

Subject 2452

October 6, 2017

SUMMARY OF TOPICS

The Standard for Electric Swimming Pool and Spa Cover Operators, UL 2452, is being proposed as a replacement of Outline of Investigation for Electric Swimming Pool and Spa Cover Operators, UL 2452.

1. The Proposed First Edition of the Standard for Electric Swimming Pool and Spa Cover Operators, UL 2452, covers pool cover operators intended for installation and use in accordance with Article 680 of the National Electrical Code, NFPA 70, and addresses fire, electric shock, and casualty hazards.

STP BALLOTS AND ALL COMMENTS DUE: November 20, 2017

UL's goal is to have no interest category comprise more than one-third of the STP membership balance. To improve the current balance for STP 1081, UL is looking for participants in the AHJ, Commercial/Industrial User, Consumer, Government, and Supply Chain interest categories. Definitions for these interest categories are available on the Standards STP Internet site:

<http://ulstandards.ul.com/develop-standards/participation/interest-categories/>

If you are interested in applying for STP 1081 membership or are aware of potential candidates for this STP, please contact the STP Project Manager, Megan.Monsen@ul.com.

For your convenience in review, proposed additions to existing requirements are shown underlined and proposed deletions are shown ~~lined-out~~.

1. The Proposed First Edition of the Standard for Electric Swimming Pool and Spa Cover Operators, UL 2452, covers pool cover operators intended for installation and use in accordance with Article 680 of the National Electrical Code, NFPA 70, and addresses fire, electric shock, and casualty hazards.

RATIONALE

Proposal submitted by: Gary Siggins, UL LLC

The proposed first edition is based on Outline 2452 with the addition of topics as detailed below.

Update for Low-Voltage Motors

A new Part 2 is proposed to be added to address operators with immersed low-voltage motors. These designs employ immersed tubular motor/gear assemblies. They are powered by remote transformers or power supplies. In such designs the risk of electric shock is largely mitigated by the remote power unit. The proposed requirements for the remote power units are essentially the same as those used for underwater swimming pool luminaires.

Update to the Requirements for Circuits and Controls

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Safety Critical Functions

Historically, safety critical functions have not been explicitly identified for a given appliance. Controls/circuits employing safety critical functionality have been identified by differing terms in the various UL appliance standards. They were referred to as "safety controls", "limiting-controls" or "safety circuits." Controls of appliances that were evaluated to the UL 60730 family of controls standards might have been identified as "Protective Controls", "Protective Electronic Controls" or simply as "Controls with Class B control function."

All of these terms reflect the same basic philosophy. The phrase used in this proposal to identify these types of circuits is those that provide Safety Critical Functions.

A function is considered a Safety Critical Function (SCF) if failure (loss or malfunction) of its functionality would result in an unacceptable risk of fire, electric shock or injury to persons using the appliance. Some of these functions address the mitigation of risks in normal operation, while other functions address the mitigation of risk during abnormal operating conditions.

Terminology Concerning Control Functions

This edition of UL 2452 uses the terminology of UL 60335-1 for consistency with other published appliance standards and those to be similarly revised.

There are two key definitions that significantly influence the application of the requirements:

PROTECTIVE ELECTRONIC CIRCUIT – An electronic circuit that prevents a hazardous situation under abnormal operating conditions.

DANGEROUS MALFUNCTION – Unintended operation of the appliance that may impair safety.

All Protective Electronic Circuits would be considered to perform Safety Critical Functions. Dangerous Malfunction represents a situation where all or part of an appliance operates unexpectedly, resulting in a hazard to the user.

The Safety Critical Functions for typical swimming pool cover operators are detailed in a separate new section of the Standard. These defined SCFs can then be referenced in other parts of the standard that address the evaluation of these and other electronic circuits.

Basic Requirements for the Evaluation of Electronic Circuits that Provide Safety Critical Functions

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

- a) Reliable, and
- b) Not susceptible to electromagnetic environmental stresses encountered in the anticipated installation environment.

Reliable in this case is defined as being able to maintain the SCF in the event of single defined component faults within the circuit providing the SCF. The original test that caused the Protective Electronic Circuit to operate is repeated with defined single component faults. The Safety Critical Function of this circuit should not be adversely affected.

The resistance to electromagnetic environmental stresses encountered in the anticipated installation environment is also defined in the standard.

Why incorporate UL 60335-1 electronic circuit requirements into UL 2452?

UL 60335-1 (Household and similar electrical appliances – Safety – Part 1: General requirements) is a tri-national (U.S., Canada, Mexico) appliance standard, based on IEC 60335-1, that specifies general requirements for all appliances. It is the foundation on which a diverse set of UL appliance standards are already based. These include the specific requirements for HVAC equipment and motor compressors, refrigerators / freezers, electric irons, shavers and hair clipping appliances and, soon, several commercial cleaning machine applications. The electronic circuit requirements of UL 60335-1 are substantially a consolidated version of requirements appearing in the many component standards referenced by UL 2452 (some differences exist and are described below). They also fill some gaps in requirements because they are up-to-date, reflecting the latest safety considerations for electronic circuit technologies. Also, as the controls of swimming pool cover operators are usually custom designed for a specific operator, a self-contained set of circuit requirements should be part of UL 2452.

The specification of circuits requirements from UL 60335-1 should also facilitate the future evolution of UL 2452 into an international harmonized standard.

How does UL 60335-1 requirements differ from the legacy requirements that have been used from UL 244A and UL 991?

There are three main differences between the UL 60335-1 requirements and the ones based on UL 244A and UL 991. The requirements for electronic circuits in legacy UL component standards have generally been based on the risk of fire mitigation by limiting energy in vulnerable components in such circuits. They specify conducting component fault tests wherever available energy is in excess of Class 2 circuits as defined in the National Electrical Code (NEC), ANSI/NFPA 70.

UL 60335-1 requirements do not stop at an NEC Class 2 circuit. The requirements proposed for UL 2452 are based on investigating the risk of electrically generated fire at the circuit board level down to a 15 watt available power point. How the circuit is investigated will not necessarily result in a technical difference in the design of the electronic circuit under investigation. It will, however, provide for the maximum design flexibility and potential for a single circuit design being utilized in both U.S. and International markets.

The requirements of UL 60335-1 differ in the expectation that the circuitry shall be able to safely tolerate a single fault in the end application. There also are some differences in the EMI immunity requirements as well as a test to determine the effects of supply voltage supply dips.

Programmable Devices in Circuits that Perform Safety Critical Functions

Early generations of circuits were only evaluated from the view of simple faults at the various outputs. No evaluation was made of the reliability of the programmable components or their software/firmware other than that they functioned under certain tests of the appliance. A programmable component can have errors due to software specification mistakes (wrong requirements), implementation mistakes (coding errors), tool problems (compiler flaws), component defects (transistors shorting within the programmable device), external disturbances (EMI), and the like. Where a control, protection or other function of an electronic circuit has safety significance, establishing the reliability of the software/firmware of the circuit to perform its intended function becomes critical. This is part of the requirements based on UL 60335-1.

Update to Spacings Requirements

This edition of UL 2452 is updated to allow the use of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, to evaluate spacings in pool cover operators and in particular spacings on the line-voltage portions of printed wiring boards.

Virtually all of UL's Standards for electrical products include fixed minimum acceptable spacings between live parts and accessible metal parts, between live parts and dead metal parts, between line-voltage circuits and isolated low-voltage circuits and between live parts of opposite polarity. These spacings are provided so as to mitigate the risk of fire and electric shock. Spacings can be categorized as either:

- Creepage – defined as a spacing over the surface of one or more insulating materials or
- Clearance – defined as a spacing through air

From a physics standpoint, fixed minimum acceptable spacing requirements are always established as a "worst case", since the effectiveness of a spacing to insulate an applied electrical potential difference is a function of several or many other variables. In the case of a clearance, for example, the effectiveness of the spacing will depend upon the geometry of the conductors, their surface finish, the material the conductor is composed of, the freedom from conductive pollution, etc. In the case of a creepage, the effectiveness of the spacing will depend very heavily upon those properties of the conductor as well as the properties of the insulating material(s). This having been provided as background, the requirements for spacings in most UL standards have historically been based on conservative values that produced an acceptable field history for the product. Thus, a fixed minimum acceptable spacing will always be larger (often many times larger) than what is required for most actual constructions.

UL 840 includes requirements for an alternative approach to specifying through-air spacings (clearances) and over-surface spacings (creepage distances) for electrical equipment through the use of the principles of insulation coordination. This standard provides an alternative to fixed minimum acceptable spacings by allowing a combination of test criteria and, in the case of clearance, insulating material properties, to specifically evaluate the construction at hand. This alternative often enables the manufacturer to design and manufacture products with spacings much smaller than would be allowed by fixed minimum acceptable spacings, with no sacrifice whatsoever in the level of safety provided. In many products, applying the UL 840 approach translates into significantly higher levels of electrical and mechanical efficiency for the product.

The application of the principles of UL 840 (or its IEC counterpart(s), the IEC 60664 series) is, as noted above, dependent upon several variables which must be controlled if the results are to be relied upon as characteristic of the product in actual use.

The results of a UL 840 evaluation are dependent upon Pollution Degree, Overvoltage Category and, in the case of creepage, the Material Group [Comparative Tracking Index (CTI) of the insulating material(s)].

Update to the Requirements for Switches

UL 2452 requires a switch that controls a motor load to be suitably rated for the application in terms of voltage, current, and load rating. The Standard for Special Use Switches, UL 1054, was withdrawn in June 2015 and has been replaced by the Standard for Switches for Appliances - Part 1: General Requirements, UL 61058-1. UL 61058-1 is a parameters based (or declarative-type) standard, in the same way as UL 60730-1. These parameters, or the declared end-use ratings, must be specified in the end product appliance standard, to give technical guidance to both end-use cover operator manufacturers, as well as to switch manufacturers.

UL 2452 has been updated to allow switches evaluated to UL 61058-1.

Update to the Requirements for Cover Drain Pumps

Covers would now be required to be provided with drain cover pumps that ***automatically*** activate when water accumulates. This is to help mitigate the risk of drowning of infants and small children that might crawl on the cover.

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PROPOSAL

PART 1 – ALL UNITS

INTRODUCTION

1 Scope

1.1 These requirements cover electric swimming pool cover operators intended for installation and use in accordance with Article 680 of the National Electrical Code, NFPA 70.

1.2 These requirements are intended to address, but not be limited to, fire, electric shock and casualty hazards. The requirements are not intended to address the ability of the cover to function as a barrier to unauthorized access to a swimming pool or spa to help prevent drowning.

2 Units of Measurement

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

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

3 Undated References

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

4 Glossary

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

4.2 ACCESSIBLE PART – A part located so that it can be contacted by a person.

4.3 ACCESSIBLE TO THE OCCUPANT (OF THE SWIMMING POOL) – Any surface or component within 5 feet (1.52 m) of the swimming pool water, measured by any convenient method such as a measuring tape or a 5-foot flexible wire, cord, or string.

4.4 CONFORMAL COATING – An insulating coating that conforms to the configuration of the object that is coated. The coating is used as a covering to protect against environmental conditions.

4.5 CONTROLLED ENVIRONMENT – An environment that is relatively free from conductive contaminants, such as dust and carbon particles, and that is protected against humidity and condensation. A controlled environment may be provided by a hermetically sealed enclosure, encapsulation, or a conformal coating.

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

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4.7 ELECTRONIC DISCONNECTION – The de-energizing of the functional load of the appliance by an electronic device of a circuit with no air gap.

4.8 ENCLOSURE – That part of a unit that renders inaccessible any part that may present a risk of electric shock, prevents emission of flame or molten material, or prevents unintentional contact with internal parts that may involve a risk of injury.

4.9 GROUNDING TERMINAL – A designated pressure wire connector located within the field wiring compartment to terminate the equipment grounding conductor of the supply circuit.

4.10 INTENTIONALLY WEAK PART – A part intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition that could impair compliance with this standard.

4.11 ISOLATING TRANSFORMER – A transformer with one or more output windings electrically separated from the input winding and all other output windings.

4.12 LOW-POWER CIRCUIT – A circuit or parts of circuits farther from the supply source than a low-power point.

4.13 LOW-POWER POINT – A point closest to the supply source in an electronic circuit where the maximum available power to an external load at the end of 5 seconds does not exceed 15 watts.

4.14 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a hazardous situation under abnormal operating conditions. The function of a Protective Electronic Circuit would be considered a Safety Critical Function. See 4.18.

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4.15 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist whenever the available current exceeds the limits specified in Table 4.1 when measured as described in the Available Current Test, Section 29. Other current waveforms than specified in Table 4.1 are considered to comply with the intent of this requirement if the maximum available current to ground does not exceed the startle current threshold and the maximum point-to-point current, when unreliable control isolation layers are removed, does not exceed the let-go current threshold as specified in IEC TS 60479-2, Effects of current on human beings and livestock – Part 2: Special aspects.

Table 4.1
Risk of electric shock limits

Location	Limit, milliamperes, 50 or 60 Hz AC	Limit, milliamperes, pure DC ^a
Current circulating in the water from two points immersed in the water	0.5	2.0
Pool water and ground	0.5	2.0
Any point accessible to the pool occupant and ground	0.5	2.0
Any two points in circuits accessible to pool occupant	5.0	30.0
NOTE: The 0.5 and 2.0 mA limits specified correspond to the startle current threshold. The 5.0 and 30 mA limits specified correspond to the let-go current threshold.		
^a DC current is considered to be pure DC only if it is confirmed through test that the peak-to-peak value of ripple in the current is not more than 10 percent of the DC current.		

4.16 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where a power of more than 15 watts can be delivered into an external resistor connected between the two points.

4.17 SAFETY CRITICAL FUNCTION – Control, protection and monitoring functions which are being relied upon to reduce the risk of fire, electric shock or casualty hazards. See 5.1.3.

4.18 SECONDARY CIRCUIT – A circuit supplied from an output winding of an isolating transformer.

5 Circuits that Perform Safety Critical Functions

5.1 General

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

5.1.2 Electronic circuits that manage a Safety Critical Function shall be:

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

5.1.3 Electronic circuits shall be evaluated according to the control and other circuits requirements in Control and Other Circuits, Section 26.

5.2 Operator Control Safety Critical Functions

5.2.1 The operator control shall be designed so that continuous manual operation of a key, button or the like is required in order for the cover to move in any direction. Loss of this function shall be considered a Dangerous Malfunction.

5.2.2 The operator control shall be of a design that reduces the likelihood of unauthorized operation. A control requiring the use of a key or the required entering of a PIN on a keypad to allow operation is considered an acceptable means. Loss of this function shall be considered a Dangerous Malfunction.

5.2.3 Operator controls using a PIN activated keypad shall timeout from non-activity after no more than 20 seconds and shall require a minimum 4 numeral PIN for access. Loss of this function shall be considered a Dangerous Malfunction.

CONSTRUCTION

6 General

6.1 A unit shall be evaluated for both indoor and outdoor use.

Exception: A unit is not prohibited from being evaluated for indoor use only when it is marked in accordance with 44.1(e).

7 Component Specifications

7.1 General

7.1.1 Except as indicated in 7.1.2, a component of a product covered by this standard all comply with the requirements for that component.

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

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

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

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

7.1.5 Components shall be suitable for the intended use and installation environment. This suitability shall assume the following installation parameters as specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840:

- a) If suitable for outdoor use, Pollution Degree III installations. If suitable for indoor use only, Pollution Degree II.
- b) Overvoltage Category II.

7.1.6 Components not anticipated by the requirements of this standard, not specifically covered by a component standard of 7.2 – 7.7, and which pose a potential risk of electric shock, fire or casualty hazard shall be additionally investigated. Reference to other product standards is appropriate where those standards anticipate normal and abnormal use conditions consistent with the application of this standard.

7.2 Quick-connect wire connectors

7.2.1 Quick-connect type wire connectors shall be suitable for the wire size, type (solid or stranded), conductor material (copper or aluminum) and the number of conductors terminated. If insulated, they shall be rated for the voltage and temperature of the intended use. They shall be applied per the installation instructions of the wire connector manufacturer.

7.2.2 Quick-connect type wire connectors shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

7.3 Switches and controllers

7.3.1 A switch, relay, or other control device shall be rated for the type, current and voltage, of load that it controls. Control devices shall be evaluated for a minimum 30000 cycles at the controlled load.

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

- a) The Standard for General-Use Snap Switches, UL 20, or
- b) The Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;

7.3.3 Switches that comply with the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, shall be rated as specified in 7.3.4 – 7.3.6.

7.3.4 Power switches shall be rated as follows:

- a) For a voltage not less than the rated voltage of the appliance;
- b) For a current not less than the rated current of the appliance;
- c) For Continuous Duty;
- d) With respect to load:
 - 1) Switches for motor-operated appliances: for resistance and motor load in accordance with 7.1.2.2 of Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, or
 - 2) Switches may be regarded as switches for a declared specific load in accordance with 7.1.2.5 of UL 61058-1, and may be classified based upon the load conditions encountered in the appliance under normal load.
- e) For ac if the appliance is rated for ac;
- f) For dc if the appliance is rated for dc.

7.3.5 Ratings and load classifications for switches other than power switches shall be based on the conditions encountered in the appliance under normal load.

7.3.6 Switches shall also be rated with respect to endurance as follows:

- a) Power switches: 10000 cycles;
- b) Power switches provided with series electronics shall be subject to an additional 1000 cycles of operation with the electronics bypassed;
- c) Switches other than power switches, such as speed selector switches, that may be switched under electrical load: 6000 cycles;
- d) The following non-power switches are not required to be rated for endurance:
 - 1) Switches intended for operation without electrical load, and which can be operated only with the aid of a tool or are interlocked so that they cannot be operated under electrical load; or
 - 2) Switches for 20 mA load as classified in Clause 7.1.2.6 of Standard for Switches for Appliances - Part 1: General Requirements, UL 61058-1.

7.4 Terminal blocks

7.4.1 Terminal blocks shall comply with:

- a) The Standard for Terminal Blocks, UL 1059, or
- b) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-1: Ancillary Equipment – Terminal Blocks for Copper Conductors, UL 60947-7-1, or
- c) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-2: Ancillary Equipment – Protective Conductor Terminal Blocks for Copper Conductors, UL 60947-7-2, or
- d) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-3: Ancillary Equipment – Safety Requirements for Fuse Terminal Blocks, UL 60947-7-3.

7.4.2 The UL 60947-7-x Standards are used in conjunction with the Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1.

7.4.3 Terminal blocks shall be suitable for the number of conductors per termination, wire size, type (solid or stranded), conductor material (copper or aluminum), voltage and current of the intended use.

7.5 Wire connectors

7.5.1 Wire connectors shall be suitable for the wire size, type (solid or stranded), conductor material (copper or aluminum) and the number of conductors terminated. If insulated they shall be suitable for the voltage and current of the intended use. They shall be applied per the installation instructions of the wire connector manufacturer.

7.5.2 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

7.6 Overcurrent protection

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

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

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

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

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

7.7 Relays and contactors

7.7.1 Relays shall be suitable for the voltage, current and type of load controlled and shall comply with the Standard for Industrial Control Equipment, UL 508.

8 Frame and Enclosure

8.1 General

8.1.1 An enclosure shall be provided to house all electrical parts that may cause a risk of fire, electric shock, or injury to persons under any conditions of operation.

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

8.1.3 Electrical enclosures, field-wiring compartments, and interconnecting wiring systems, cords and cables installed below grade shall be suitable for temporary immersion. See Immersion Test, 36.3.

Exception: This requirement does not apply to components that are secured a minimum 12 inches (0.3 m) above the bottom of the below grade equipment well.

8.2 Metal enclosures

8.2.1 The outer enclosure of a unit, if of sheet metal, shall not be less than 0.032 inch (0.81 mm) thick if uncoated steel, not less than 0.034 inch (0.86 mm) thick if galvanized steel, and not less than 0.045 inch (1.14 mm) thick if nonferrous. The enclosure shall also comply with Resistance to Corrosion, Section 13.

8.2.2 An enclosure of sheet metal, other than that covered in 8.2.1, shall be evaluated with regard to its size, shape, and thickness, considering the intended use of the complete unit. Sheet steel shall have a thickness of not less than 0.026 inch (0.66 mm) if uncoated when measured, or 0.029 inch (0.74 mm) if galvanized. Nonferrous sheet metal shall have a thickness of not less than 0.036 inch (0.91 mm).

Exception: Any relatively small area or surface that is curved or otherwise reinforced may be thinner than specified if the construction results in equivalent strength and rigidity.

8.2.3 Cast metal portions of an enclosure shall be no thinner than indicated in Table 8.1.

Table 8.1
Minimum thicknesses of enclosure metal

Metal	At small, flat unreinforced surfaces and at surfaces that are reinforced by curving, ribbing, or the like (or are otherwise of a shape or size or both) to provide physical strength,		At relatively large unreinforced flat surfaces,	
	inch	(mm)	inch	(mm)
Die-cast	3/64	(1.2)	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	3/32	(2.4)
Other cast metal	3/32	(2.4)	1/8	(3.2)

8.3 Nonmetallic enclosures

8.3.1 Among the factors taken into consideration when evaluating the acceptability of a nonmetallic material, other than a polymeric material, when used to enclose grounded metal or live parts are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture absorptive properties;
- d) Combustibility; and
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use.

8.3.2 A polymeric material used as the enclosure of live parts, or as a barrier in lieu of spacings shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, based on the application and, if intended to be exposed to sunlight, it shall also be investigated for resistance to the ultraviolet light exposure requirements as specified in UL 746C.

8.3.3 For the purposes of evaluation as specified in 8.3.2, an operator intended for indoor use shall be subjected to resistance to impact testing in a normal room ambient of $23.0 \pm 2.0^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$).

8.4 Drainage

8.4.1 An enclosure of an outdoor unit containing an electrical component that is mounted above grade shall have provision for drainage when there is a knockout or un-threaded opening in the enclosure, or when there is risk of condensation accumulation.

8.4.2 A unit provided with a separate enclosure from the motor to terminate the supply system shall have provisions such that moisture shall not migrate down to the motor.

Exception: A unit utilizing a supply cord for interconnection between enclosures shall not be required to employ additional sealing against moisture migration if the cord and strain relief system complies with the Water Exposure Tests, Section 36.

8.4.3 Each operator shall be provided with a portable pool cover pump intended to drain accumulated water from the top of the cover. The pool cover pump shall:

- a) Automatically activate when water accumulates;
- b) Be supplied with a length of flexible cord Type SJW or SJTW of sufficient length to reach the edge of the pool; and
- c) Be provided with a length of tubing sufficient to reach the edge of the pool, or an output fitting suitable for a standard garden hose.

8.5 Mounting pads or holes

8.5.1 A unit shall be provided with means for mounting or support. Fittings necessary for proper mounting, such as brackets, hangers, or the like, shall be furnished with the unit.

9 Mechanical Assembly

9.1 A unit shall be assembled so that it will not be adversely affected by the vibration of operation. Brush caps shall be tightly threaded or otherwise designed so as not to loosen.

9.2 The means for preventing the loosening mentioned in 9.1 is to consist of more than friction between surfaces - for example, a lock washer may be used as means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

9.3 Each uninsulated live part shall be secured to the base or mounting surface so that it will not turn or shift in position if such motion may result in a reduction of spacings below the minimum values indicated in Spacings, Section 22.

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

9.5 Screws that attach a cover, door, or other part that is removed to operate the unit or to install field wiring shall be retained by at least two full threads into metal.

Exception: Other materials using other means of securement may be used if determined to serve the purpose.

9.6 Screws, bolts, and similar fasteners used to secure sheet metal as the outer enclosure of an outdoor unit shall have a diameter at least 50 percent greater than the thickness of the sheet metal but no less than No. 6.

10 Securement with Adhesives

10.1 An adhesive used for securement that is relied upon to reduce the risk of fire, electric shock, and/or injury to persons shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

10.2 The requirement in 10.1 applies to an adhesive used to secure a part that, if loosened or dislodged, is capable of:

- a) Energizing an accessible dead-metal part;
- b) Making a live part that presents a risk of electric shock (as defined in 4.16) accessible;
- c) Reducing spacings below the minimum values described in Spacings, Section 22;
- d) Short-circuiting live parts; or
- e) Bridging live parts to ground, to dead metal, or to a Class 2 or safety circuit.

11 Accessibility Requirements

11.1 To reduce the risk of unintentional contact with an uninsulated live part, film-coated wire, or a moving part that may involve a risk of injury, an opening in the enclosure of a unit shall comply with the requirements specified in Table 11.1.

Exception: Parts that users and/or service personnel anticipate moving during normal operation of the unit.

Table 11.1
Paragraphs, figures, and tables for evaluating the accessibility of
uninsulated live parts, film-coated wire, and moving parts
that may involve a risk of injury to persons

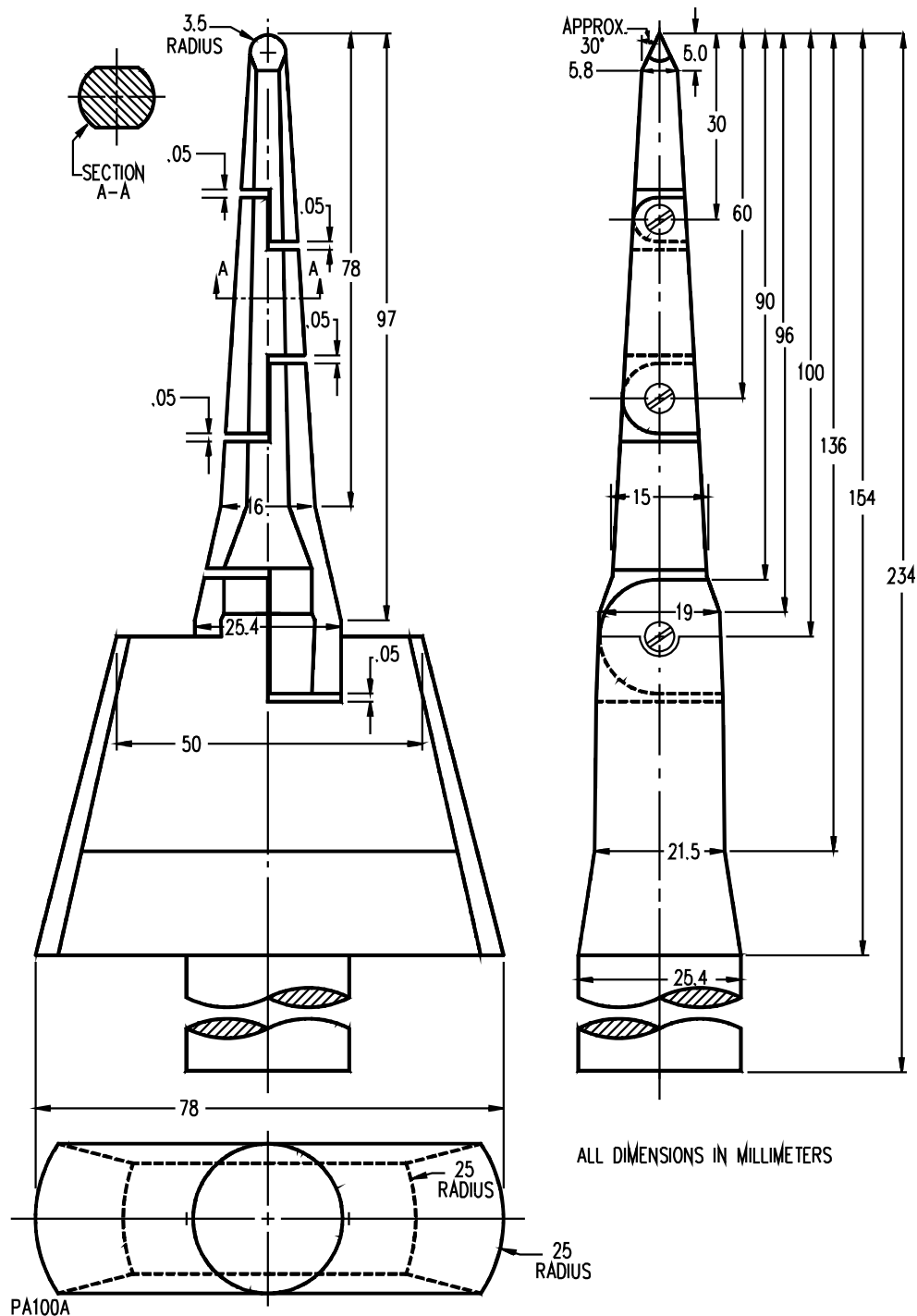
	Directly accessible motor	Indirectly accessible motor ^a	Enclosure other than that of a motor
Uninsulated live part	$MD^b < 25/32$ inch 11.7 Figure 11.2 $MD \geq 25/32$ inch 11.8 Figure 11.5 $X = 3-5/32$ inches	$MD < 3/4$ inch 11.7 Figure 11.3 $MD \geq 3/4$ inch 11.8 Figure 11.5 $X = 4$ inches	$MD < 1$ inch 11.7 Figure 11.1 $MD \geq 1$ inch 11.8 Figure 11.5 $X = 6-1/16$ inches
Film-coated wire	$MD < 3/4$ inch 11.7 Figure 11.4 $MD \geq 3/4$ inch 11.8 Figure 11.5 $X = 4$ inches	$MD < 3/4$ inch 11.7 Figure 11.4 $MD \geq 3/4$ inch 11.8 Figure 11.5 $X = 4$ inches	$MD < 1$ inch 11.7 Figure 11.4 $MD \geq 1$ inch 11.8 Figure 11.5 $X = 6-1/16$ inches
Moving part that may involve a risk of injury to persons	$MD < 3/4$ inch 11.7 Figure 11.4 $MD \geq 3/4$ inch 11.9 Table 11.3	$MD < 3/4$ inch 11.7 Figure 11.3 $MD \geq 3/4$ inch 11.9 Table 11.3	$MD < 1$ inch 11.7 Figure 11.1 $MD \geq 1$ inch 11.9 Table 11.3
^a See 11.5 for an explanation of an indirectly accessible motor. ^b MD = See 11.6 for an explanation of a minor dimension of an opening. NOTE – SI units for values specified in this table are: $3/4$ inch (19.1 mm) $25/32$ inch (19.8 mm) 1 inch (25.4 mm) $3-5/32$ inches (80 mm) 4 inches (102 mm) $6-1/16$ inches (154 mm)			

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Figure 11.1
Articulate probe with web stop



NOTE – The UL articulate probe without the web stop may be used for openings having a minor dimension less than 3/4 inch (19.1 mm).

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