned lugs or a cupped washer or the equivalent shall be provided with a wire-binding screw and shall be capable of retaining a conductor of the size intended under the head of the screw or washer.

11.1.12 Where continuity or secureness of an electrical connection involves a threaded joint, at least two full threads shall be engaged in the threaded joint and, for a screw with a tapered end, any threads on the tapered end shall be disregarded.

Exception: The threaded joint of a component complying with applicable component requirements for threaded joint design, continuity, and secureness is not required to comply with this requirement.

11.1.13 Where pigtail leads are provided for field wiring connections, a threaded joint at the product end of the lead shall comply with 11.1.12.

11.1.14 A field-wiring terminal intended for the connection of a grounded conductor shall be of (or plated with) a metal substantially white in color and shall be readily distinguishable from the other terminals, or identification of the terminal shall be clearly shown in some other manner.

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

11.2 Wet-niche and no-niche luminaires

11.2.1 Wet-niche and no-niche luminaires shall be provided with a permanently attached length of flexible cord for routing through the conduit connected to the luminaire housing or mounting bracket and for connecting to the power source. The flexible cord shall extend a minimum of 3.7 m (12 feet) from the point at which the cord emerges from the luminaire.

11.2.2 A grounding conductor in the flexible cord shall be green with or without one or more yellow stripes.

11.2.3 The end of the flexible cord jacket and the flexible cord conductor terminations shall be covered with or encapsulated in a potting compound to prevent the entry of water into the luminaire through the cord or its conductors. In addition, a ground connection within the luminaire, if provided, shall be similarly treated to protect such connection from the deteriorating effect of chemicals in the water in the event of water entry into the luminaire.

11.2.4 Strain relief shall be provided to prevent a mechanical stress on the flexible cord from being transmitted directly to terminals, splices, or interior wiring of the luminaire. The strain-relief means shall comply with the Strain-Relief Test, Section 37.

11.2.5 The flexible cord specified in 11.2.1 shall be considered a pigtail lead with regard to the requirements in 11.1.1 – 11.1.15.

11.3 Dry-niche luminaires

11.3.1 Connections between the luminaire conductors and the conductors of the power supply circuit shall be accessible for inspection without requiring the disconnection of any portion of the wiring.

11.3.2 The luminaire shall provide:

a) Ample space for any required splices to the supply conductors and

b) Means for independent termination of at least two equipment grounding conductors.

11.3.3 When flexible cord is used to supply the lamp assembly of a dry-niche luminaire, the end of the flexible cord jacket and the flexible cord conductor terminations shall be covered with or encapsulated in a potting compound to protect such connections from the deteriorating effect of chemicals in the water in the event of water entry into the lamp assembly.

11.4 Low voltage luminaires

11.4.1 Luminaires rated no more than as follows and marked in accordance with 44.13 are considered low voltage luminaires for the purpose of this standard and are eligible to apply the requirements in this section:

– 15 V sinusoidal AC;

– 21.2 V peak non-sinusoidal AC;

– 30 V DC (DC interrupted at a rate from 10 – 200 hz is limited to 12.4 V).

Other requirements of this Standard apply to low voltage luminaires unless specifically exempted in this section.

11.4.2 The grounding conductor specified in 10.3 or 11.2.2, or the ground conductor termination specified in 11.3.2(b), shall not be provided on a low voltage luminaire.

11.4.3 Low voltage luminaires shall have no provision for grounding and are exempt from the requirements in Sections 22 (Position of Live Parts), 23 (Spacings), 25 (Grounding), and 26 (Bonding).

Exception: A low voltage luminaire with dead metal parts in contact with the water shall comply with the Exception to 26.1.1.

11.4.4 Low voltage luminaires are exempt from the Bonding Millivolt Drop Test (Section 38), the High Current Test (Section 39), and the Electric Shock Test (Section 41).

Exception: A low voltage luminaire with dead metal parts in contact with the water shall comply with the Bonding Millivolt Drop Test.

11.4.5 Low voltage luminaires are permitted to use hard usage cords, per 10.3(a), not smaller than 0.20 mm^2 (24 AWG).

12 Diffusers

12.1 *Deleted*

13 Guards

13.1 A metal guard, when provided, shall be conductively connected to the point of attachment of the equipment grounding conductor to the luminaire.

13.2 If a luminaire must be provided with a guard in order to comply with the requirements concerning the risk of electric shock, the construction shall be such that the luminaire cannot be installed without the guard.

13.3 There shall be no sharp or protruding edges of a guard or other parts of the luminaire that may be contacted by persons in a pool.

13.4 A guard for an upward-facing luminaire shall comply with the Static Load Test (Section 54) and the Cylinder Impact Test (Section 55).

14 Gaskets

14.1 A gasket shall be of a material able to withstand the temperature and use to which it will be subjected. The gasket material shall be resistant to aging. A gasket that will be disturbed during routine servicing, such as during lamp replacement, shall be formed of resilient material such as neoprene or silicone rubber.

14.2 A gasket of neoprene, rubber, neoprene composition, or rubber composition used to prevent the entry of water into a luminaire shall be subjected to the Gasket Accelerated Aging Test, Section 42.

14.3 A gasket material other than those specified in 14.2 is not prohibited from being used when determined to have equivalent characteristics, including resistance to aging. Such material is considered resistant to aging when there is no visible evidence of deterioration (such as cracking after flexing, softening, or hardening) after these characteristics are investigated.

15 Adhesives Used in Underwater Luminaires

15.1 An adhesive relied upon for water barrier integrity shall comply with the Adhesives, Specialized Applications requirements, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, modified as specified in this section. Joints bonded by fusion techniques, such as with a solvent or ultrasonic welding are considered acceptable without further evaluation.

15.2 The reduced sample set size (UL 746C clause 69.7.3) is permitted to be used. Each sample set shall consist of specimens of the adhered or sealed joint assembly configured in accordance with the Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal), ASTM D 1002, and shall be tested for adhesive strength in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, Bond Strength Properties of Adhesives, Method A (shear strength through tension loading).

15.3 The sample sets shall be subject to the "as received," "effect of temperature," "effect of cold," and "effect of cyclic conditions" test programs. In lieu of the "effect of humidity" conditioning, a sample set shall be subject to water immersion conditioning as follows. A sample set shall be placed in a pool water solution maintained at a temperature of 25°C (77°F) for a period of 24 hours. The pool water solution is to consist of distilled water plus cyanuric acid at a concentration of 100 ppm, calcium chloride for hardness at a concentration of 100 ppm and chlorine content of 5.0 ppm provided by calcium hypochlorite. The pH of the solution is to be adjusted to be 7.4. Upon removal, the specimens shall be placed in an oven for 24 hours at 10°C (18°F) above the measured maximum operating temperature of the adhesive. This water immersion / oven aging conditioning cycle is to be repeated three times. Specimens are permitted to be stored at room temperature (25°C / 77°F) between conditioning segments. The pool water solution shall be replaced for each cycle.

15.4 The bond strength of the adhesive shall not be reduced by more than 50 percent from the "as received" bond strength following each conditioning.

16 Wiring Devices

16.1 A porcelain lampholder mounted by means of a screw ring shall not be used without the gasket usually supplied with this type of lampholder.

16.2 A lampholder, receptacle, or other device supporting current-carrying parts shall be of porcelain or of cold-molded, phenolic, or urea composition.

16.3 Fiber or other absorptive material shall not be used as electrical insulation.

16.4 A wiring device (lampholder, receptacle, or the like) shall be prevented, by means other than friction, from any turning that applies tension to splices or other wiring connections, causes damage to the wiring, or otherwise adversely affects the assembly.

17 Wireways

17.1 A luminaire shall be constructed so wires can be pulled through, or the luminaire otherwise wired, without resulting in damage to the coverings or insulation on the conductors. A wireway shall be smooth and free from burrs and fins.

17.2 Screw threads are not prohibited from being exposed in a wiring compartment when the wires are held or positioned away from such screws.

17.3 When conductors pass through an opening in sheet metal, they shall be held away from the edges of the opening or shall be protected by a bushing, a grommet, or by rolling the edge of the metal at the opening not less than 120 degrees. A bushing, when used, shall be held in place. An insulating bushing shall have a minimum thickness of 1.2 mm (3/64 inch) and shall be capable of withstanding the temperatures involved. Any burr, fin, or sharp edge shall be removed from the edges of an opening in cast metal to reduce the risk of abrasion of the conductor insulation.

17.4 A fiber bushing shall not be used.

18 Wiring

18.1 Wires and splices within the luminaire shall be located so that they are not disturbed when lamps are being replaced.

18.2 The requirement in 18.1 does not apply to leads attached to a lampholder that is supported by a lamp that is in turn supported by the luminaire.

18.3 A conductor shall have insulation rated for a potential of 300 volts or more and for the temperature to which it will be subjected under conditions of intended use as determined in the Temperature Test, Section 33.

18.4 A conductor shall have:

a) Rubber or neoprene insulation and a saturated braid or

b) Thermoplastic insulation.

The thickness of the insulation shall be at least 0.8 mm (1/32 inch).

18.5 A conductor shall be of copper and of such size that its ampacity is not less than that required for the load supplied, but not smaller than 0.82 mm^2 (18 AWG) in any case. The wire gage requirement for the equipment grounding conductor is specified in 10.3.

19 Splices

19.1 A splice shall be made mechanically and electrically secure with solder or a wire connector. A soldered joint or a joint made with an uninsulated pressure wire connector shall be covered with insulation equivalent to that on the conductors.

20 Polarization and Identification

20.1 Each lampholder screwshell shall be connected to a grounded conductor or terminal.

21 Exposure of Live Parts

21.1 A luminaire shall have no uninsulated live part exposed to contact by persons during intended use.

21.2 A luminaire rated more than 15 volts shall have no uninsulated live part (other than the lamp contacts of a screw shell lampholder) accessible during relamping.

Exception No. 1: The lamp contacts of a screwshell lampholder are permitted to be accessible when the lamp is removed.

Exception No. 2: The lamp terminals of a double-ended lamp are permitted to be accessible under the following conditions:

a) All ungrounded circuit conductors are disconnected by an interlock switch before the parts become accessible; or

b) The supply circuit has one grounded conductor, and the lamp terminals can only make initial contact with the grounded lampholder terminal; or

c) The supply circuit has one grounded conductor, and in order to be fully installed the lamp is required to be inserted into the grounded lampholder terminal first. The luminaire shall be marked adjacent to the lampholder connected to the grounded (neutral) supply connection to indicate insertion of the lamp in this lampholder first.

22 Position of Live Parts

22.1 With the luminaire lens removed (to simulate a broken lens) but with any luminaire guard, grid, or barrier in place, the resulting lens opening or openings in the guard, grid, or barrier shall be such that:

a) A 203-mm (8-inch) diameter disc held parallel to the pool wall will not enter the opening and

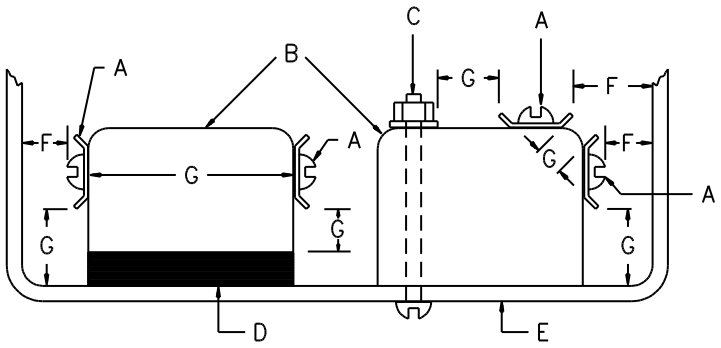
b) All uninsulated live parts (including the live parts within the lamp) are recessed at least one-seventh of the major dimension of any front opening or 25.4 mm (1 inch), whichever is greater, from the plane of that opening.

23 Spacings

23.1 There shall be a spacing of at least 6.4 mm (1/4 inch) through air, or at least 9.5 mm (3/8 inch) over surface of insulating material, between uninsulated live parts of opposite polarity and between an uninsulated live part and metal that may be grounded when a luminaire is installed.

Exception: The spacings required do not apply between an uninsulated live part of a wiring device, such as a lampholder, and dead metal that is part of the wiring device (including mounting screws, rivets, yoke, clamp, and the like), or between such live part and that part of the dead metal surface of the luminaire on which the device is mounted in its intended manner. Some examples of these spacings are illustrated in Figure 23.1.

Figure 23.1
Spacings at wiring devices



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A – Uninsulated live parts of wiring device.

B – Insulating material of wiring device.

C – Mounting screw of wiring device.

D – Dead-metal parts of wiring device.

E – Dead-metal parts of luminaire.

F – Spacings to which 23.1 applies.

G – Spacings to which 23.1 does not apply.

24 Barriers

24.1 A barrier or liner of insulating material shall be of nonabsorptive material at least 0.8 mm (1/32 inch) thick. Treated fiber or similar material shall not be used.

Exception: A barrier that is held in place and not exposed or otherwise likely to be damaged mechanically after installation is not prohibited from being less than 0.8 mm but shall not be less than 0.4 mm (1/64-inch) thick.

25 Grounding

25.1 A luminaire with a dead-metal part is to have provision for the connection of a supply-circuit, equipment-grounding conductor.

Exception No. 1: The following components are not to be considered a dead-metal part warranting the luminaire to have provision for the connection of a supply circuit equipment grounding conductor.

a) The interior metal coating of lamps and

b) A metal ring or similar part crimped around the jacket of a flexible cord to provide strain relief and that is subsequently encapsulated in a potting compound to a thickness of not less than 13 mm (1/2 inch).

c) A metal screw or other fastener used to secure a wet-niche or no-niche luminaire to its luminaire housing or mounting bracket where the metal screw or fastener is conductively connected to the conduit and equipment-grounding conductor specified as locations 26.1.4 (b) and (c).

Exception No. 2: A low voltage luminaire shall not have provision for connection of a supply-circuit, equipment grounding conductor.

25.2 When the luminaire is supplied by flexible cord, the means for connecting the equipment-grounding conductor shall be the grounding conductor that is part of the cord. When the luminaire is not supplied by flexible cord, the means for connecting the grounding conductor shall accommodate a 3.3 mm^2 (12 AWG) grounding conductor. Solder shall not be depended on for securing the equipment grounding conductor.

25.3 The means for securing a field-connected grounding conductor of a dry-niche luminaire shall comply with the requirements in 11.1.4 – 11.1.15. A wire-binding screw shall have a green-colored, slotted, hexagonal-shaped head. A wire-binding screw or stud shall be 4.8 mm diameter (No. 10) or larger. All parts of the terminating assembly shall be of copper, brass, or equivalent corrosion resistant material; ferrous materials (other than stainless steel) or aluminum materials shall not be used.

Exception: An internal bonding jumper is not required to be identified by color or other means.

25.4 A luminaire housing (forming shell) for a wet-niche luminaire, and the mounting bracket for a no-niche luminaire, shall be provided with a terminal for the connection of a 8.4 mm^2 (8 AWG) stranded copper equipment-grounding conductor. The terminal shall:

a) Consist of a pressure terminal connector of a corrosion-resistant material secured to the internal wall of the luminaire housing and the luminaire side of a mounting bracket and

b) Comply with the requirements in 11.1.4 – 11.1.15.

The design shall permit the wire to be connected to the connector without removing the wire connector. The connector for the equipment grounding conductor shall be free of rough or sharp edges, or shall be located so that when the luminaire is installed as intended, the flexible cord will not be in contact with the connector. A positive stop shall be provided that will prevent the equipment grounding conductor from passing completely through the wire connector and contacting the supply cord insulation.

Exception: A luminaire housing and mounting bracket marked in accordance with 45.5 for use only with metal conduit is not required to be provided with a terminal for an equipment grounding conductor.

26 Bonding

26.1 Ground-fault current path continuity

26.1.1 Except as specified in the Exceptions to 26.1.4 and 26.1.5, all dead-metal parts shall be bonded to all supply-circuit equipment-grounding conductors.

Exception: A low voltage luminaire with no provision for a supply-circuit grounding connection, per Exception No. 2 to 25.1, but with dead metal in contact with the water shall include provision for bonding those parts to the forming shell or mounting bracket.

26.1.2 When the dead-metal parts are capable of being inadvertently and directly energized through the failure of electrical insulation, electrical spacings, or both, the impedance of the bond specified in 26.1.1 shall comply with the provisions of 26.1.4 and 26.1.5, as applicable.

Exception: The impedance of the bond is not required to comply with the provisions of 26.1.4 and 26.1.5 when the location on the dead-metal part is capable of being directly energized only because:

a) The lamp envelope has broken and the dead-metal part is in direct contact with the lamp filament or filament support or

b) The dead-metal part and an uninsulated live part are both in contact with water that is assumed to have entered the luminaire through a damaged lens or a leaking gasket. As an example, the uninsulated live parts of a lamp base or the lampholder are often capable of being in contact with water that has entered the luminaire.

For this exception, electric current entering dead-metal from a supply circuit equipment grounding conductor shall be disregarded as a way of directly energizing the location on the dead-metal part. This exception does not preclude the requirement that the involved dead-metal part be bonded to all supply-circuit equipment grounding conductors as specified in 26.1.1. Only the magnitude of the bond impedance is exempted.

26.1.3 The sections of a lamp spring or lamp clip not embedded in the potting compound of a wet-niche swimming pool luminaire are examples of locations on a dead-metal part that often are capable of being energized only as specified in the Exception to 26.1.2. The bond impedance from these sections of such a lamp spring or lamp clip is not required to comply with the provisions of 26.1.4 or 26.1.5. The bond impedance from the lamp spring sections or lamp clip sections that are embedded in potting compound and that are capable of being inadvertently and directly energized through the failure of electrical insulation, electrical spacings, or both shall comply with the provisions of 26.1.4 or 26.1.5.

26.1.4 For wet-niche and no-niche luminaires that are not prohibited from being connected to supply circuits rated 20 amperes or less, the impedance between each of the dead-metal parts specified in 26.1.2 and the locations specified in (a) – (c) shall not be greater than 0.050 ohm. For a luminaire that must be connected to a supply circuit rated more than 20 amperes and not greater than 60 amperes, the impedance between these locations shall not be greater than 0.030 ohm.

a) The grounding conductor within the flexible cord.

b) Rigid metallic conduit connected to the forming shell or mounting bracket.

c) An 8 AWG copper conductor connected to the supplemental grounding conductor terminal on the wet side of the forming shell or mounting bracket.

Compliance is to be confirmed through the Bonding Millivolt Drop Test, Section 38.

Exception No. 1: The following dead-metal parts are not required to be bonded to the conduit and grounding conductors specified in (a) – (c).

a) The interior metal coating of lamps and

b) A metal ring or similar part crimped around the jacket of a flexible cord to provide strain relief and that is subsequently encapsulated in a potting compound to a thickness of not less than 13 mm (1/2 inch).

Exception No. 2: Dead-metal parts of a luminaire housing, mounting bracket, or other dead-metal parts that are not part of – or attached to – a wet-niche or no-niche luminaire when the luminaire is removed from the pool water for relamping or other servicing are not required to be bonded to the grounding conductor within the luminaire's flexible cord.

Exception No. 3: A metal screw or other fastener used to secure a wet-niche or no-niche luminaire to its luminaire housing or mounting bracket is not required to be bonded to the grounding conductor within the luminaire's flexible cord but shall be bonded to the conduit and equipment-grounding conductor specified in (b) and (c).

Exception No. 4: The bond between a metal rivet and a dead-metal part to which it is secured is not required to be further evaluated.

26.1.5 For a dry-niche luminaire that is not prohibited from being connected to a supply circuit rated 20 amperes or less, the impedance between each dead-metal part specified in 26.1.2 and a 3.3 mm^2 (12 AWG) copper conductor connected to the terminal or lead provided for connection of the supply-circuit equipment-grounding conductor shall be maximum 0.050 ohm. For a luminaire that must be connected to a supply circuit rated more than 20 amperes and maximum 60 amperes, the impedance between these locations shall be maximum 0.030 ohm. Compliance is to be confirmed through the Bonding Millivolt Drop Test, Section 38.

Exception No. 1: The dead-metal parts specified in Exception No. 1 to 26.1.4 are not required to be bonded to the grounding conductor.

Exception No. 2: The bond between a metal rivet and a dead-metal part to which it is secured is not required to be further evaluated.

26.1.6 With regard to the requirements in 26.1.4 and 26.1.5, a luminaire must be connected to a supply circuit rated at more than 20 amperes when:

a) The luminaire includes an admedium, mogul, or other heavy-duty lampholder or

b) The current calculated by taking the quotient of the wattage rating of the highest wattage lamp for which the luminaire is intended to be suitable and the voltage rating of the luminaire exceeds 16 amperes.

26.1.7 The path from locations on a dead-metal part to the equipment grounding conductors and conduit specified in 26.1.4 or 26.1.5, as applicable, shall comply with the High Current Test, Section 39, when:

a) The lamp filament or filament support is capable of contacting the location on the dead-metal part with the lamp envelope broken and

b) The dead-metal part's presence and its bond to an equipment grounding conductor is relied upon to comply with the Electric Shock Test, Section 41.

The capability of contact referenced in (a) shall be assessed after all parts have stopped moving upon lamp envelope breakage, not during part motion associated with lamp envelope breakage. Sections of a lamp spring or a lamp clip are examples of locations on dead-metal parts that meet the criteria specified in (a) and (b). Contact assessment is completed after the lamp spring or lamp clip has stopped moving upon lamp envelope breakage.

26.2 Continuity to pool bonding grid conductor

26.2.1 The pressure terminal connector specified in 26.2.2 shall be provided and all dead-metal parts of the luminaire, luminaire housing, and mounting bracket shall be bonded to the pressure terminal connector as specified in 26.2.3.

Exception: The following dead-metal parts are not required to be bonded to the pressure terminal connector:

a) The interior metal coating of lamps and

b) A metal ring or similar part crimped around the jacket of a flexible cord to provide strain relief and that is subsequently encapsulated in a potting compound to a thickness of not less than 13 mm (1/2 inch).

26.2.2 The pressure terminal connector (including the set-screw type) specified in 26.2.1 shall be provided on the exterior surface of the luminaire housing (forming shell) of a wet-niche luminaire, the

mounting bracket of a no-niche luminaire, and the enclosure of a dry-niche luminaire, for the connection of an 8.4 mm^2 (8 AWG) solid copper conductor to facilitate bonding the luminaire housing or mounting bracket or dry-niche luminaire enclosure to the common bonding grid of a swimming pool. The pressure terminal connector shall comply with the requirements in 11.1.4 – 11.1.15.

26.2.3 The impedance between a dead-metal part and an 8 AWG copper conductor connected to the bonding grid conductor terminal specified in 26.2.2 shall be maximum 0.020 ohm. Compliance is to be confirmed by the Bonding Millivolt Drop Test, Section 38.

Exception: The impedance from a location on a dead-metal part to an 8 AWG copper conductor connected to the bonding grid conductor terminal is not required to be maximum 0.020 ohm or to be subjected to the bonding millivolt drop test when both (a) and (b) apply.

a) All dead-metal current paths between the candidate dead-metal part location and all other dead-metal parts that are capable of being inadvertently and directly energized through the failure of electrical insulation, electrical spacings, or both, must include a dead-metal part that is bonded to the terminal specified in 26.2.3 with an impedance of maximum 0.020 ohm. Energization of a dead-metal part through the manner described in (a) or (b) of the Exception to 26.1.2 is not to be considered for sub-item (a) of this exception.

b) All dead-metal current paths between the candidate dead-metal part location and each and all supply-circuit equipment grounding conductors (other than the equipment grounding conductor within the flexible cord of a wet-niche or no-niche luminaire) must include a dead-metal part that is bonded to the terminal specified in 26.2.2, with an impedance of maximum 0.020 ohm as specified in 26.2.3. For wet-niche and no-niche luminaires, all dead-metal current paths to the equipment grounding conductor and conduit specified in 26.1.4 (b) and (c) shall still include a dead-metal part that is bonded to the terminal specified in 26.2.2, with an impedance of maximum 0.020 ohm.

26.2.4 The Exception to 26.2.3 does not preclude the requirement that the involved dead-metal part be bonded to the 8 AWG copper conductor connected to the bonding grid conductor terminal as specified in 26.2.3. Only the magnitude of the bond impedance is exempted.

27 Drainage and Water Entry

27.1 A dry-niche luminaire shall have provision for drainage, below the lowest live part, to prevent the accumulation of water within the luminaire.

27.2 Where needed to comply with the Temperature Test, Section 33, wet-niche and no-niche luminaires shall be provided with at least four openings to permit free passage of water from the pool, fountain, or the like into the wet-niche luminaire housing and between a no-niche luminaire and its mounting bracket. Such openings shall be of a size and be distributed around the circumference of the bezel so as to reduce the likelihood of being blocked or plugged during installation.

28 Integral Overheating Protection

28.1 A luminaire shall be provided with integral protection against overheating and shall be subjected to the Abnormal Operation Tests, Section 34.

Exception: A luminaire shown by test to be acceptable for continuous operation out of water or designed to be inoperable out of water is not required to be provided with integral protection against overheating.

28.2 The integral protection against overheating shall be of the automatic-reset type.

Exception: A tamperproof, one-time device (such as a thermal cutoff) is not prohibited from being used when the luminaire is tested as specified in 34.7 and marked as indicated in 44.6.

28.3 When protection against overheating is provided by a heat-sensitive device, such as a thermostat, it shall have a current rating not less than the rated luminaire wattage divided by the rated luminaire voltage, and a voltage rating not less than the rated voltage of the luminaire.

CONSTRUCTION – LUMINAIRE HOUSINGS (FORMING SHELLS) FOR WET-NICHE LUMINAIRES

29 General

29.1 The mechanical strength of a luminaire housing and mounting bracket shall be such as to withstand all conditions of intended use.

29.2 Tin-lead solder shall not be used for the fastening of seams or the assembly of parts of a luminaire housing.

29.3 A metal luminaire housing and mounting bracket shall be of copper or a copper alloy having a zinc content not in excess of 15 percent, or of an equivalent corrosion-resistant metal. Aluminum and aluminum alloys shall not be used.

29.4 Paint, enamel, or other coatings that inhibit bonding of parts or reduce the electric-field shielding effect (where required) shall not be used on either the inside or the outside of a luminaire housing.

30 Sheet Metal

30.1 The thickness of sheet metal in a luminaire housing and mounting bracket shall be as indicated in Table 30.1.

Table 30.1
Minimum thickness of sheet metal

Location	Drawn or spun stainless steel,[a]		Drawn or spun stainless alloy,[a]		Fabricated sheet metal,	
	mm	(inch)	mm	(inch)	mm	(inch)
At any point where a conduit hub is secured	0.51	0.020	1.02	0.040	1.02	0.040
At any other point:						
Housing that is 305 mm (12 inches) or less diameter	0.51	0.020	0.51	0.020	1.02	0.040
Housing that is over 305 mm diameter	0.51	0.020[b]	0.51	0.020[b]	1.02	0.040

[a] Metal other than stainless steel or copper alloy, 0.51 mm (0.020 inch) minimum, is not prohibited from being used when equivalent strength and rigidity are provided.

[b] A greater thickness may be required when equivalent strength and rigidity are not provided.

31 Cast Metal

31.1 The thickness of cast metal shall be as indicated in Table 8.1.

32 Connections for Wiring Systems

32.1 A luminaire housing and mounting bracket shall have provision for the connection of rigid metal or nonmetallic conduit of a size that will accommodate the flexible cord described in 10.3 and 11.2.1 supplying the luminaire with which the housing is to be used.

PERFORMANCE

33 Temperature Test

33.1 When the luminaire is operated continuously at rated lamp wattage with the largest lamp (or lamps) with which the luminaire is intended to be operated, the temperature attained shall not exceed the temperature ratings of the materials used. When the temperature of the supply conductors of a dry-niche luminaire exceeds 60°C (140°F), the luminaire shall be marked where visible during installation to indicate that wire rated for 75°C (167°F) is to be used. The luminaire shall be tested as described in 33.2 – 33.4.

Exception: A luminaire that is not marked "Submerge before lighting" or the equivalent shall be operated in air at room temperature.

33.2 A wet-niche or no-niche luminaire is to be mounted in its forming shell or to its mounting bracket in the intended manner, with the flexible cord passing out through a 1-m (3-foot) length of conduit attached to the forming shell. The mounting bracket for a no-niche luminaire shall be mounted to a plywood panel or other required structure simulating a pool wall, to restrict water circulation between the luminaire and simulated pool wall as in the intended installation. The luminaire and luminaire housing or mounting bracket are to be completely submerged in a tank of water with the face of the luminaire in a vertical plane. The water temperature in the tank is to be maintained between 20 – 30° C (68 – 86° F), and the temperatures measured on the luminaire are to be corrected to a water temperature of 25°C (77°F).

33.3 To prevent the entrance of water into the luminaire, it may be necessary to provide means for thermocouple entrance into the luminaire. A tube that is welded to an opening in the luminaire and that extends above the water level may be used for this purpose, or equivalent means may be used.

33.4 A dry-niche luminaire is to be installed in an opening in one side of a tank of water, so that the face of the luminaire is exposed to water. The supply conductors and the thermocouples are to be brought out through a 1-m (3-foot) length of rigid metal conduit attached to the luminaire in the intended manner. The open end of the conduit is to be closed by cotton loosely packed around the supply conductors and the thermocouples where they emerge from the conduit. The water temperature in the tank is to be maintained between 20 – 30°C (68 – 86°F), and the temperatures measured on the luminaire are to be corrected to a water temperature of 25°C (77°F).

34 Abnormal Operation Tests

34.1 To determine compliance with the requirement in 28.1, a luminaire is to be tested as described in 34.2 – 34.7.

34.2 The luminaire is to be operated continuously under the applicable abnormal conditions described in 34.3 – 34.7 at rated lamp wattage using the highest wattage lamp or lamps for which the luminaire is marked, until ultimate results have been obtained. Results are in compliance when the rated temperature of any material used in the luminaire is not exceeded by more than 30°C (54°F) at any time during the test and, for a wet-niche and no-niche luminaire, when the external temperature of any part of the luminaire that is likely to be contacted by the flexible cord does not exceed the temperature rating of the cord by more than 30°C.

Exception: It is not prohibited for the temperature limit identified in 34.2 to be exceeded during the first two cycles of an automatic-reset type temperature control as described in 34.3.

34.3 An automatic-reset-type temperature control used as the integral overheating protection required in 28.1 may have temperature cut-off characteristics that allow a temperature higher than the calibrated opening temperature of the control during the first two cycles of operation. The first two cycles of operation are defined as the temperature rise after the first and second functioning of the temperature control in each test condition, followed by the temperature decline to the lowest point before rising again. During these first two cycles only, the temperature of any of the materials used in the luminaire may exceed their rated temperature limit by not more than 55°C (118°F).

34.4 A wet-niche luminaire is to be mounted in its forming shell in the intended manner. A no-niche luminaire is to be installed on its mounting bracket and simulated pool wall as specified in 33.2. The flexible cord is to be wrapped two full turns around the luminaire enclosure or cord-wrap feature and then passed out through a 1-m (3-foot) length of conduit attached to the forming shell. The luminaire and luminaire housing or mounting bracket are to be placed in a tank with the face of the luminaire in a vertical plane. The luminaire is to be operated in each case until ultimate results are obtained, first with no water in the tank, then with the luminaire and luminaire housing or mounting bracket submerged in turn 25 percent and then 75 percent, and finally with the luminaire out of the niche while still wet and lying on its side on a flat wooden deck. The water temperature in the tank is to be maintained between 20 – 30°C (68 – 86°F), and the temperatures measured on the luminaire are to be corrected to an ambient water or air temperature of 25°C (77°F).

34.5 To prevent the entrance of water into the luminaire, it may be necessary to provide means for thermocouple entrance into the luminaire. A tube that is welded to an opening in the luminaire and that extends above the water level may be used for this purpose, or equivalent means may be used.

34.6 A dry-niche luminaire is to be installed in an opening in one side of a tank of water, so that the face of the luminaire is exposed to the inside of the tank. The luminaire is to be operated in each case until ultimate results are obtained, first with no water in the tank, and then in turn with 25 percent and 75 percent of the vertical height of the face of the luminaire exposed to water. The supply conductors and the thermocouples are to be brought out through a 1-m (3-foot) length of rigid metal conduit attached to the luminaire in the intended manner. The open end of the conduit is to be closed by cotton loosely packed around the supply conductors and the thermocouples where they emerge from the conduit. The water temperature in the tank is to be maintained between 20 – 30° C (68 – 86° F), and the temperatures measured on the luminaire are to be corrected to an ambient water or air temperature of 25°C (77°F).

34.7 In addition to the tests described in 34.1 – 34.6, a luminaire provided with a one-time operation thermal sensitive device and marked in accordance with 44.6 shall additionally be tested in a totally dry condition by operation out of water while resting face down on a flat wooden deck. This test verifies that the luminaire will not become permanently inoperable during lamp replacement if the luminaire is briefly energized prior to re-installation. The temperature of the luminaire at the start of the test shall be 25 ±5°C (77 ±9° F). Results are acceptable if the protective device does not operate during the first 3 minutes of operation.

35 Water Leakage Test

35.1 A luminaire shall be operated for at least 6 hours under a 31-cm (1-foot) head of water as measured to the top of the lens, in cycles of 1/2 hour on and 1/2 hour off. The results are in compliance when there is no entry of water into the luminaire.

35.2 The jacket of the cord for a wet-niche or no-niche luminaire is to be removed for a distance of at least 25.4 mm (1 inch), the removed portion starting at a distance of 15.2 cm (6 inches) outside the point of

entry into the luminaire. This section of the cord is to be completely immersed in the water during the water leakage test described in 35.1.

35.3 Unless the luminaire construction provides for venting the luminaire enclosure during intended use, a tube such as described in 33.3 is not to be used during the water leakage test described in 35.1.

36 Dielectric Voltage-Withstand Test

36.1 A luminaire shall be subjected for 1 minute to the application of a 60-hertz alternating potential between live parts and dead metal parts. The test potential shall be 1000 volts plus twice the rated voltage of the luminaire. The results are in compliance when there is no dielectric breakdown.

36.2 The test is to be conducted immediately following the water leakage test described in 35.1. The luminaire is to be tested by means of a 500-volt-ampere or larger transformer, the output voltage of which is sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached, and held at that value for 1 minute. The applied potential is to be increased at a uniform rate, and as rapidly as accurate voltmeter readings will allow.

37 Strain-Relief Test

37.1 A strain-relief device shall be subjected to a direct pull by means of a 22.7-kg mass (50-pound weight) applied to the cord as described in 37.2.

37.2 The pull is to be applied by suspending a 22.7-kg mass (50-pound weight) on the cord so the pull is in a direction normal to the plane of the fitting through which the cord enters the luminaire. The cord conductors are to be severed immediately adjacent to the terminals or splices when it is determined that the permitted movement of the cord results in strain on the terminals or splices. The pull is to be maintained for 1 minute. The construction is in compliance when there is no movement of the cord more than 3.2 mm (1/8 inch) from the point where it exits the luminaire.

38 Bonding Millivolt Drop Test

38.1 General

38.1.1 The impedance between the parts specified in 26.1.4, 26.1.5, and 26.2.3 is to be determined as specified in this section. This is to be done by measuring the voltage potential between the specified points while a test current of 30 amperes (AC or DC) conducts through the specified parts and not less than 15 seconds after applying the test current. The impedance is to be determined by taking the quotient of the measured voltage potential and the test current. The test is to be performed with the product dry.

38.1.2 The test equipment used to monitor the current is to indicate the test current with a resolution and accuracy of 1/2 ampere or better.

38.1.3 The test equipment used to measure the voltage potential specified in 38.2.1.1, 38.2.2.1, and 38.3.1 is to indicate the measured voltage with a resolution and accuracy of 3 percent of the involved maximum permitted voltage potential or better.

38.1.4 Within 1 hour prior to conducting this test, all screws that are loosened and tightened during relamping, gasket replacement, or other anticipated servicing, are to be loosened and then tightened with a screwdriver to the following torque based on the screw size. When tightening the screws, the specified torque is to be held for 5 ±1 seconds.

Screw size	Tightening torque
3.5 mm (6 AWG)	1.4 N·m (12 lb-in)
4.2 mm (8 AWG)	1.8 N·m (16 lb-in)
4.8 mm (10 AWG)	2.3 N·m (20 lb-in)

38.1.5 Some swimming pool luminaires are built with a joint between two dead-metal parts where the final position of the parts may vary between two installations or between various instances of servicing. The different positions such parts may acquire may also serve to vary the quality or existence of a bond between such parts. When such a joint is involved, this test is to be conducted with the involve parts positioned or electrically isolated in a manner representing the most adverse variation that might be encountered during installation or as a result of servicing.

38.2 Ground-fault current path impedance determination

38.2.1 Wet-niche and no-niche luminaires

38.2.1.1 For a wet-niche and no-niche luminaire, there is to be a voltage potential of not more than 1.5 volt (corresponding to a maximum, 0.050-ohm impedance conducting 30 amperes) between each dead-metal part specified in 26.1.3 and each location specified in (a) – (c). For a luminaire that must be connected to a supply circuit rated more than 20 amperes and not greater than 60 amperes, there is to be a voltage potential of not more than 0.90 volt (corresponding to a maximum 0.030 ohm impedance conducting 30 amperes) between the dead-metal parts specified in 26.1.3 and the following locations:

a) The grounding conductor within the flexible cord.

b) Rigid, metallic conduit connected to the luminaire housing or mounting bracket (the conduit is to be tightened to the torque specified in 11.1.3 prior to the test).

c) An 8.4 mm^2 (8 AWG) stranded copper conductor connected to the grounding conductor terminal on the wet side of the forming shell or mounting bracket.

Exception No. 1: The test is not required for the dead-metal parts specified in the Exceptions to 26.1.4.

Exception No. 2: The test involving rigid metallic conduit is not required for luminaire housings with plastic hubs or sockets and without any means for bonding dead-metal parts to connected metallic conduit.

38.2.1.2 For testing involving the conduit, one leg of the current source circuit is to be connected to the rigid metallic conduit not less than 13 cm (5 inches) from the hub on the luminaire housing or mounting bracket. For testing involving the 8 AWG conductor connected to the grounding conductor terminal on a luminaire housing or mounting bracket, one leg of the current source circuit is to be connected to the conductor not less than 15 cm (6 inches) from where the conductor connects to the terminal. For testing involving the grounding conductor of a flexible cord, one leg of the current source circuit is to be connected to the grounding conductor not less than 15 cm from where the flexible cord enters the luminaire.

38.2.1.3 The remaining leg of the current source circuit is to be connected at a location on each dead-metal part that is representative of where current enters the part as described in 26.1.3. Only one location is to be connected at a time during the test. The conductor used to introduce the test current into the dead-metal part is to be minimum 15 cm (6 inches) long, not smaller than a 10 AWG (5.3 mm^2) copper or an 8 AWG (8.4 mm^2) aluminum conductor, and soldered, brazed, or welded to the dead-metal part.

Exception: When all involved agree, the conductor is not prohibited from being secured to the dead-metal part in a manner that results in more impedance in the joint, such as with a spring-type clip, or by drilling a

hole in the dead-metal part and securing the conductor with a crimped-on, loop-type terminal connector with screw and nut.

38.2.1.4 One voltage probe is to be connected to the conductor supplying the 30-ampere current to the dead-metal part under test 5 ±1 cm (2.0 ±0.4 inch) from where the conductor terminates on the dead-metal part.

38.2.1.5 For testing involving the conduit, the second voltage probe is to be connected to the conduit 3 mm (1/8 inch) from the conduit hub. For testing involving the conductor connected to the luminaire housing or mounting bracket grounding conductor terminal, the second voltage probe is to be connected to the conductor (conducting the test current) 5 ±1 cm (2 ±0.4 inch) from where the conductor connects to the terminal. For testing involving the grounding conductor of a flexible cord, the second voltage probe is to be connected to the grounding conductor 5 ±1 cm from where the flexible cord enters the luminaire.

38.2.2 Dry-niche luminaires

38.2.2.1 For a dry-niche luminaire, there is to be a voltage potential of not more than 1.5 volts (corresponding to a maximum 0.050-ohm impedance conducting 30 amperes) between each dead-metal part specified in 26.1.3 and a 12 AWG (3.3 mm^2), copper conductor connected to the terminal or lead provided for connection of the supply-circuit, equipment-grounding conductor. For a luminaire that is connected to a supply circuit rated more than 20 amperes and not greater than 60 amperes, there is to be a voltage potential of not more than 0.90 volts (corresponding to a maximum, 0.030-ohm impedance conducting 30 amperes) between these locations.

Exception: The test is not required for the dead-metal parts specified in the Exceptions to 26.1.5.

38.2.2.2 One leg of the current source circuit is to be connected to the 12 AWG (3.3 mm^2) conductor not less than 15 cm (6 inches) from the point where the conductor terminates at the equipment-grounding conductor terminal or lead in the luminaire splice compartment.

38.2.2.3 The remaining leg of the current source circuit is to be connected at a location on each dead-metal part that is representative of where current enters the part as described in 26.1.3. The characteristics specified in 38.2.1.3 for the remaining leg of the current source and its connection to the dead-metal part also apply.

38.2.2.4 One voltage probe is to be connected to the conductor supplying the test current to the dead-metal part under test 5 ±1 cm (2 ±0.4 inch) from where the conductor terminates on the dead-metal part.

38.2.2.5 The second voltage probe is to be connected to the 12 AWG (3.3 mm^2) conductor (conducting the test current) 5 ±1 cm (2 ±0.4 inch) from the point where the conductor terminates at the equipment grounding conductor terminal or lead in the luminaire splice compartment.

38.3 Impedance to pool bonding grid determination

38.3.1 There shall be a voltage potential of not more than 0.60 volts (corresponding to a maximum 0.020 ohm impedance conducting 30 amperes) between an 8 AWG (8.4 mm^2) solid copper conductor connected to the bonding grid conductor terminal and each dead-metal part of the luminaire, luminaire housing, and mounting bracket.

Exception: The test is not required for the dead-metal parts specified in Exception No. 1 to 26.2.1.

38.3.2 One leg of the current source circuit is to be connected to the 8 AWG (8.4 mm^2) conductor connected to the pool bonding grid conductor terminal not less than 15 cm (6 inches) from the point where the 8 AWG conductor connects to the terminal.

38.3.3 The second leg of the current source circuit is to be connected at a location on each dead-metal part. When the dead-metal part is adjacent to or enclosing wiring, splices, lampholder terminals, thermal protectors, and other live parts, the second leg of the current source circuit is to be connected at a location representative of where current would enter the part in the event a fault involving the live part occurs. When the dead-metal part is not adjacent to or enclosing a live part, the second leg of the current source circuit is to be connected to the location on the part nearest, electrically, a swimmer in contact with the luminaire. Only one location is to be connected at a time during the test. The method of connection, and the conductor to be used, is to be as indicated in 38.2.1.3.

38.3.4 One voltage probe is to be connected to the conductor supplying the test current to the dead-metal part under test 5 ±1 cm (2 ±0.4 inch) from where the conductor terminates on the dead-metal part.

38.3.5 The second voltage probe is to be connected to the 8 AWG conductor (conducting the 30-ampere current) 5 ±1 cm (2 ±0.4 inch) from where the conductor terminates at the bonding grid conductor terminal.

39 High Current Test

39.1 This test is to be conducted when:

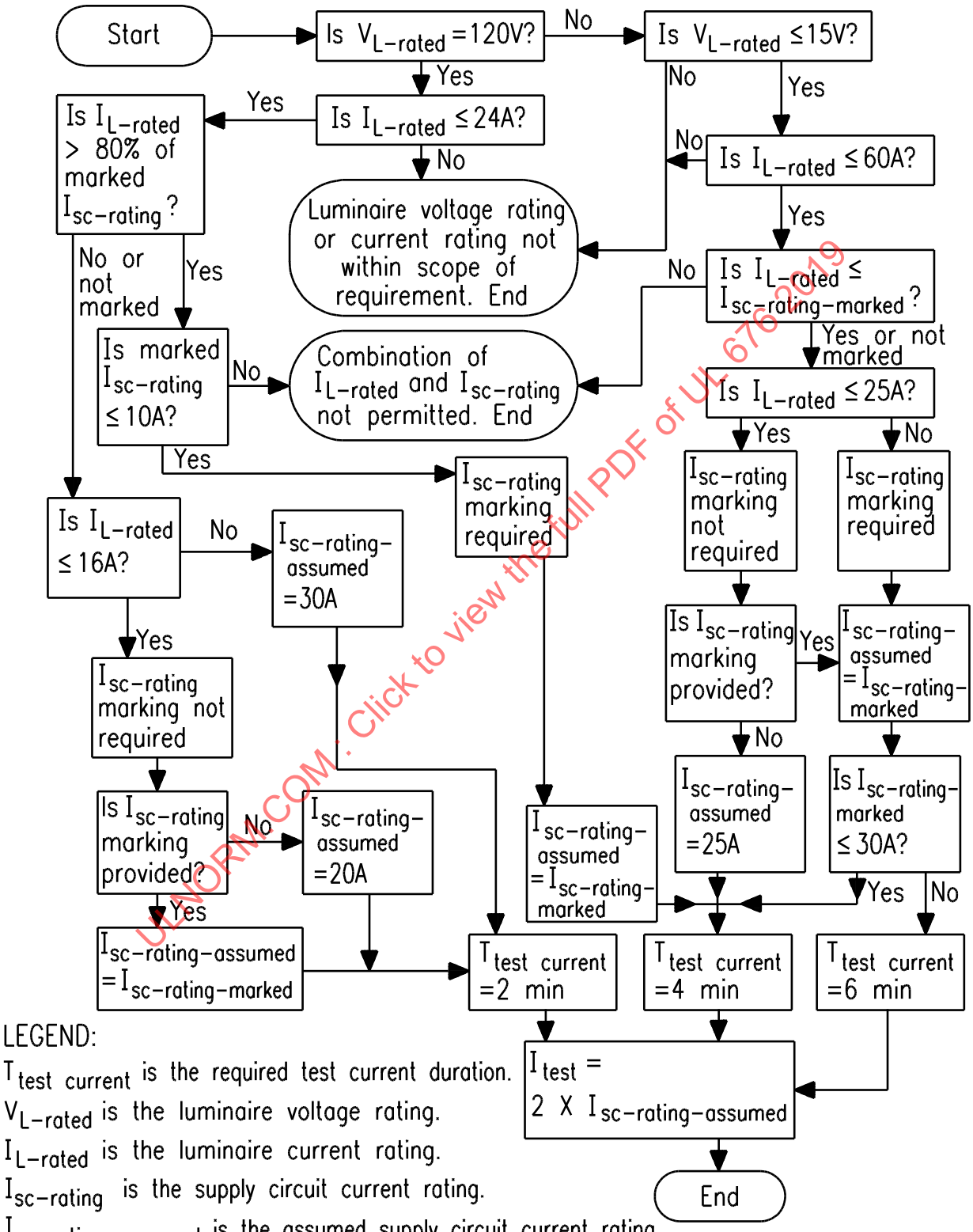
a) A dead-metal part is capable of contacting the lamp filament or filament support with the lamp envelope broken and

b) The dead-metal part's presence and its bond to an equipment grounding conductor is relied upon to comply with the Electric Shock Test, Section 41.

The capability of contact referenced in (a) is to be assessed after all parts have stopped moving upon lamp envelope breakage, not during part motion associated with lamp envelope breakage. Sections of a lamp spring or a lamp clip are examples of dead-metal part locations that meet the criteria specified in (a) and (b). Contact assessment is completed after the lamp spring or lamp clip has stopped moving upon lamp envelope breakage.

39.2 The ground-fault current path from dead-metal part locations that are capable of being contacted by the lamp filament or filament support with the lamp envelope broken shall withstand, for a period of time, a current as specified in Figure 39.1.

Figure 39.1
Test current value and duration and need for marking specifying supply circuit rating



LEGEND:
$T_{test\ current}$ is the required test current duration.
$V_{L-rated}$ is the luminaire voltage rating.
$I_{L-rated}$ is the luminaire current rating.
$I_{sc-rating}$ is the supply circuit current rating.
$I_{sc-rating-assumed}$ is the assumed supply circuit current rating.
$I_{sc-rating-marked}$ is the marked supply circuit current rating.

S4376A

39.3 As a result of this test, all parts of the luminaire shall not be affected to the extent that the luminaire no longer complies with any other requirement in this standard. Compliance with the Electric Shock Test, Section 41, is to be considered. The ability of a lamp spring or lamp clip (if involved) to deflect for lamp replacement and also, when necessary, to flex back to a position enabling compliance with the electric shock test shall not be compromised. A lamp spring or lamp clip involved in the high current test shall demonstrate this ability by withstanding 30 lamp replacements and 30 simulated lamp envelope breakages (simulated with lamp removal).

39.4 Assessment of the requirement in 39.3 is to be performed after all applicable luminaire parts have been allowed to cool to room temperature following application of the test current.

39.5 The test is to be performed with a dry product.

39.6 When required in Figure 39.1, the luminaire shall be marked as specified in 44.12 with the maximum rating for the supply circuit overcurrent protection device.

39.7 The provisions of 38.1.2, 38.1.4, 38.1.5, 38.2.1.2, and 38.2.2.2, as applicable, shall apply when conducting this test.

39.8 Where two or more equipment grounding conductors are intended to be connected to the luminaire with luminaire housing or luminaire mounting bracket, if involved, all such conductors shall be connected to the sample under test and connected together at the current source circuit.

39.9 The second leg of the current source circuit is to be connected to the location on the dead-metal part where the lamp filament or filament support is capable of contacting the dead-metal part with the lamp envelope broken. The conductor used to introduce the test current into the dead-metal part is to be minimum 15 cm (6 inches) long, not smaller than a 10 AWG (5.3 mm^2) copper or an 8 AWG (8.4 mm^2) aluminum conductor, and soldered, brazed, or welded to the dead-metal part.

Exception: Upon agreement from all involved, the conductor is not prohibited from being secured to the dead-metal part in a manner that results in more impedance in the joint, such as with a spring-type clip, or by drilling a hole in the dead-metal part and securing the conductor with a crimped-on, loop-type terminal connector with screw and nut.

39.10 The sample is to be subjected to the test current for the time period specified in Figure 39.1 with a time period precision of +2/-0 seconds.

40 Impact Test

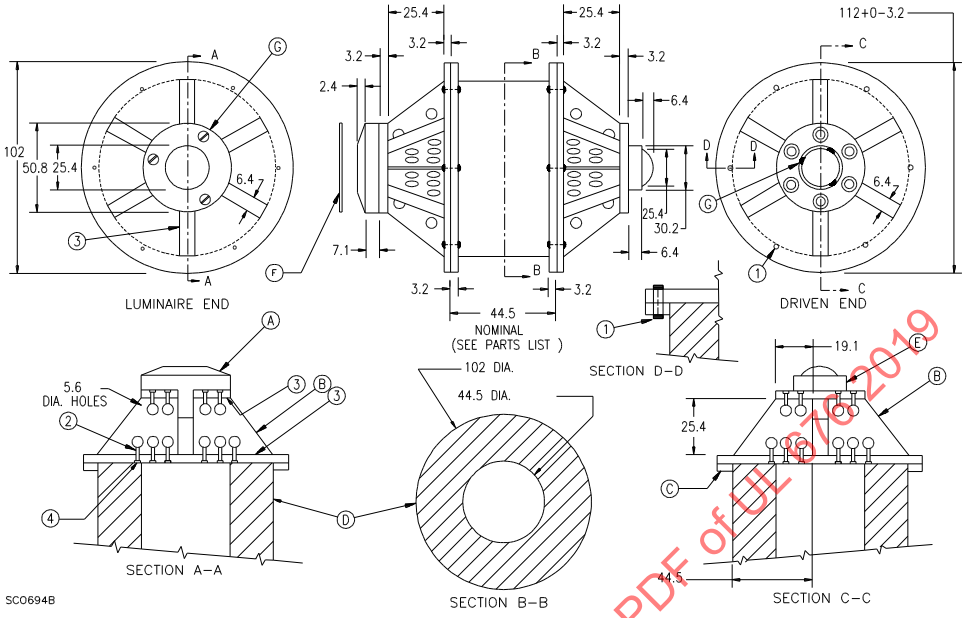
40.1 The luminaire shall withstand three impacts applied by the method described in 40.2 – 40.4 without:

a) Breaking of the lens or panel in such a manner that injury to persons could result and

b) Producing any mechanical distortion or displacement of the luminaire that would result in failure to comply with the requirements in any one of the following: 6.1, 9.1, 9.2, 13.1 – 13.3, 35.1, 38.2.1.1, 38.2.2.1, 38.3.1, or 41.1.

40.2 The impacts are to be applied by an apparatus consisting of a driving mass and a deceleration unit. For a wet-niche luminaire, a simulated niche mounting as specified in Figure 40.1 – Figure 40.3, or the equivalent, is to be used. Each of the three impacts may be applied at a different location on the surface of the luminaire exposed to swimmer contact. In the selection of these impact points or locations, consideration is to be given to points of contact that could lead to lens breakage, fracture of lens grids or guards, and twisting or loosening of the luminaire within the luminaire housing or on its mounting bracket.

Figure 40.1
Decelerating unit



Note – Dimensions are in mm. See Table 40.1 for item descriptions.

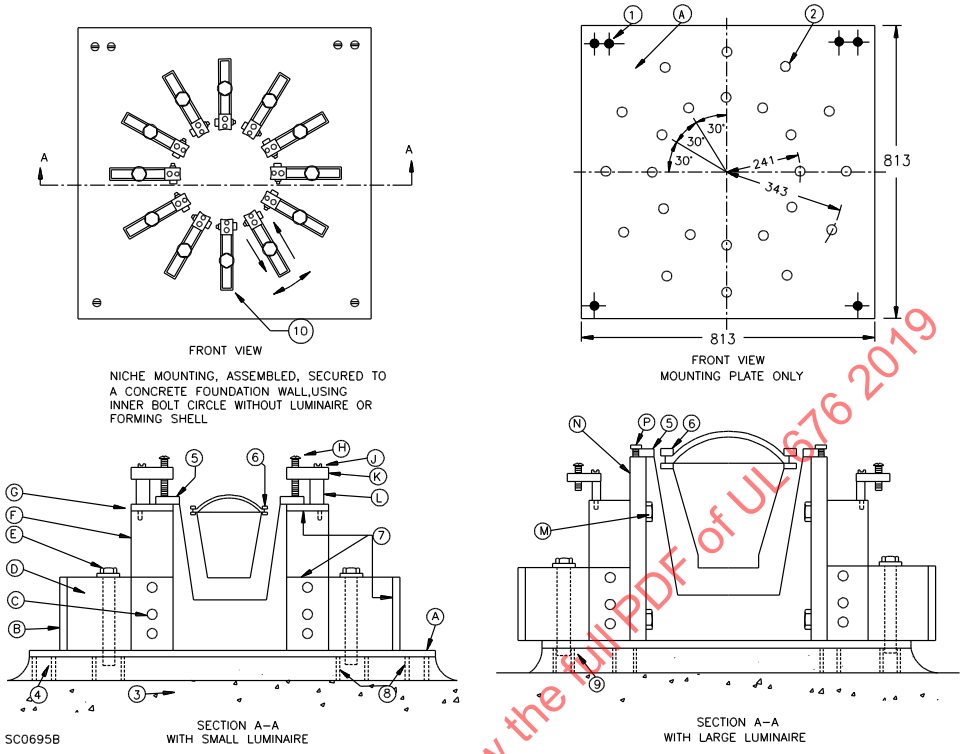
SI equivalents

mm	(inches)
2.4	3/32
3.2	1/8
5.6	7/32
6.4	1/4
7.1	9/32
19.1	3/4
25.4	1
30.2	1-3/16
44.5	1-3/4
50.8	2
102	4
112	4-13/32

Table 40.1
Decelerating unit descriptions

A	–	Replaceable aluminum nosepiece.
B	–	End caps. Rigid but light assemblies fabricated by riveting and brazing 6.4 mm thick aluminum ribs to 3.2 mm thick aluminum discs. Maximum weight of each end cap, including nosepiece (A) on luminaire end and striking anvil (E) on driven end, equals 225 ±23.4 g (9 ±1 ounce).
C	–	Spring retaining rings. Aluminum, 102 mm inside diameter, must provide a snug fit on ends of elastomer spring to restrain radial expansion of elastomer at ends.
D	–	Spring material. GRS (butadiene styrene), shore durometer 65, 102 mm outside diameter with 44.5 mm inside diameter core hole 44.5 mm thick [final trimming of thickness made by a cut and try operation to obtain a spring constant of 1.17 MN/m (6700 pounds per inch) at a 6672 N (1500-pound) static loading for the entire deceleration unit]. This material is available as 102 mm outside diameter, 19.1 mm inside diameter Cylinder Spring Rubber stock used for punch press and die stripper service from mechanical rubber goods supply houses. Inside diameter is enlarged to 44.5 mm by grinding or with a hole saw.
E	–	Driving end striking anvil. Steel, single unit or fabricated in two sections, approximate spherical surface.
F	–	Replaceable sheet lead or nitrile rubber buffer pad, 50.8 mm in diameter, 1.6 mm (1/16 inch) thick. Used over nosepiece when bearing against glass surfaces. Compliant results obtained without the pad are acceptable. Alternative materials with a Type A Shore durometer hardness of 60 (±5) are acceptable.
G	–	Three 6 – 32 steel screws per end cap.
1	–	Light gage brass or aluminum rivets.
2	–	3.2 mm diameter steel pop rivets. Cinched ends expand into the holes drilled through the end cap ribs.
3	–	Aluminum braze all rib joints at plates.
4	–	Counter bore all end cap plates at rivet holes to make rivet heads flush with exterior surfaces.

Figure 40.2
Simulated niche mounting



Note – Dimensions are in mm. See Table 40.2 for item descriptions.

SI equivalents

mm	(inches)
241	9-1/2
343	13-1/2
813	32

Table 40.2
Simulated niche mounting descriptions

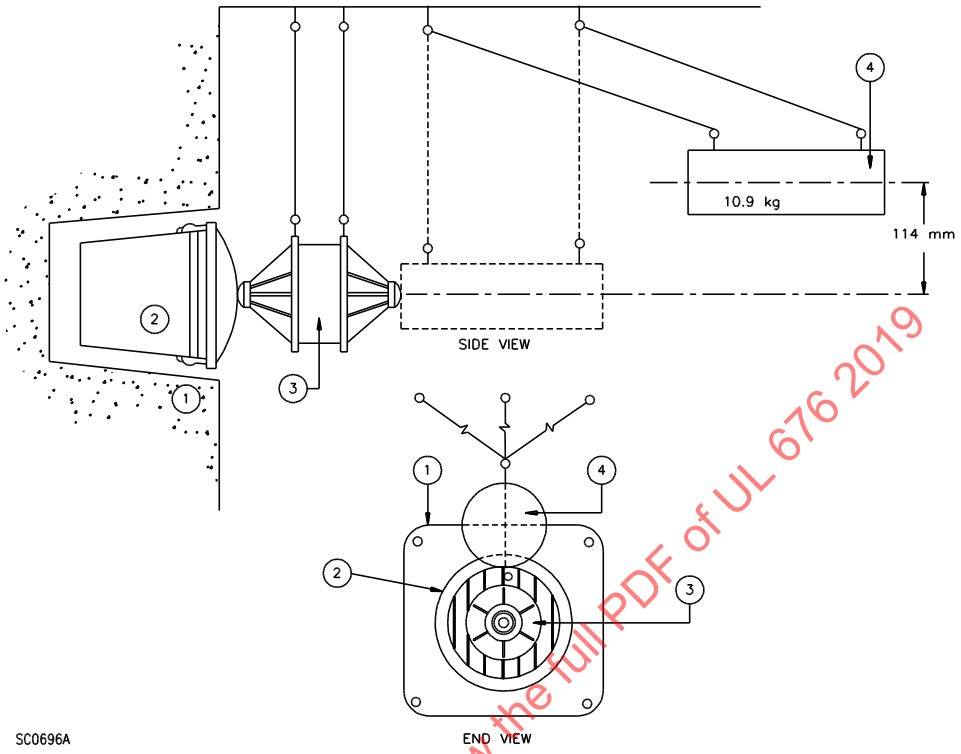
A	–	Mounting plate, steel, 813 by 813 by 12.7 mm thick.
B	–	Cold-rolled steel, 6.4 by 28.6 by 152 mm, one per bracket.
C	–	Bolts, steel, 12.7 mm, three per bracket.
D	–	Cold-rolled steel, 6.4 by 152 by 203 mm, two per bracket.
E	–	Mounting bolt, steel, 16 x 178 mm, one per bracket. Threads into mounting plate (A), provided with 44.5 mm diameter flat washer under head to clamp both side plates (D) simultaneously.
F	–	Cold-rolled steel, 19.1 by 63.5 by 254 mm, one per bracket.
G	–	Cold-rolled steel, 12.7 by 31.8 by 63.5 mm, one per bracket.
H	–	Screw, steel, 6.4 by 50.8 mm. Threads through (K), used to clamp forming shell bezel to end of bracket. 1 per bracket.
J	–	Bolt, steel, 9.5 by 76.2 mm, one per bracket. May be loosened to allow clamp to be turned away from luminaire when extension posts N are used or if extra clearance is needed for the impact device.
K	–	Cold-rolled steel, 12.7 by 31.8 by 63.5 mm, one per bracket.
L	–	Spacer, 31.8 mm length of 19.1 mm pipe.
M	–	Bolts, steel, 9.5 by 38.1 mm, two per bracket. Used only when extension posts (N) are used. Thread into part (F).
N	–	Extension posts, cold-rolled steel, 31.8 by 31.8 by 381 mm, one per bracket. Used only when required for testing a luminaire which is too deep for mounting in the unextended bracket.
P	–	Screw, any convenient size, threads into (N), used with washers or other appropriate hardware to clamp the forming shell bezel to the end of the extension post.
1	–	Drill and countersink for flat head wall anchor bolts.
2	–	Drill and tap for 15 mm bolt threads.
3	–	Vertical concrete building foundation wall or an equivalent, solid masonry mass.
4	–	Mounting plate is grouted to wall on which it is fastened, maximum thickness of grouting 32 mm, no voids or air pockets permitted in grout.
5	–	Luminaire forming shell.
6	–	Luminaire mounted inside the forming shell in intended manner.
7	–	Weld of braze.
8	–	Pipe caps or other cup-shaped pieces welded or brazed to back of mounting plate to prevent grout from filling bolt holes and to form recesses for the extension of bolt (E) threads beyond plate.
9	–	Outer bolt circle shown being used to accommodate a large luminaire.
10	–	Each individual luminaire support bracket may be maneuvered along and around its mounting bolt (E) to locate it in its most effective position for support of forming shell bezel. Mounting bolt (E) may be located in either the inner or outer bolt circle to accommodate a wider range of luminaire sizes. After positioning of the bracket, the assembly bolt (E) is drawn tight to lock the individual bracket, then screw (H) or (P) is tightened to lock the forming shell. Depending upon physical obstructions on forming shell bezel, it is possible that not all of the 12 brackets may be successfully positioned to support forming shell. But in no case are less than 10 brackets to be used to support the forming shell and luminaire during performance of impact tests.

See Table 40.3 for SI equivalents.

Table 40.3
SI equivalents

Note	mm	(inches)
A	813 by 813 by 12.7	32 by 32 by 1/2
B	6.4 by 28.6 by 152	1/4 by 1-1/8 by 6
C	12.7	1/2
D	6.4 by 152 by 203	1/4 by 6 by 8
E	15.9 by 178	5/8 by 7
	44.5	1-3/4
F	19.1 by 63.5 by 254	3/4 by 2-1/2 by 10
G	12.7 by 31.8 by 63.5	1/2 by 1-1/4 by 2-1/2
H	6.4 by 50.8	1/4 by 2
J	9.5 by 76.2	3/8 by 3
K	12.7 by 31.8 by 63.5	1/2 by 1-1/4 by 2-1/2
L	31.8	1-1/4
	19.1	3/4
M	9.5 by 38.1	3/8 by 1-1/2
N	31.8 by 31.8 by 381	1-1/4 by 1-1/4 by 15

Figure 40.3
Impact device



1 – Forming shell imbedded in concrete, or supported by an equivalent rigid mounting; see Figure 40.2.

2 – Luminaire with lens, mounted in forming shell.

3 – Deceleration unit, supported as a pendulum by two light cables of any convenient length. Construction as per Figure 40.1. Nosepiece with sheet lead buffer pad positioned in direct contact with lens (no spacing).

4 – Driving mass, 10.9 kg (24 pounds), 76.2-mm (3-inch) diameter, 305-mm (12-inch) long cold-rolled steel round stock, or equivalent rigid steel or iron mass. Supported as a pendulum by four cables of any convenient length. Drawn back to elevate mass 114 mm (4.5 inches), then allowed to fall freely against deceleration unit.

40.3 The luminaire housing of a wet-niche luminaire or the luminaire enclosure of a dry-niche luminaire is to be mounted in the simulated niche or equivalent, resulting in the firmest mounting likely to be encountered in service. The mounting bracket shall be mounted to a simulated pool wall that results in the firmest mounting encountered in service. The nosepiece of the deceleration unit is to be placed normal to the surface of the luminaire chosen at the point of contact. The line of motion of the mass driving the deceleration unit during the application of force to the luminaire is to be horizontal and in line with the axis of the deceleration unit.

40.4 A sheet lead or nitrile rubber buffer pad (item F of Figure 40.1 and Table 40.1) is to be secured over the point of contact, and the deceleration unit and driving mass are to be suspended as shown in Figure 40.3. The driving mass is to be raised a total height of 114 mm (4.5 inches) and released.

41 Electric Shock Test

41.1 General

41.1.1 A luminaire shall be investigated with regard to the risk of electric shock with:

a) Its lens broken;

b) A ground on either side of an isolated supply; and

c) The swimmer in contact with the luminaire.

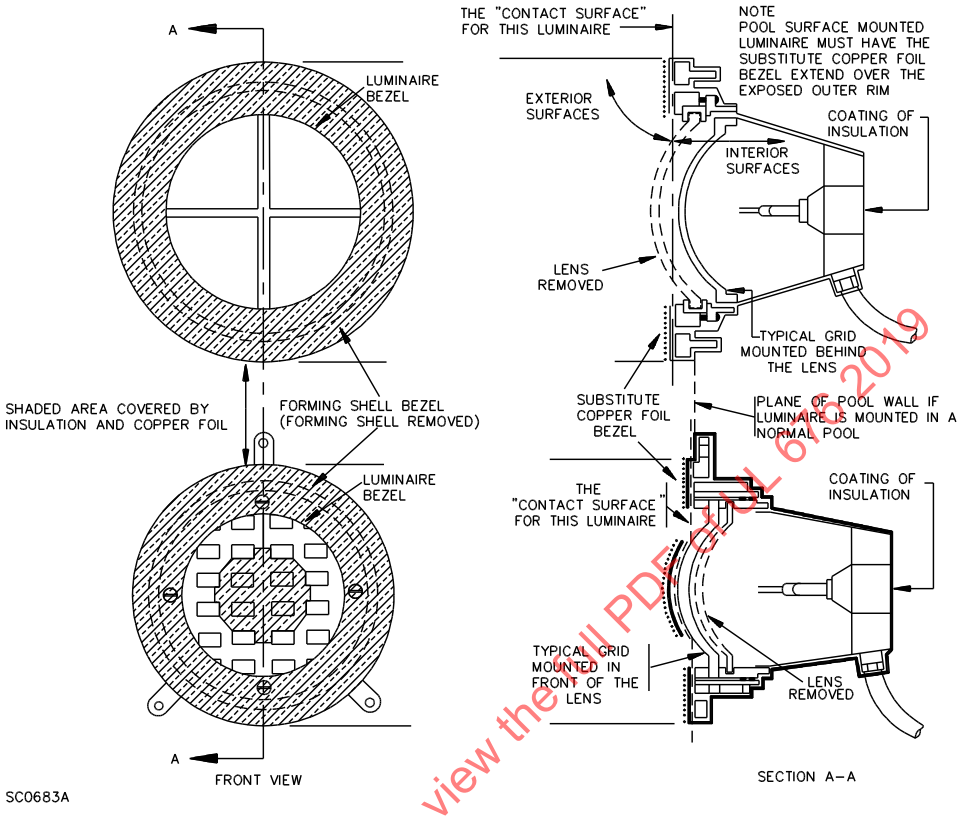
The results are in compliance when the luminaire does not introduce a current density (D) greater than 30 microamperes per square centimeter.

Exception: For a luminaire intended to be connected directly to a grounded supply, the current density (D) may be 60 microamperes per square centimeter with the polarity of the luminaire leads reversed.

41.1.2 The test conditions described in 41.1.3 – 41.1.11 apply to incandescent lamp luminaires constructed such that no part of either lamp electrode is more than 76 mm (3 inches) from an uninsulated part of the opposite polarity lamp electrode or grounded luminaire enclosure. The distance specified is the conductive path distance through water of a flooded luminaire with the lamp modified as described in 41.1.6. Intervening nonconductive parts of the luminaire and the glass of a PAR lamp reflector are to be taken into account in measuring these distances. For other luminaire constructions, an investigation is to be conducted to determine the test conditions necessary to obtain the current density or differential current.

41.1.3 The following is a description of the test-modified luminaire shown in Figure 41.1. The widest forming shell bezel of a wet-niche luminaire forming shell that is intended to be used with the luminaire is to be removed from the forming shell and attached to the luminaire bezel. With the luminaire lens and the lamp or lamps removed, a "contact surface" is to be established that approximates the surface of contact between a swimmer and the front of the luminaire. All surfaces of the luminaire, luminaire bezel, shielding grids, lens guard, or the like extending from this established contact surface into the interior of the luminaire are considered to be interior surfaces of the luminaire for the purposes of this test. All other surfaces, either located on the established contact surface or on the outer surface of the luminaire, are considered to be exterior surfaces of the luminaire for the purpose of this test.

Figure 41.1
Test modified luminaire

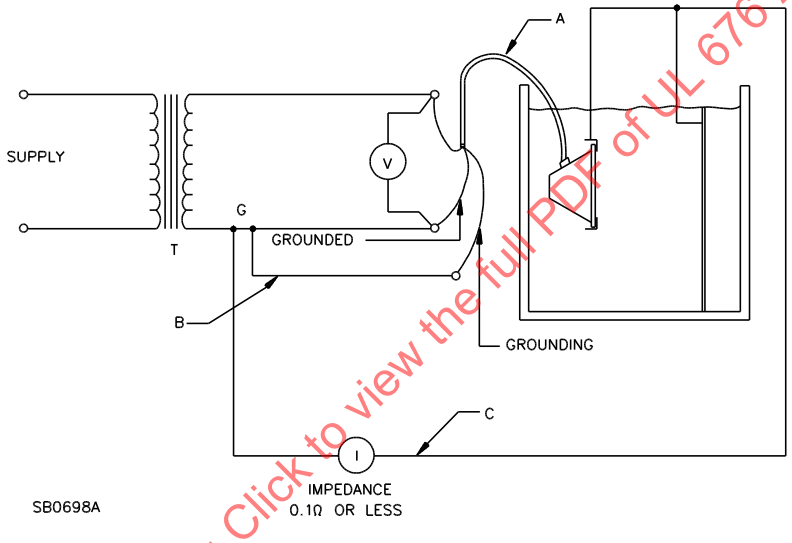


41.1.4 All interior surfaces of the luminaire are to remain unmodified.

Exception: Conductive parts having coatings (such as paint), the insulating properties of which are in question, are to be covered with additional insulating material, or the coating is to be completely removed to expose the conductive parts, whichever produces the most adverse results.

41.1.5 All exterior surfaces of the conductive parts of the luminaire, luminaire bezel, forming shell bezel, shielding grid, lens guard, or the like are to be coated with an insulating material. Of these coated exterior surfaces, those surfaces which also form part of the contact surface are to be covered with copper foil in such a way that the foil is not electrically connected to the luminaire bezel, grid, guard, or the like. An insulated lead is to be attached to the copper foil for connection in the circuit shown in Figure 41.2.

Figure 41.2
Measuring circuit



A – Not more than 1.8 m (6 feet) of cord or wire.

B – Not more than 3.0 m (10 feet) total of a copper conductor of a size consistent with the current rating of the luminaire, but not less than 3.3 mm^2 (12 AWG).

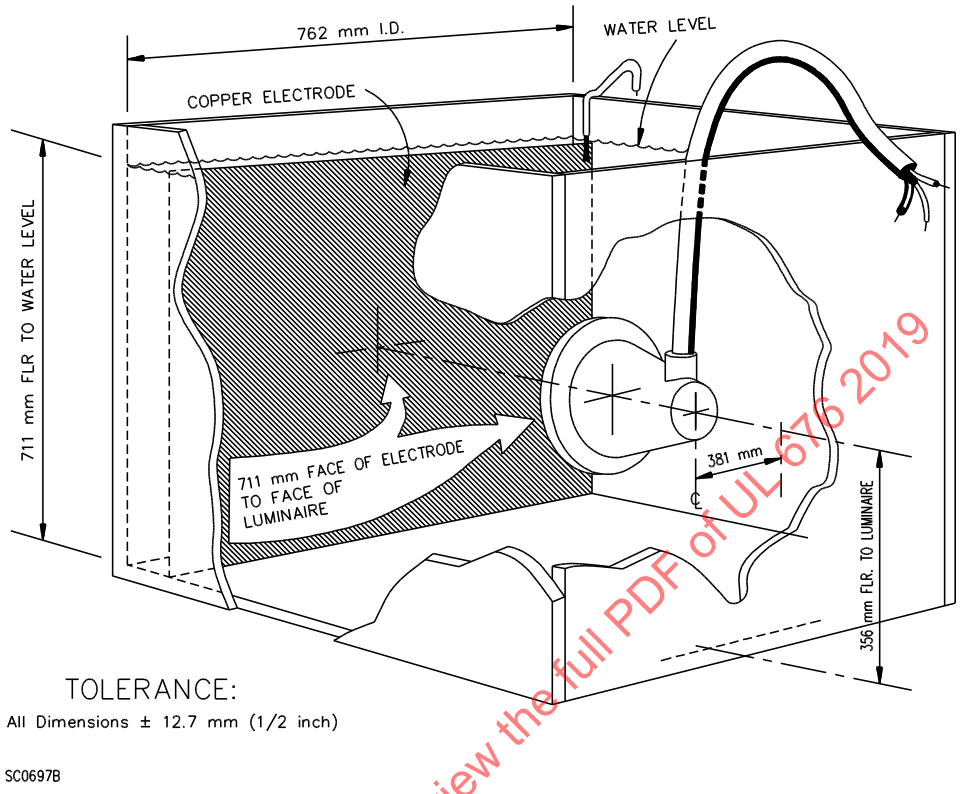
C – Not more than 3.0 m total of a copper conductor 3.3 mm^2 or larger.

T – Isolation transformer.

41.1.6 For the performance of the test, the complete lens is to be removed and the lamp or lamps are to be modified by the removal of the glass envelope and filament wire, but not the filament leads or supports. When the positioning of the filament leads or supports is not controlled by the construction of the lamp and its mounting, the filament leads are to be positioned, within the limits imposed by the construction, by rotating the lamp or lampholder, or both, to produce the maximum value of current (I) as described in 41.1.9. A PAR lamp is to have only the front section of glass and the filament wire removed.

41.1.7 The modified luminaire is to be placed in a tank constructed of nonconductive material, with dimensions as illustrated in Figure 41.3.

Figure 41.3
Test tank



SI equivalents

mm	(inches)
356	14
381	15
711	28
762	30

41.1.8 The tank is to be filled with water to a height of 71 cm (28 inches). When the luminaire is to be marked as suitable for use in sea water, the resistivity of the water is to be adjusted to 22 ohm-centimeters; otherwise, the resistivity of the water is to be adjusted to 300 ohm-centimeters. The resistivity of the water is to be adjusted by the addition of sodium chloride, or an equivalent salt, to tap water.

41.1.9 The luminaire is to be connected in the circuit illustrated in Figure 41.2. The frequency of the supply is to be 60 hertz unless the luminaire is otherwise rated. The voltage across the supply leads to the luminaire is to be maximum rated voltage. When the marked voltage is in the 105 – 120 volt range, the potential of the supply circuit is to be 120 volts. Current (I, the current that flows from the copper electrode in the water and the copper foil coating on the luminaire to point G in the circuit) is to be observed from the time the luminaire is first energized until the reading becomes stabilized, but for at least 30 minutes. The maximum value of current (I) is to be recorded. The test is then to be repeated with the polarity of the supply leads to the luminaire reversed, with the lamp reoriented, if necessary, to obtain the maximum value of current (I), and the maximum value of current (I) is to be recorded.

41.1.10 The isolation transformer shown in Figure 41.2 is provided to reduce the risk of electric shock to personnel conducting the test and to decrease the possibility of errors in measurement that may result from incidental conductive paths between the tank water and ground.

41.1.11 The value of current density (D) is to be obtained by dividing the recorded value of the current (I) by the product of the area of the face opening (A) and the luminaire constant (N) which is 80 for 22 ohm-centimeter water and 20 for 300 ohm-centimeter water. The referenced values are defined as:

D – Current density in water, expressed in microamperes per square centimeter.

I – Current expressed in microamperes.

A – Total opening area of the luminaire face resulting from the removal of the lens, less any "contact surface" area of a grid or guard structure (shown in Figure 41.1, center shaded area) expressed in square centimeters.

N – The ratio of the current (I) measured under the conditions of this test to the current (I) that would flow in the circuit with a person positioned directly over the luminaire.

41.2 Sea water tests

41.2.1 Although the branch-circuit overcurrent protective devices are not considered to reduce the risk of electric shock, the test circuit currents are not to be limited by any branch-circuit overcurrent protector ratings. Provisions may therefore be required in the test setup to supply the large magnitudes of line current that may result from testing with 22 ohm-centimeter water. However, before proceeding to large current supplies, it may be advantageous to perform the test first with a setup of rated current capacity, but starting with reduced voltages. When the obtained value of the current (I) results in an unacceptable value of current density (D), the test results at rated voltage would also be unacceptable.

42 Gasket Accelerated Aging Test

42.1 Three specimens of a gasket of neoprene, rubber, neoprene composition, or rubber composition used to prevent the entry of water into the luminaire shall be subjected to an accelerated aging test as specified in Table 42.1. Results are in compliance when, following the test, there is no visible evidence of deterioration (such as cracking after flexing, softening, or hardening).

Exception: Neoprene material is acceptable for 60° C (140° F) and silicone rubber for 105° C (221° F), without test.

Table 42.1
Accelerated aging conditions

Measured temperature rise[a]				
More than		Not more than		
°C	(°F)	°C	(°F)	Test program[b]
0	0	35	63	Air-circulating oven aging for 70 hours at 100°C (212°F)
35	63	50	90	Air-circulating oven aging for 168 hours at 100°C (212°F)
50	90	55	99	Air-circulating oven aging for 168 hours at 113°C (235°F)
55	99	65	117	Air-circulating oven aging for 240 hours at 121°C (250°F)
65	117	80	144	Air-circulating oven aging for 168 hours at 136°C (277°F)
80	144	120	216	Air-circulating oven aging for 1440 hours at 150°C (302°F)
120	216	125	225	Air-circulating oven aging for 1440 hours at 158°C (316°F)
125	225	130	234	Air-circulating oven aging for 1440 hours at 164°C (327°F)
130	234	140	252	Air-circulating oven aging for 1440 hours at 174°C (345°F)
140	252	150	270	Air-circulating oven aging for 1440 hours at 184°C (363°F)
150	270	160	288	Air-circulating oven aging for 1440 hours at 194°C (381°F)
160	288	170	306	Air-circulating oven aging for 1440 hours at 204°C (399°F)
170	306	175	315	Air-circulating oven aging for 1440 hours at 210°C (410°F)
175	315	185	333	Air-circulating oven aging for 1440 hours at 220°C (428°F)
185	333	195	351	Air-circulating oven aging for 1440 hours at 230°C (446°F)
195	351	205	369	Air-circulating oven aging for 1440 hours at 240°C (464°F)
205	369	215	387	Air-circulating oven aging for 1440 hours at 250°C (482°F)
215	387	225	405	Air-circulating oven aging for 1440 hours at 260°C (500°F)

[a] Maximum temperature rise measured on the material during the temperature test.

[b] Air-circulating oven temperatures specified have a tolerance of ±2°C (±3.6°F).

43 Flexible Cord Guard and Support Test

43.1 Guards and structural members used to comply with the requirements of 10.10(c) shall comply with this test.

43.2 The luminaire, guards and structural members shall be assembled and rigidly mounted as described in the installation instructions.

43.3 A vertical downward force of 889 N (200 pounds) shall be applied to the guard or structural member guarding or supporting the flexible cord. A horizontal force of 222 N (50 pounds) shall be applied to the guard or structural member guarding or supporting the flexible cord.

43.4 When the construction of the guard or structural members is capable of being more adversely affected by a force consisting of horizontal and downward components, the guard and structural members shall also be subjected to such a force. The force shall be determined from the following equation:

$$\text{Force} = 667 \cdot \sin\theta + 222, \text{ for a force in newtons}$$

$$\text{Force} = 150 \cdot \sin\theta + 50, \text{ for a force in pounds}$$

in which θ is the angle above horizontal from which the force is applied.

43.5 A single sample shall be subjected to the 222- and 889-N (50- and 200-pound) forces and, when determined applicable, the additional forces described in 43.4. The sample shall not be subjected to more than one force at a time; however, the forces shall be applied in the order that produces the most adverse results. Each force shall be left in place for 5 minutes.

43.6 The guard and structural members shall not distort, break, crack, or be otherwise damaged.

43A Conduit Hub Torque Test

43A.1 An enclosure with a non-integral conduit hub shall be rigidly mounted or supported. A short length of rigid metal conduit shall be threaded into the hub and the torque forces specified in Table 43A.1 shall be applied. The hub shall not turn in the enclosure and shall not exhibit stripping of any threads.

Table 43A.1
Torque forces for the Conduit Hub Torque Test

Conduit trade size Applied torque, N-m (lb-in)	Applied torque, N-m (lb-in)
3/4 inch or smaller	90.4 (800)
1, 1-1/4, and 1-1/2 inch	113.0 (1000)
2 inch and larger	180.8 (1600)

MARKINGS

44 Luminaires

44.1 A luminaire shall be marked as required in 44.3 – 44.10. The location of the markings shall be as shown in Table 44.1. All markings shall be legible and permanent and shall be in the form of die-stamped or die-cast lettering or in a form investigated as described in 44.2. Unless otherwise specified, the markings shall be in letters at least 3.2 mm (1/8 inch) high.

Table 44.1
Location of required markings

Marking	Applicable reference	Location	
		wet-niche	dry-niche
Manufacturer's identification, catalog number, type designation, or the like	44.3	a	b
Type and maximum wattage of lamp(s)	44.3	a	c
"Fresh water," "Sea water," "Sea or fresh water" or equivalent	44.3	d	d
Voltage rating	44.3	a	b
"CAUTION" and the following: "To reduce the risk of electric shock submerse before lighting," or equivalent	44.4	e	e
Housing identification	44.7	a	b
"Top" or "Bottom"	44.8	a	d
Factory identification	44.9	f	f
“WARNING – Risk of Electric Shock. Supply circuit must be rated maximum ___ A”	44.12	d	d

Table 44.1 Continued on Next Page

Table 44.1 Continued

Marking	Applicable reference	Location	
		wet-niche	dry-niche
[a] Where visible when the luminaire is removed from the forming shell for relamping.			
[b] Where accessible after installation, without the use of tools.			
[c] Where accessible after installation without the use of tools, and during lamp replacement.			
[d] Where visible during installation.			
[e] On bezel of luminaire where visible after complete installation.			
[f] Not specified.			

44.2 The investigation specified in 44.1 is to include a determination of the legibility and permanence of the marking under conditions of intended use, including the effects of temperature, water, chlorine, salt, and other environmental conditions.

44.3 Each luminaire shall be marked with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified, and also with the following:

a) A catalog number, type designation, or the equivalent;

b) The type and maximum wattage of the lamp (or lamps) for which the luminaire is intended;

c) The voltage rating; and

d) "Fresh water," "Sea water," "Sea or fresh water" or equivalent.

44.4 A luminaire shall be marked with the word "CAUTION" and the following or the equivalent: "To reduce the risk of electric shock, submerse before lighting." The lettering shall be at least 6.4 mm (1/4 inch) high, placed on the bezel of the luminaire.

Exception: A luminaire determined to be acceptable for continuous operation out of water, including the effect of temperature on flexible cord that may contact the luminaire, need not be so marked.

44.5 A luminaire designed to be inoperable when not submerged shall be marked "This luminaire will not light out of water."

44.6 A luminaire using a one-time operation thermal sensitive device shall be marked on the outside of the luminaire: "Out of water operation (for longer than 3 minutes) will permanently disable (this) luminaire." Words in parentheses are optional.

44.7 A wet-niche and no-niche luminaire shall be marked with the catalog number or equivalent of the housing or housings or mounting bracket with which it is to be used.

44.8 When the acceptable performance of a luminaire depends upon its location or position, the luminaire shall be marked (such as "Top" or "Bottom") to indicate the way it is to be installed or used, unless the position is obvious.

44.9 When a manufacturer produces or assembles luminaires at more than one factory, each luminaire shall have a distinctive marking, which is not prohibited from being in code, by which the luminaire may be identified as the product of a particular factory.

44.10 Literature provided with each luminaire shall include installation instructions that contain the statement: "Except when the luminaire is installed in an area of the swimming pool that is not used for

swimming and the lens is adequately guarded to keep any person from contacting it, the luminaire shall be installed in or on a wall of the pool, with the top of the lens opening not less than 457 mm (18 inches) below the normal water level of the pool." The inclusion of the value in parentheses is optional.

44.11 The installation instructions for a luminaire provided with a non-enclosed flexible cord as described in 10.10(c) shall include instructions for the proper routing and securement of the flexible cord and for the installation of any required guards or structural members.

44.12 When the luminaire is required to be marked with a maximum rating for the supply-circuit overcurrent protection device as specified in Figure 39.1, the marking shall consist of the word "WARNING" and the following or equivalent: “Risk of Electric Shock. Supply circuit must be rated maximum __ A". The blank shall be filled in with the value as specified in Figure 39.1. This value shall be a standard rating for a branch-circuit overcurrent protection device. The installation instructions for the luminaire shall also include instructions to this affect and the specific text of this marking.

44.13 A luminaire rated in accordance with 11.4.1 shall be marked “For supply connection, use only an isolating low voltage power supply with ungrounded output, evaluated for swimming pool use.” This marking shall be visible during installation; a cord tag is permitted.

44.14 A luminaire evaluated for upward-facing mounting per 6.4 is permitted to include this mounting option in its installation instructions.

45 Luminaire Housings

45.1 A luminaire housing and mounting bracket shall be legibly and permanently marked (as described in 44.1), such that the marking is visible after the luminaire housing or mounting bracket is installed, with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product is identified, and with a catalog number, type designation, or the equivalent. The marking is considered visible even when the luminaire must be removed from the luminaire housing or mounting bracket to view the marking.

45.2 A luminaire housing and mounting bracket shall be marked to indicate the luminaire (or luminaires) with which it is to be used.

45.3 When the luminaire housing and mounting bracket is depended on to orient the luminaire in the position that is required for its intended performance, the housing shall be marked (such as "Top" or "Bottom") to indicate the position in which it is to be installed.

45.4 When a manufacturer produces or assembles luminaire housings or mounting brackets at more than one factory, each finished housing or bracket shall have a distinctive marking, which is not prohibited from being in code, by which it is capable of being identified as the product of a particular factory.

45.5 A luminaire housing or mounting bracket that is not provided with a grounding terminal as described in 25.4 shall be permanently marked: "CAUTION – For proper grounding use only with metal conduit." The marking shall be in letters not less than 3.2 mm (1/8 inch) high, and located so that it is visible when the luminaire is removed from the luminaire housing or mounting bracket.

45.6 A luminaire housing or mounting bracket that is to be used with a luminaire provided with a minimum 12 AWG (3.3 mm^2) Type SJ, SJT, or SJTO flexible cord, as specified in 10.3, shall be marked: "Use minimum 19.1 mm (3/4 inch) conduit."

PART II – SUBMERSIBLE LUMINAIRES

CONSTRUCTION

46 General

46.1 A submersible luminaire is defined as a luminaire intended for use in water other than in a swimming pool or spa.

46.2 In addition to the requirements in Sections 46 – 57, a submersible luminaire shall also comply with the following requirements of Part I: 6.1, 6.4, 6.8, 7.1, 8.1, 9.1, 10.5, 11.1.4 – 11.1.15, 11.2.3, 13.1, 14.1 – 14.3, 16.1 – 16.4, 17.1 – 17.4, 18.1 – 18.4, 19.1, 20.1, 21.1, 21.2, 23.1, 25.1 – 25.3, and 44.9.

Exception: Low voltage luminaires rated in accordance with 11.4.1 and marked as follows need not comply with 23.1 or 25.1 – 25.3: "For supply connection, use only an isolating low voltage power supply with ungrounded output." The marking shall be visible during installation; a cord tag or removable label is permitted.

46.3 A luminaire shall be constructed to provide an enclosure for all electrical parts, including the lamp bulb.

Exception: The supply cord and the lens face of a PAR lamp are not required to be enclosed.

46.4 A lens guard intended for use with a submersible luminaire shall comply with the requirements in 46.7, 54.1, and 55.1.

46.5 When a submersible luminaire is otherwise complete and complies with the appropriate requirements in this standard, the mounting means may be independent of the luminaire.

46.6 A submersible luminaire shall be removable from the water for relamping, inspection, and maintenance.

46.7 A lens guard shall have no opening that will allow the insertion of a 50.8-mm (2-inch) diameter cylindrical probe such that the probe can contact the luminaire lens.

46.8 A submersible luminaire using a fluorescent or HID lamp shall comply with requirements in the Standard for Luminaires, UL 1598, as applicable for the lamp type.

47 Corrosion Protection

47.1 All metal parts, including assembly rivets, screws, and the like, shall be of copper, copper alloy, stainless steel, or equivalent corrosion-resistant metal. Copper alloy parts that form the luminaire enclosure or that come into contact with water shall be made of an alloy that consists of not more than 15 percent zinc.

Exception: A part is not prohibited from being aluminum or aluminum alloy when it is:

a) Completely within the luminaire enclosure,

b) Not relied upon to keep water out of the luminaire, and

c) Either encapsulated with a potting compound or does not contact the luminaire enclosure or support any live part.