UL 1838

STANDARD FOR SAFETY

Low Voltage Landscape Lighting Systems

UL Standard for Safety for Low Voltage Landscape Lighting Systems, UL 1838

Third Edition, Dated January 13, 2003

Summary of Topics

The revisions of ANSI/UL 1838 dated July 11, 2023 include the following changes in requirements:

- ***Removed the output circuit VA power limitation; 1.3, 1.4, and 56.6***
- ***Definition Removals; 2.5, 2.13, 2.14, 2.14.1, 2.19.1, 7.1, and 10.1***
- ***Clarified the requirements applicable to class 2 circuits within a power unit; 15.1.1 and 15.1.2***
- ***Protective Devices; 20.1 and 20.4***
- ***Elimination of multiple branch circuit supply connections; 24.1.2 and 50.9***
- ***Power supply cords with integral attachment plugs; 24.3.3***
- ***Maximum Output Test; 28.2.2***
- ***Overload Test; 29.2 and Figure 29.1***
- ***Short Circuit Test revision and elimination of Limited Short Circuit Test; 44.1 and Section 45***
- ***Shifted the Manufacturing and Production Tests to an informative Annex; Section 46, Section 47, Section 48 and Appendix B***
- ***Rating and marking adjustments; 49.1, 56.2 and 56.4***
- ***Use of websites and QR Codes for required product instructions; Table 50.1***
- ***Insulation Piercing Terminal Temperature Test; 53.4.4, 55.3, 55.5 and Figure 55.1***
- ***Dielectric Withstand Test; 32.1 and Appendix A***
- ***Editorial; Section 13 title***

Text that has been changed in any manner or impacted by ULSE'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 March 3, 2023.

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UL 1838

Standard for Low Voltage Landscape Lighting Systems

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January 13, 2003

This ANSI/UL Standard for Safety consists of the Third edition including revisions through July 11, 2023.

The most recent designation of ANSI/UL 1838 as an American National Standard (ANSI) occurred on July 11, 2023. 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 ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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CONTENTS

INTRODUCTION

PART 1 – POWER UNITS

MECHANICAL CONSTRUCTION

ELECTRICAL CONSTRUCTION

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

RATINGS

MARKING

PART 2 – EQUIPMENT CONNECTED TO THE POWER UNIT OUTPUT

CONSTRUCTION

PERFORMANCE

MARKING

PART 3 – TUNGSTEN-HALOGEN LUMINAIRES

INTRODUCTION

CONSTRUCTION

PERFORMANCE

MARKING

PART 4 – POND AND SMALL DECORATIVE FOUNTAIN LUMINAIRES AND FITTINGS

INTRODUCTION

CONSTRUCTION

PERFORMACE

MARKING

INSTRUCTIONS

Appendix A

Appendix B (informative)

INTRODUCTION

1 Scope

1.1 The requirements in this standard apply to a low-voltage landscape lighting system and components that consist of an isolating type power unit, low voltage cable or flexible cord, and luminaires. The equipment is intended to be installed in accordance with the National Electrical Code, ANSI/NFPA 70, Article 411.

1.2 Landscape lighting power units covered by this standard have a maximum output circuit voltage as specified in Table 2A.1.

1.3 This standard covers power units where each output circuit is rated maximum 25 A.

1.4 This standard covers landscape lighting system luminaires and other system components that are intended for use on circuits rated maximum 25 A, and the voltage specified in Table 2A.1.

1.5 The luminaires and low voltage system components covered by this standard are intended for garden, walkway, patio areas, or similar outdoor locations and for certain indoor locations such as atriums and shopping malls. The power units are to be installed indoors or outdoors in accordance with the marking on the product.

1.6 This standard covers luminaires and low voltage system components intended for use submersed in or floating on:

a) portable self-contained fountains; and

b) ponds and other natural and artificially made body of water within the scope of Article 682 “Natural and Artificially Made Bodies of Water” of the National Electrical Code, NFPA 70.

1.7 Throughout this standard, all requirements identified as applicable to luminaires and low voltage system components used submerged in or floating on ponds also apply to luminaires and low voltage system components intended for use in other bodies of water covered by Article 682 of the National Electrical Code, ANSI/NFPA 70. Further, markings, instructions, and other product specific information shall be permitted to refer to one or more bodies of water covered by Article 682 in addition to ponds or instead of ponds.

1.8 The luminaires and low voltage system components covered by this standard are not suitable for use in swimming pools, spas, other bodies of water intended to contain immersed persons, or permanent fountains covered by Part V of Article 680 of the National Electrical Code, ANSI/NFPA 70. Luminaires intended for use in these locations are covered by the Standard for Underwater Luminaires and Junction Boxes, UL 676. Fountains covered by Part V of Article 680 of the National Electrical Code, ANSI/NFPA 70 are permanent, not self-contained, not portable, or exceed 5 feet (1.5 m) in any dimension.

1.9 Fluorescent and high intensity discharge lighting systems will be investigated in accordance with the applicable requirements in this standard and with the applicable requirements in the Standard for Luminaires, UL 1598, as intended.

1.10 Light emitting diode (LED) components and subassemblies, such as drivers, control gear, and LED arrays, shall comply with the applicable requirements of the Standard for Lighting Emitting Diode (LED) Equipment for Use in Lighting Products, UL 8750.

2 Glossary

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

2.2 ACCESSIBILITY BARRIER – A material provided to restrict access to:

a) Uninsulated current carrying parts; and

b) Current carrying parts insulated with materials not intended to be subject to user contact. All or part of the barrier is able to serve as an enclosure.

2.2.1 CLASS 1 WIRING METHODS– Wiring methods specified in Chapter 3 of the National Electrical Code, ANSI/NFPA 70.

2.2.2 CLASS 2 CIRCUIT – A circuit supplied by either (a) a transformer complying with the construction and performance requirements for Class 2 transformers in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; or (b) a power unit complying with the construction and performance requirements in the Standard for Class 2 Power Units, UL 1310.

2.3 *Deleted*

2.4 CONNECTOR – A generic term used to refer to an electrical fitting that:

a) Connects the luminaire to the main low voltage cable (also called line-to-luminaire connector); or

b) Is used to extend main low voltage cable (also called line-to-line connector).

2.5 *Deleted*

2.6 ELECTRICAL FITTING – Any device that supports or encloses uninsulated current carrying parts.

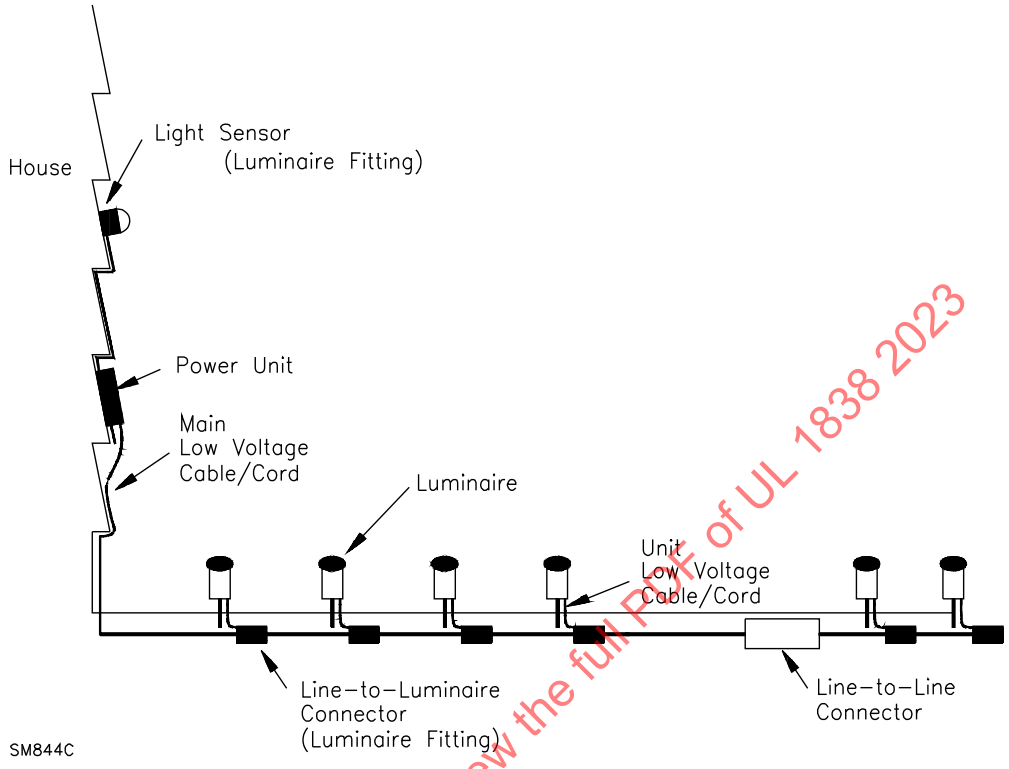
2.7 ELECTRONIC POWER UNIT – Equipment that powers and controls the lamps used for a landscape lighting system and consists of electronic circuits to isolate the secondary from the primary circuit and reduce voltage and limit available power.

2.8 ENCLOSURE – A material provided to enclose electrical parts and components that involves a risk of fire. All or part of the enclosure serves as an accessibility barrier.

2.9 LANDSCAPE LIGHTING SYSTEM – The system consisting of the power unit, luminaire, luminaire fittings, and wiring. See Figure 2.1 for a diagram of a typical landscape lighting system.

Figure 2.1

Typical landscape lighting system



2.10 *Deleted*

2.11 LUMINAIRE – An assembly that consists of the lamps, enclosures, mounting means, luminaire fittings, and the means of connection to unit low voltage cable or the main low voltage cable.

2.12 LUMINAIRE FITTING – An individual component or accessory that is provided with a luminaire or that is electrically or mechanically connected to the power unit.

2.13 *Deleted*

2.14 *Deleted*

2.14.1 *Deleted*

2.15 POWER UNIT – The equipment that powers and controls the lamps used for the landscape lighting system. A power unit consists of one or more of the following:

a) Transformer or solid-state circuitry to isolate the output circuit from the primary input circuit, reduce voltage and limit available power;

b) Timers, switches, sensors, or similar devices to control the lighting; and

c) Integral overcurrent protection.

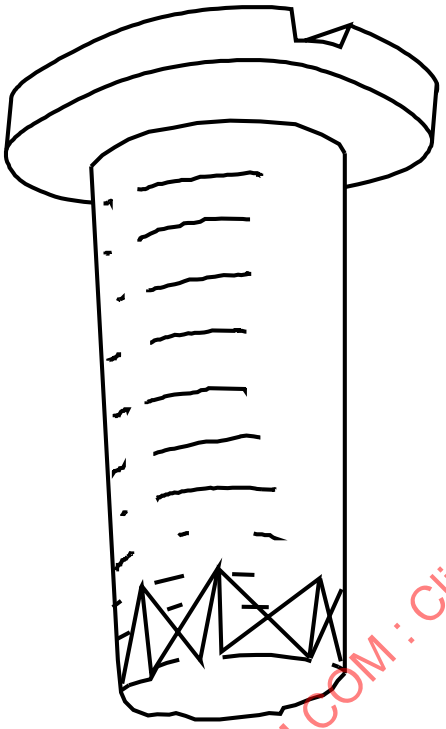
2.16 RISK OF ELECTRIC SHOCK – See Section 2A.

2.17 SCREW, SHEET-METAL – A screw with threads having a pitch such that thinner sheet metal is able to be secured by physical fit between successive threads. Self-tapping screws are also known as sheet-metal screws.

2.18 SCREW, THREAD-FORMING – A screw with a tapered end that is criss-cross stamped as shown in Figure 2.2. When screwed into an open hole, the screw forces the sheet-metal around the open hole to expand and form threads. A thread-forming screw will not necessarily follow the same threads if reinserted into the same opening.

Figure 2.2

Thread-forming screw



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2.19 SECONDARY WIRING – Wiring connecting the output of the power unit to the luminaire, including the main low voltage cable and the unit low voltage cable.

2.19.1 *Deleted*

2.20 SPLICE – Any point where one wire is connected to another wire. A wire terminating at a pressure wiring terminal or wire binding screw is not determined to be a splice.

2.21 TERMINAL, INSULATION PIERCING – A terminal having a contact pin that punctures the conductor insulation and is inserted into strands of the conductor. Also an insulation displacement terminal where the insulation is cut and the conductor is positioned between the pins of the terminal.

2.22 WATER BARRIER – All parts such as a lens, luminaire body, gasket, or sealant/adhesive material that are in contact with water under normal use conditions and that, if compromised, would allow water to reach uninsulated parts that pose a risk of electric shock (see Section 2A). A water barrier includes a part

not directly isolating water from a dry location but that is relied upon for water barrier integrity, such as a bezel or face/trim ring that bears against a lens that, in turn, bears against/compresses a gasket.

2A Electric Shock

2A.1 An uninsulated conductive part is considered to pose a risk of electric shock when the voltage potential between the part and earth ground or any other accessible part exceeds the values specified in Table 2A.1.

Table 2A.1
Maximum voltage considered not a risk of electric shock, and the maximum permitted output circuit voltage for landscape lighting systems

	Voltage type	Maximum Voltage
1.	Sinusoidal, ac	15 V, rms
2.	Nonsinusoidal, ac	21.2 V, peak
3.	Pure dc [a, b]	30 V
4.	Combinations of dc and sinusoidal ac at frequencies not greater than 100 Hertz	c

[a] If the peak-to-peak ripple voltage generated by an electronic power unit is more than 10 percent of the dc voltage, see footnote c.

[b] DC waveforms interrupted at frequencies between 10 – 200 Hz shall be limited to 12.4 V.

[c] The voltage limit shall be the non-sinusoidal ac limit where the dc voltage is no more than 10.4 V, and shall be (16.5 + 0.45 Vdc) where the dc voltage is between 10.4 and 30 V.

Figure 2A.1
Maximum voltage for combinations of dc and sinusoidal ac voltage at frequencies not greater than 100 hertz
Figure deleted

Table 2A.2
Maximum current considered not a risk of electric shock
Table deleted

Figure 2A.2
Maximum current for combinations of dc and sinusoidal ac current at frequencies not greater than 100 hertz
Figure deleted

3 Components

3.1 Except as indicated in 3.2, 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.

3.2 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.

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

3.4 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.

4 Units of Measurement

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

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

5 Undated References

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

6 Organization and Application

6.1 The standard is organized as follows:

Introduction – This covers general statements and requirements necessary to apply the requirements in the standard.

Part 1 – This part covers the construction, performance, and marking requirements for all power units.

Part 2 – This part covers equipment, including luminaires, low voltage cables, and other system components connected to the output circuit of a power unit.

Part 3 – This part covers luminaires that use tungsten halogen lamps.

Part 4 – This part covers luminaires for ponds and small decorative fountains.

6.2 *Deleted*

6.3 *Deleted*

PART 1 – POWER UNITS

MECHANICAL CONSTRUCTION

7 General

7.1 Sheet metal screws and thread forming screws with screw threads as shown in Figure 2.2 shall not be used to secure electrical parts or enclosure components in place or together when the screw threads contact only sheet aluminum, copper, or aluminum or copper alloys.

Exception No. 1: A sheet metal screw or thread forming screws are able to be used if intended results are observed during the test described in 39.1.

Exception No. 2: A sheet metal screw or thread forming screw is able to pass through sheet aluminum, copper, or aluminum or copper alloys if it then threads into steel having a minimum thickness as specified in 9.1.

Exception No. 3: A sheet metal screw is able to be used for mounting or support of a part (such as a transformer) if the part weighs less than 7-1/2 pounds (3.4 kg).

7.2 The method of making a joint between metal parts and of fastening arms and supports, shall provide strength and rigidity and prohibit turning that results in movement of wires or wiring devices after the assembly is completed. If wires passing through the joint are concealed, the joint shall be so designed that rotation is 360 degrees or less.

7.3 With regard to 7.2, friction alone between parts shall not be the means to prohibit turning more than 360 degrees. Turning shall be prohibited by:

a) The use of a lock washer, properly applied;

b) A locknut seated against another nut or metal surface; or

c) By some other positive mechanical method where two parts mate by interference fit.

7.4 Components shall be secured by a means other than friction.

7.5 An adhesive used to secure components or the enclosure shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Solvent bonding is able to be used without complying with UL 746C.

7.6 *Deleted*

8 Enclosures

8.1 All splices, transformers, current carrying parts or devices with current carrying parts that are not enclosed, and all leads or terminals for field connection of supply wires shall be enclosed in material specified in 8.2.

8.2 An enclosure specified in 8.1 shall be constructed of metal or a polymeric material that complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The minimum thickness for metal shall be as specified in Metal Thickness, Section 9. If the enclosure is constructed of polymeric material, compliance with Section 40, Polymeric Enclosure Conduit Connection Tests is required.

8.3 An enclosure shall be provided with integral mounting means and shall be so constructed as to prohibit the wetting of current carrying parts in circuits over 15 volts or electrical components or wiring not specified for use in contact with water, and to reduce the risk of electric shock due to weather exposure. Parts specified for use in contact with water include flexible cords marked in accordance with 24.4.1, liquid tight flexible metal conduit, outlet boxes marked for use in wet locations, rigid conduit, and similar parts.

Exception: A power unit marked for indoor use only is not required to comply with this requirement.

8.4 To determine compliance with 8.3, a complete power unit is to be subjected to the tests specified in Weather Tests, Section 37.

9 Metal Thickness

9.1 Sheet metal

9.1.1 The thickness of sheet metal in a power unit, other than at openings for conduit connection, shall be no less than 0.020 inch (0.51 mm) for uncoated steel, 0.023 inch (0.58 mm) for zinc coated steel, and 0.025 inch (0.64 mm) for copper, brass, zinc, or aluminum.

Exception: The thickness of metal is not specified for:

a) A purely ornamental part; or

b) Any part not required to serve as the enclosure, provided structural integrity, or act as support of a wiring device.

9.1.2 At openings for conduit connection, the minimum metal thickness shall be 0.032 inch (0.81 mm) for uncoated steel, 0.034 inch (0.86 mm) for zinc coated steel, and 0.040 inch (1.02 mm) for copper, brass, zinc, or aluminum.

9.1.3 The values for minimum thickness indicated in 9.1.1 apply to measurements made on a formed part prior to the application of paint, varnish, or similar applications.

9.2 Extrusions

9.2.1 An extruded metal part shall comply with the thickness requirements for sheet metal as described in 9.1.1.

9.3 Cast metal

9.3.1 The minimum thickness of cast metal shall be in accordance with Table 9.1.

Table 9.1
Minimum acceptable thickness of cast metal

Metal	At un-reinforced areas exceeding 35 square inches (226 cm^2)		At all other areas	
	Inch	(mm)	Inch	(mm)
Die-cast metal	5/64	2.0	3/64	1.2
Cast malleable iron or permanent mold cast aluminum	3/32	2.4	1/16	1.6
Other cast metal	1/8	3.2	3/32	2.4

10 Corrosion Protection

10.1 The inside and outside surfaces of cast ferrous metal, sheet steel, or ferrous tubing shall be protected against corrosion by one of the coatings described in Table 10.1.

Exception No. 1: Other finishes, including paints, special metallic finishes and combinations of the two that have, by comparative tests with galvanized sheet steel conforming with designation (A) Type G90 of Table 10.1, indicated they provide equivalent protection, are able to be used.

Exception No. 2: A metal part that is not required for conformance with this standard need not be protected against corrosion.

Exception No. 3: Stainless steel need not be additionally protected against corrosion.

Exception No. 4: Edges, fasteners, and welds complying with 10.2, 10.3, 10.4, and 10.5 need not be additionally protected against corrosion.

Exception No. 5: If the inside surfaces on the power unit are protected from the elements such that no water enters the unit during the Weather Tests described in Section 37, the inside surfaces are able to be provided with corrosion protection equivalent to that specified in 10.2.

Exception No. 6: A power unit marked for indoor use only need not comply with this requirement.

10.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion by zinc coating, cadmium plating, enameling, painting, or be provided with equivalent protection against corrosion on all surfaces.

Exception No. 1: Hinge pins need not be provided with corrosion protection.

Exception No. 2: A power unit marked for indoor use only need not comply with this requirement.

10.3 Sheet steel or other metal that is painted to comply with 10.2 shall be properly cleaned of grease and similar products prior to painting.

10.4 Punched holes and cut edges in ferrous material need not be corrosion protected.

10.5 Welds in iron or steel (other than stainless steel) shall be painted with one coat of any outdoor paint.

Exception No. 1: A power unit marked for indoor use only need not comply with this requirement.

Exception No. 2: One coat of any indoor paint is allowed over a spot weld on galvanized steel.

Table 10.1
Sheet steel coatings

Type of coating	Type or thickness[a] Inches	(mm)	Description
(A) Hot-dipped mill galvanized steel	G90[b]		–
	G60[b]		with 1 coat of outdoor paint[c]
	A60[b]		with 1 coat of outdoor paint[c]
(B) Zinc coating other than Type (A)	0.00061	(0.0155)[d]	–
	0.00041	(0.0104)[d]	with 1 coat of outdoor paint[c]
(C) Cadmium coating	0.0010	(0.0254)	–
	0.00075	(0.01905)	with 1 coat of outdoor paint[c]
	0.0005	(0.0127)	with 2 coats of outdoor paint[c]
(D) Vitreous enamel[e]	–		–
(E) Organic coatings[f]	–		–

[a] As determined by ASTM Method B555, Guidelines for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test.

[b] Conforming with the coating designation G90, G60, or A60 in Table 1 of ASTM A525, Specification for Sheet Steel, Zinc-Coated (Galvanized) by the Hot Dip Process, General Requirements, with no less than 40 percent of the zinc on any side based on the minimum single spot test requirement in this ASTM standard.

[c] Labeled as outdoor paint by paint manufacturer.

[d] Average thickness with a spot minus tolerance of 0.00007 inch (0.00178 mm).

[e] Sheet steel rated at least 0.026 inch (0.66 mm) thick.

[f] Complying with the Standard for Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment, UL 1332.

11 Open Holes

11.1 An open hole in an enclosure containing current-carrying parts involving a risk of electric shock shall not exceed the dimensions specified in Table 11.1.

Exception: An open hole need not comply with Table 11.1 if an articulate probe as specified in Figure 11.1 does not contact uninsulated current carrying parts involving a risk of electric shock.

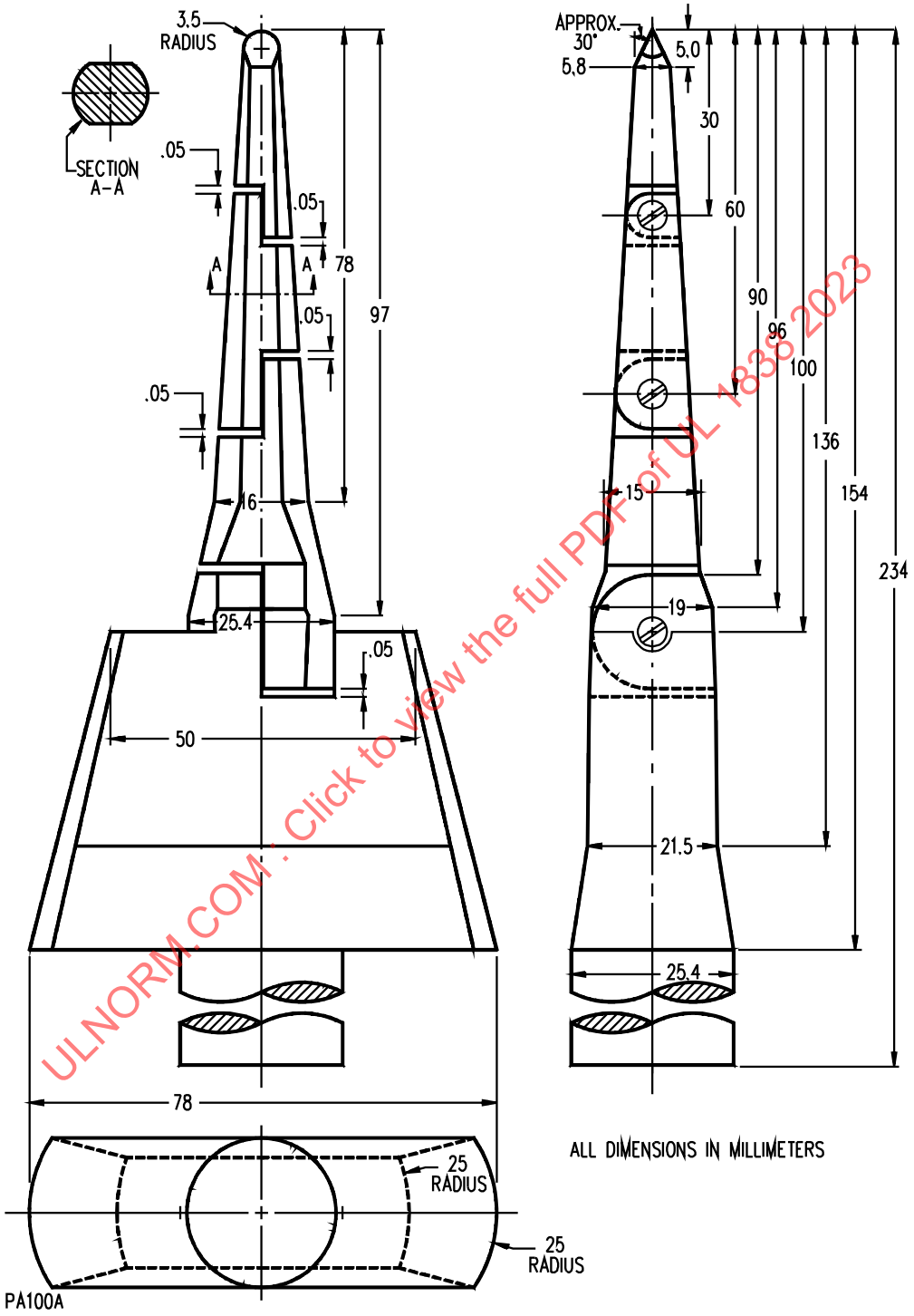
Table 11.1
Maximum size of open holes

Opening shape	Dimension inch	(mm)	Maximum area in^2	(cm^2)
Slot[a]	3/8 (width)	9.6	1-1/2	9.68
Square	1/2 (side)	12.7	–	–
Round	1/2 (diameter)	12.7	–	–
Irregular	3/8	9.6	1-1/2	9.68

[a] An open hole between two assembled parts that does not exceed 1/32 inch (0.8 mm) need not comply with the area dimensions.

Figure 11.1

Articulate with web stop



NOTES:

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

High impact polystyrene articulate probes available from Underwriters Laboratories Inc.

11.2 The requirements of this section do not apply to drain holes, which are addressed in Drain Holes, Section 12.

11.3 The total area of one or more open holes shall be no more than 15 percent of the area of the surface in which the hole or holes are located. This includes a wiring compartment or integral outlet box compartment.

Exception: This requirement does not apply if the power unit complies with the impact test described in Impact Test on Units With Open Holes, Section 42 and with the Component Fault Test described in Section 43.

11.4 An enclosure containing a fuse mounted in an open type fuseholder shall have no open holes.

12 Drain Holes

12.1 An open drain hole shall be provided on all power units to prohibit the accumulation of water above a level that results in the wetting of an electrical part or opening for the connection of conduit or for an auxiliary part. The hole shall be as specified in Table 12.1.

Exception No. 1: A power unit that has been subjected to the Weather Tests as required in Section 37 need not be provided with a drain hole if no water enters the enclosure.

Exception No. 2: A ground mounted power unit shall not be provided with a drain hole.

Exception No. 3: A power unit marked for indoor use only need not comply with this requirement.

Table 12.1
Size of drain holes

Opening shape	Minimum dimension		Minimum area		Maximum dimension		Maximum area	
	Inch	(mm)	Inch^2	(mm^2)	Inch	(mm)	Inch^2	(cm^2)
Slot	1/8 (width)	3.2	0.012	7.74	3/8 (width)	1-1/2	1-1/2	9.68
Square	1/8 (side)	3.2	–	–	1/2 (side)	12.7	–	–
Round	1/8 (diameter)	3.2	–	–	1/2 (diameter)	12.7	–	–
Irregular	–	–	0.012	7.74	–	–	1-1/2	9.68

13 Knockouts

13.1 A knockout shall be secured in place so that it is removed readily without distortion of the enclosure, but will remain in place during normal handling as determined in Tests on Knockouts, Section 41.

14 Gaskets and Bushings

14.1 A gasket or bushing shall comply with the requirements of the thermal conditioning test described in 37.7.1 – 37.7.3.

Exception: Neoprene rubber meets the intent of the requirement for 60°C (140°F) and silicone rubber meets the intent of the requirement for 105°C (221°F) without being subjected to an investigation.

14.2 A gasket shall be so secured that intended use will not cause the gasket to loosen. Clips or a clamping ring are allowed as the means of securement. An adhesive or other means shall be investigated.

14.3 If an adhesive is used to secure a gasket as described in 14.2, the gasket assembly shall comply with the gasket adhesion test described in 37.8.1.

ELECTRICAL CONSTRUCTION

15 General

15.1 Class 2 Circuits Within Power Unit

15.1.1 Components of a Class 2 Circuit within but not mounted to the power unit enclosure are required to comply with only the following requirements in PART 1 of this standard.

a) Separation of Circuits, Section 22;

b) Electrical Spacings, Section 23; and

c) Dielectric Voltage Withstand Test, Section 32.

15.1.2 *Deleted*

15.1A Class 2 Power Units

15.1A.1 A power unit whose output is marked as Class 2, in accordance with 50.23, shall comply with PART 1 of this standard and additionally be evaluated and found to comply with the applicable output performance requirements of the Standard for Class 2 Power Units, UL 1310, or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

15.2 Wiring devices

15.2.1 A wiring device (a switch, fuseholder, lampholder, or similar wiring device) shall be prohibited from any turning, by a means as specified in 7.2 and 7.3, that does not apply tension to splices or other wiring connections, cause damage to the wiring, or otherwise adversely affect the assembly.

15.3 Internal wiring connections

15.3.1 A soldered lead shall be mechanically secured at the point of connection before soldering, or shall be welded in place.

15.3.2 With respect to the requirement in 15.3.1, a lead is determined to be mechanically secured when one or more of the following is provided:

a) At least one full wrap around a terminal;

b) At least one right angle bend when passed through an eyelet or opening; or

c) The lead is twisted with other conductors.

15.3.3 Other types of wiring connections that provide for a secure connection are allowed.

15.4 Insulation

15.4.1 Nonabsorptive electrical insulation shall be used in the construction of electrical components where it is relied upon to provide electrical spacings or sole support of live electrical parts or as electrical insulation. Untreated fiber and similar products, are examples of materials that shall not be used; while treated cellulosic fiber, phenolic, urea, porcelain, and similar products, are materials that meet the intent of the requirements. Other materials relied upon as electrical insulation shall comply with the insulation requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

15.4.2 Coil insulation, unless inherently moisture resistant, shall be treated to render it resistant to moisture by a coating, varnish, or similar treatments.

15.5 Prevention of wire damage

15.5.1 A power unit shall be so designed that wires are able to be pulled through, or the power unit otherwise wired, without damaging the coverings of insulation on the conductors. A wire enclosure shall be free from burrs, fins, and other sharp edges that come in contact with wires.

15.5.2 Threads of sheet metal and self-tapping screws shall not be exposed in a wiring enclosure for a distance of more than 3/16 inch (4.8 mm).

Exception: Wires that are held away from or positioned away from such screw threads are not prohibited from being within 3/16 inch (4.8 mm) of the threads.

15.5.3 When a conductor passes through an opening or crosses over the edge of metal, it shall be held away from contacting the edges or be protected from cutting and abrasion. Sleeving shall not be used as a means of prohibiting cutting and abrasion of wires.

15.5.4 For sheet metal less than 0.042 inch (1.07 mm), protection shall be provided by one of the following methods:

a) Rolling of the edge of metal by at least 120 degrees; or

b) A bushing or grommet of a material other than rubber of a minimum thickness of 0.047 inch (1.2 mm).

16 Device and Conductor Ratings

16.1 Voltage

16.1.1 Electrical devices and insulated conductors shall have a voltage rating at least equal to the voltage applied to them in intended use.

16.2 Current

16.2.1 An electrical device shall have an ampere rating and insulated conductors shall have an ampacity rating for the total current, as specified in 16.2.2 and 16.2.3 to which they are subjected to in their intended use.

16.2.2 The total current referred to in 16.2.1 shall be the combination of:

a) The sum of the ampere ratings of all load devices (transformer, relay, and similar materials) that use the conductor for their supply.

b) 15 amperes for a receptacle.

16.2.3 A cord connected power unit shall be rated a maximum of 80 percent of the intended branch circuit (for example, 12 amperes for a 15-ampere circuit).

17 Switches and Relays

17.1 The ampere rating of a switch and relay shall be multiplied by the derating factor as indicated in Table 17.1 before determination of its current handling capability for the specified load.

Table 17.1
Switch and relay derating factors

Switching load	Switch type			
	AC general use[a]	AC "L" AC-DC "T"[b]	AC resistive	DC
Transformer	none	none	1/2	–
Receptacle	none	none	1/6	1/10
Incandescent Lamp	none	none	1/6	1/10

[a] This column applies not only to general-use AC switches (for mounting in flush-device outlet boxes) but also to switches of the unit, pendant, and through-cord types rated AC only.

[b] A switch, other than a type mentioned in note[a], that has been investigated for the control of tungsten filament lamps, is marked with the letter "T" or "L" in conjunction with the current rating at which the tungsten-filament lamp rating applies, for example, "1 ampere, 125 volt, T."

17.2 A switch used in a multiwire circuit shall be of the multipole type and shall be connected such that all ungrounded wires are switched.

17.3 A switch, if provided in the primary circuit, shall be connected in the ungrounded conductor.

18 Convenience Receptacles

18.1 A convenience receptacle shall not be provided in a ground mounted power unit.

18.2 No more than one duplex or two single convenience receptacles are to be provided with each unit.

18.3 A convenience receptacle shall be of the grounding type.

18.4 A convenience receptacle shall be of the GFCI type or shall be marked for installation to a GFCI-protected circuit (see 50.10).

18.5 The face of a convenience receptacle that is less than 5/8 inch (15.9 mm) wide or 7/8 inch (22.2 mm) long shall project a minimum of 0.015 inch (0.38 mm) and a maximum of 3/16 inch (4.8 mm), from any part of the receptacle-mounting surface, including screwheads, that is within a rectangle 5/8 inch wide and 7/8 inch long, the rectangle being symmetrically located about the receptacle contacts.

Exception: The minimum projection shall be 3/32 inch (2.4 mm) if the mounting surface for the receptacle is electrically conductive.

18.6 A power unit provided with a receptacle shall be constructed to prohibit the entrance of water into the receptacle with or without an attachment plug in place. The power unit with receptacle shall be weather tested in accordance with 37.3.4.

Exception: A power unit marked for indoor use only is not required to comply with this requirement.

19 Wiring and Conductors

19.1 A conductor shall be made of copper or copper alloy.

19.2 A conductor shall have insulation rated for the voltage, temperature, and condition of service to which it will be subjected under conditions of intended use. The flammability rating shall be VW-1. A wire or each insulated conductor of a cord that is rated for 90°C (194°F), 105°C (221°F) or 125°C (257°F) is rated 150°C (302°F) if each wire is individually provided with supplementary insulation that consists of snugly fitting woven glass sleeving or tape at least 0.010 inch (0.25 mm) thick.

19.3 An external supply conductor connecting the power unit to the branch circuit supply shall not be smaller than 18 AWG (0.82 mm^2).

20 Protective Devices

20.1 A protective device is permitted to limit the output of the power unit to 25 amperes maximum, as determined by the Maximum Output Test, 28.2.

20.2 If a nonresettable thermal protective device is used, the device shall be inaccessible and shall be located within the enclosure.

20.3 If an automatic reset protective device is used, it shall comply with the 6,000 cycle Endurance Test in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873.

20.4 When needed to comply with the Maximum Output Test of 28.2, a protective device shall be located in each output circuit unless a single protective device located in the primary circuit protects all output circuits.

21 Printed Wiring Boards

21.1 A printed wiring board shall have a minimum V2 flammability rating and a temperature rating sufficiently high to withstand the temperatures attained in the power unit during the Temperature Test described in Section 33.

22 Separation of Circuits

22.1 General

22.1.1 Circuit components and conductors operating at different voltage potentials shall be separated from each other as specified in 22.2 – 22.3 and 23, Electrical Spacings. This requirement also applies to Class 2 circuit separation from non-Class 2 circuits.

22.2 Separation of Conductors

22.2.1 Secondary circuits shall be separated from other circuits in accordance with 22.2.2 – 22.2.6. Insulated conductors shall be separated by barriers or segregated from:

a) Each other when used in different internal wiring circuits; and

b) Uninsulated current carrying parts connected to different circuits.

Exception: Separation is not required when all conductors are provided with insulation rated for the highest voltage involved.

22.2.2 Segregation of insulated conductors shall be accomplished by clamping, routing, or equivalent means that results in permanent separation from insulated or uninsulated current carrying parts of a different circuit.

22.2.3 Means shall be provided for separation of field-installed conductors of the output circuit from:

a) Field and factory-installed conductors connected to any other circuit.

Exception: Complete instructions in conjunction with a wiring diagram is able to be used in lieu of a barrier when, upon investigation, the combination is found to meet the intent of the requirement and the instructions specify that the conductors of both circuits are to be insulated for the maximum voltage of either circuit.

b) Uninsulated current carrying parts of any other circuit of the device.

22.2.4 Segregation of field-installed conductors from each other and from uninsulated current carrying parts of the equipment connected to different circuits is attainable by arranging the location of openings in an enclosure for the various conductors with respect to the terminals or other uninsulated current carrying parts so that conductors or parts of different circuits do not intermingle.

22.2.5 With reference to 22.2.4, the opening shall be evaluated such that a conductor entering the opening is connected to the terminal opposite that opening. When more than the minimum number of openings are provided, the risk of a conductor entering an opening other than the one opposite the terminal to which it is intended to be connected shall be evaluated. The risk of such a conductor contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit shall be evaluated.

22.2.6 To determine compliance with 22.2.2, the equipment is to be wired as intended for service with an amount of slack left in each conductor within the enclosure and average care is to be exercised in stowing the slack into the wiring compartment.

22.3 Output circuit isolation

22.3.1 Each output circuit shall be electrically isolated from the power unit supply circuit by one of the means specified in 22.3.2. No output circuit shall be bonded to the supply circuit equipment grounding conductor or to dead metal bonded to the supply circuit equipment grounding conductor.

22.3.2 Isolation between the supply and output circuit shall be provided by:

a) A transformer with primary and secondary windings mounted on separate sections of the core;

b) A transformer complying with the requirements for double insulation in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, or the Reference Standard for Double Insulation Systems for Use in Electronic Equipment, UL 2097;

c) A transformer with primary and secondary windings separated by a shield of copper that is at least 0.002 inches (0.051 mm) thick or brass minimum 0.005 inch (0.127 mm). A connection shall be made between the shield and ground by means of a bonding lead sized at least as large as the conductor used to supply the primary winding magnet wire and no smaller than 18 AWG (0.82 mm^2). The shield dimensions and placement shall leave no unshielded electrical fault path between windings through any bobbin wall, winding insulation, or both.

d) A transformer that complies with the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; or

e) A power supply that complies with the Standard for Class 2 Power Units, UL 1310, and is marked “double insulated.”

22.3.3 *Deleted*

22.3.4 *Deleted*

22.3.5 Other means to isolate the primary from the output circuit in an electronic power unit, such as optical isolators that comply with the Standard for Optical Isolators, UL 1577, shall be provided where separation through barriers or electrical spacings is not provided.

23 Electrical Spacings

23.1 Electrical spacings between:

a) Uninsulated current carrying parts of opposite polarity;

b) Uninsulated current carrying parts and dead metal parts; and

c) Uninsulated current carrying parts of an isolated circuit and uninsulated current carrying parts of another circuit

shall be no less than those indicated in Table 23.1 and for supply wiring terminals no less than indicated in 23.2.

Exception No. 1: Snap switches, lampholders, and similar component devices that comply with the requirements for components as specified in 3.1 need not comply with the spacings specified in Table 23.1 with respect to:

a) Internal features of the devices; and

b) Spacings between uninsulated current carrying parts and dead metal parts of the device (including mounting screws, rivets, yokes, clamps, or similar parts).

Exception No. 2: As an alternative to the spacings specified in Table 23.1, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are able to be used as described in 23.9 – 23.13.

Table 23.1
Electrical spacings

Spacing in inches (mm)									
	0 – 15 V (0 – 21.2 V)[a]	16 – 50 V (21.3 – 72 V)[a]		51 – 150 V (73 – 212 V)[a]		151 – 300 V (213 – 423 V)[a]		Over 300V (Over 424 V)[a]
Through Air	N/A	1/16	(1.6)	1/8	(3.2)	1/4	(6.4)	3/8
Over Surface	N/A	1/16		1/4		3/8	(9.5)	3/8
To Enclosure	N/A	1/2	(12.7)	1/2		1/2		1/2

[a] The figures in parentheses are peak voltages. When evaluating the voltage of a circuit that produces other than a sinusoidal waveform, both rms and peak values are determined and the requirement for the larger spacing is to be applied.

23.1.1 Electrical spacings between a Class 2 circuit and a non-Class 2 circuit shall also comply with the requirements of this section.

23.2 The spacings between supply wiring terminals of opposite polarity and between the terminals and a grounded dead metal part shall not be less than 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface, or as indicated in Table 23.1 whichever is greater.

23.3 The spacing between uninsulated current carrying parts of different circuits involving different voltages shall not be less than that required for the circuit of the higher voltage.

23.4 The spacings at fuses and fuseholders are to be measured with the fuses in place. The fuses are to be those with maximum standard dimensions.

23.5 The spacing at a supply wiring terminal is to be measured with wire of the correct size for the rating connected to the terminal as in actual service, but in any case with wire no smaller than 14 AWG (2.1 mm^2).

23.6 When evaluating spacings, any wire or cord not in compliance with the insulation requirements in 19.2 (including enamel-insulated wire) is determined to be a bare, current-carrying part.

23.7 If provision for the connection of conduit or armored cable is provided, spacings shall be measured with fittings in place, whether they are furnished with the unit or not.

23.8 A spade or ring wire connector shall be prohibited from turning by means of a restraint, such as a shoulder or boss, if such turning reduces spacings to values less than those required. A lock washer alone is not to be used for this purpose.

Exception: If a wiring lug or connector turns ±30 degrees from normal without reducing spacings as noted in 23.2 or Table 23.1, a restraint is not required.

23.9 As an alternative to the spacing requirements of Table 23.1, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances For Electrical Equipment, UL 840, are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

23.10 It is anticipated that the level of pollution for outdoor use equipment will be pollution degree 3. Hermetically sealed or encapsulated enclosures, or coated printed wiring boards in compliance with the Printed Wiring Board Coating Performance Test of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are assumed to be pollution degree 1.

23.11 It is anticipated the equipment will be rated overvoltage category II and overvoltage category I as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

23.12 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product.

23.13 All printed wiring boards are assumed to have a minimum comparative tracking index of 100 without further investigation.

24 Power Supply and Output Circuit Connections

24.1 Power supply connection method

24.1.1 A power unit shall be constructed so that it is able to be connected to a branch circuit wiring system by at least one of the following:

a) Provision for connection of conduit as specified in 24.2;

b) A power supply cord as specified in 24.3; or

c) Direct plug-in to a receptacle as specified in 24.3.1.1.

24.1.2 A power unit shall have provision for connection to a single branch circuit.

24.1.3 The provision for connection to the supply source shall allow all supply connections to be made at a common point without the addition of wiring in the field.

24.2 Power supply conduit connection and conductor connection provisions

24.2.1 Only one opening for the entrance of branch circuit power supply wires by conduit is to be an open hole, and it shall be so located that those wires are able to be connected readily to the power unit supply means.

24.2.2 An opening for conduit shall have dimensions as indicated in Table 24.1.

Table 24.1
Dimensions associated with openings for conduit

Nominal trade size of conduit	Minimum unthreaded opening diameter[a]		Throat diameter				Minimum diameter of flat surface	
			Minimum		Maximum			
inches	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
1/2	0.875	(22.2)	0.56	(14.2)	0.62	(15.7)	1.15	(29.2)
3/4	1.109	(28.2)	0.74	(18.8)	0.82	(20.8)	1.45	(36.8)
1	1.375	(34.9)	0.94	(23.9)	1.05	(26.7)	1.80	(45.7)
1-1/4	1.734	(44.0)	1.24	(31.5)	1.38	(35.1)	2.31	(58.7)

[a] A plus tolerance of 0.031 inch (0.79 mm) and a minus tolerance of 0.015 inch (0.38 mm) applies to the knockout diameter. Knockout diameters will be measured other than at points where a tab remains after removal of knockout.

24.2.3 The minimum unobstructed diameter of the flat surface surrounding the back of an opening for unthreaded conduit shall be as indicated in Table 24.1.

24.2.4 If threads for the connection of threaded conduit are tapped all the way through a hole, there shall be no fewer than 3-1/2 or more than 5 threads. The construction of the hole shall be such that a conduit bushing is able to be properly attached and the minimum unobstructed diameter surrounding the back of the hole shall be as indicated in Table 24.1.

24.2.5 If threads for the connection of threaded conduit are not tapped all the way through a hole, there shall be no fewer than five full threads. The unthreaded parts of the hole and the back edge shall be smooth and well rounded for protection of the conductors. The unthreaded throat diameter of the hole shall have an internal diameter as noted in Table 24.1.

24.2.6 Polymeric enclosures shall be subjected to the test program in Polymeric Enclosure Conduit Connection Tests, Section 40.

24.2.7 Free space within a wiring compartment for field connection of the power unit leads to branch circuit conductors shall be as specified in Table 24.2 for each supply wire that terminates inside the compartment. One or more grounding conductors are treated collectively as one conductor.

Table 24.2
Wire compartment size

Conductor size		Free space within box for each conductor	
AWG	(mm^2)	$inch^3$	(cm^3)
18	(0.82)	1.50	(55)
16	(1.3)	1.75	(88)
14	(2.1)	2.00	(131)
12	(3.3)	2.25	(187)

24.2.8 Leads provided for the connection to the supply branch circuit shall not extend more than 24 inches (610 mm) beyond the farthest connection point(s) of the leads within the power unit and shall be a minimum 6 inches (152 mm) in length.

24.2.9 The means for connection to the branch circuit conductors shall consist of leads, a terminal block with a pressure terminal connector or wire binding screws.

24.2.10 A field-wiring terminal shall be prohibited from turning or shifting in position by means other than friction between surfaces. This shall be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by a means indicated in 7.3.

24.3 Power supply cord

24.3.1 *Relocated as 24.3.1.2*

24.3.1.1 In addition to complying with the requirements of this standard, a direct plug-in power unit shall also comply with the mechanical assembly, input connections, grounding, and mechanical performance tests of the Standard for Class 2 Power Units, UL 1310, as applicable to direct plug-in units.

24.3.1.2 The power supply cord shall be a junior or hard service cord such as type SJ, SJO, SJT, SJTO, SO, ST, or STO.

Except for a power unit marked for indoor use only, per 50.12, both the attachment plug and the power supply cord shall be suitable for use in wet locations (the above noted cords shall have a “W” suffix).

24.3.2 The length of the supply cord shall be a minimum of 2 feet (0.6 m) and a maximum of 6 feet (1.8 m), measured from the point of exit from the power unit to the face of the attachment plug.

24.3.3 The attachment plug shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. When the attachment plug is an integral molded part of the power supply cord, the assembly shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817. The current rating of the attachment plug shall be not less than 125 percent of the current rating of the power unit.

24.3.4 If the power unit is required to be grounded, the attachment plug shall be of the grounding type; otherwise the attachment plug shall be of the polarized parallel-blade type.

24.3.5 *Deleted*

24.3.6 A grounding type adapter shall not be provided with a power unit.

24.3.7 If a power unit is provided with a receptacle for connection of an external load, the supply cord shall be a minimum 12 AWG (3.3 mm^2). If the receptacle is accessible only to equipment within the enclosure, and is marked to identify a maximum current, the minimum size of the power unit's supply cord size shall be based on the lighting load plus the receptacle rating, as shown in Table 24.3:

Table 24.3
Ampacities of power supply cord

Receptacle + Lighting Load, Amperes	Minimum size of cord
10	18 AWG (0.82 mm^2)
13	16 AWG (1.3 mm^2)
18	14 AWG (2.1 mm^2)
25	12 AWG (3.3 mm^2)

24.3.8 The power supply cord shall comply with the Strain Relief Test in Section 38. The strain shall not be transmitted to the splices.

24.4 Output circuit connection provisions

24.4.1 A power unit marked for use indoors (see 50.12) or for indoor/outdoor use (see 50.14) shall be provided, for each output circuit, with a means for connecting a Class 1 wiring method and for connecting SPT-3 or equivalent main low voltage cable.

24.4.2 A power unit marked for outdoor use only (see 50.13) shall be provided, for each output circuit, with a means for connecting a Class 1 wiring method or for connecting SPT-3 or equivalent main low voltage cable.

24.4.3 Where conduit connection is intended as one of the output circuit Class 1 wiring methods, the provisions shall comply with the requirements of 24.2.

24.4.4 Provision for a main output circuit connection to a power unit shall consist of:

a) A minimum 6 inch (152 mm) length cord. See 53.3.1 for cord type and ampacity; or

b) A terminal block so constructed as to permit connection of such secondary wiring.

24.4.5 A terminal block shall comply with the Standard for Terminal Blocks, UL 1059, and shall be suitable for field wiring use.

24.4.6 When evaluating terminal blocks used for field wiring, considerations shall be given to:

a) Temperatures reached on the terminals and terminal block;

b) Conductor size and type; and

c) Number of conductors used in the application.

24.4.7 When using a terminal block, a marking in accordance with 50.22 shall be provided.

24.4.8 Any connectors provided for connecting the main low voltage cable conductors to the minimum 6 inch length of cord or leads shall be nonferrous or the equivalent. The connection means shall be mechanically secured to the 6 inch length of cord or leads. Where crimp-type connectors are provided, they shall be insulated and not require a special tool to crimp. Wire nuts (splicing wire connectors) shall not be used outside of the power unit enclosure unless provided with corrosion protection such as potting compound and rated for outdoor use.

24.4.9 Means shall be provided to prevent the inadvertent shorting of lead connections to each other and to other uninsulated conductive parts.

24.5 ***Deleted***

25 Grounding and Bonding

25.1 Grounding

25.1.1 All conductive parts of a power unit not intended to be electrically live, that are accessible to persons and that have the potential to inadvertently become energized, shall be grounded by being conductively bonded to a common point that incorporates provision for grounding of the power unit.

Exception: The power unit is not required to be grounded when it is double insulated in accordance with the Reference Standard for Double Insulation Systems for Use in Electronic Equipment, UL 2097, or the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097. The value used for the Leakage Current Test is 0.5 mA. The Overload Test described in Section 29 shall be used rather than the test described in UL 2097.

25.1.2 A conductive part that is required to be grounded in accordance with 25.1.1, and that is coated with vitreous enamel, paint, or similar coatings, is required to be bonded. Some bonding means require treatment of the part, such as masking, removal of the coating at points of connection, or the use of fastening means that penetrate the surface coating. If special treatment is necessary or if ground continuity is not obvious, the requirement described in 25.1.14 shall be applied.

25.1.3 The continuity of the grounding system shall not rely on the dimensional integrity of a polymeric material.

Exception: This requirement does not apply to material investigated and found to comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

25.1.4 The grounding terminal of a convenience receptacle provided in a metal enclosure shall be conductively connected to the enclosure, and there shall be provision for the connection of a grounding conductor to the combination by one of the following:

a) Riveting, bolting, or welding the metal mounting yoke or strap (if provided) of the receptacle to the metal enclosure.

b) A 16 AWG (1.3 mm^2) or larger copper bonding jumper from the receptacle grounding terminal to the enclosure, the connection to the enclosure being made by riveting, bolting, or welding.

25.1.5 A grounding means shall consist of a lead grounding conductor lead, a pressure terminal connector, a wire binding screw, the grounding contact of a receptacle, the grounding pin of an attachment plug, or the equivalent. The grounding means shall be at the same location as the power supply connection means.

25.1.6 An equipment grounding conductor shall not be smaller in size than the current carrying supply conductor and in no case shall it be smaller than 18 AWG (0.82 mm^2). When insulated, the equipment grounding conductor, where visible to the installer, shall have a braid of continuous green color with or without a yellow tracer or, when no braid is employed, the insulation on the conductor shall be green with or without one or more yellow stripes. A conductor having green insulation and a braid of other than green is able to be used when the green insulation is readily visible where connections to the branch-circuit supply wires will be made.

25.1.7 An equipment grounding conductor shall not be terminated to another device or part that is removable during replacement of any device or component.

25.1.8 The cord of a cord-connected power unit provided with a metal enclosure or a metal shield shall contain an equipment grounding conductor complying with 25.1.6 and 25.1.7.

25.1.9 A wire binding screw intended for the field connection of an equipment grounding conductor shall have a green colored head that is hexagonal shaped, slotted, or both.

25.1.10 A wire binding screw, described in 25.1.9 shall be No. 8 [4.2 mm (major diameter)] or larger and shall be provided with a cupped washer or similar means to hold the wire under the head of the screw. A sheet metal screw does not meet the intent of the requirement.

Exception: A cupped washer need not be provided if the terminal plate is provided with two raised areas around the tapped hole that are at least 1/4 inch (6.4 mm) apart.

25.1.11 A pressure wire terminal intended for the field connection of an equipment grounding conductor shall be plainly identified by being marked in accordance with 50.7.

25.1.12 A terminal plate having a tapped hole for a wire binding screw shall be of metal no less than 0.030 inch (0.76 mm) in thickness and shall have no fewer than two full threads in the metal.

Exception: A tapped hole for a screw having 32 or more threads per inch is to have the metal extruded at the screw hole to provide two full threads.

25.1.13 To verify that a wire binding screw threads into metal a minimum of two full threads in accordance with 25.1.12, multiply the metal thickness in inches by the screw pitch. For example:

$$\frac{Metal\ \ thickness}{0.065\ \ inch} \times \frac{pitch}{32\ \ threads/inch} \times \frac{threads}{2.08\ \ threads}$$

25.1.14 All parts required to be grounded shall be conductively connected to the ground termination point such that the resistance between any two points is 0.1 ohm or less as determined in Grounding Continuity Test, Section 34.

25.2 Bonding

25.2.1 A part that:

a) Is required to be grounded;

b) Is able to be removed from the remainder of the power unit during normal use, including adjusting a timer; and

c) Supports a current carrying component

shall be provided with a copper 18 AWG (0.82 mm^2) or larger stranded bonding jumper from the part to grounded metal of the remainder of the power unit.

Exception: The bonding jumper need not be provided for a part that is provided with a disconnect so that during removal and replacement of the part, bonding is broken simultaneous with or after electrical contact is broken, and bonding is regained simultaneous with or before electrical contact is regained.

25.2.2 A bonding wire or jumper connector shall be secured by:

a) A machine screw and nut;

b) A machine screw that threads into metal where the metal provides at least two full threads; or

c) A rivet.

A sheet metal or self-threading screw does not meet the intent of the requirements for this use unless threads are not stripped when the screw is tightened with a torque of 30 pound-force inches (3.39 N·m) and the resistance between any two points is 0.1 ohm or less as determined in Grounding Continuity Test, Section 34.

25.2.3 A bonding wire or jump connector shall not be terminated by a screw, rivet, or equivalent device that is also used to secure another device, part, or similar object.

26 Water Shields

26.1 A non-metallic portion of the power unit enclosure that acts only to shield water, such as a door to a timer, shall comply with the requirements in 26.2 and 26.3.

26.2 A non-metallic material shall have a minimum flame rating of HB and comply with the Exposure to Ultraviolet Light Test in the Standard for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C.

26.3 The water shield shall be subjected to the Impact Conditioning, 37.2.1, except the impact energy shall be 3 ft-lb (4.1 N·m).

PERFORMANCE

27 Test Parameters

27.1 The test voltages used for the following tests shall be as specified in Table 27.1.

Table 27.1
Test voltages

Voltage rating[a]	Test voltage
110 – 125	120
220 – 240	240
254 – 277	277
440 – 480	480
560 – 600	600

[a] Other voltages not shown in these ranges shall be tested at the marked rating.

27.2 Branch circuit wiring supplying equipment under test shall be protected with a 20 ampere circuit breaker or fuse.

27.3 Where a test indicates a load or a resistive load, the load is to be a lamp load, a resistive load, or a combination of the two.

27.4 Cheesecloth used in any of the tests of this section shall be untreated cotton cloth running approximately 0.11 oz/ft^2 (34 g/m^2), with a thread count in the range of 25 – 33 × 22 – 30 threads/in (10 – 13 × 9 – 12 threads/cm).

28 Input and Output Tests

28.1 Input test

28.1.1 While connected to the rated output wattage and to the rated primary voltage, the measured input current of the power unit shall not exceed rated input by more than 10 percent. The current measurement shall be made when the power unit is in the heated condition.

28.2 Maximum output test

28.2.1 With the power unit connected to rated input voltage, the measured open circuit output voltage shall not exceed the values specified in Table 2A.1.

28.2.2 A load is to be connected to each output circuit of the power unit and adjusted to result in the power unit delivering rated output wattage to each output circuit. The unit is to operate until constant temperatures are achieved. The load on one of the output circuits is to be adjusted to the maximum it can sustain up to 33.75 A (135 percent of 25 amps). The load on any other output circuit shall be adjusted to either no load, rated load, or both, in order to test the worst case condition. If more than 25 A can be sustained, the protective device required by 20.1 shall operate within 1 hour. Each output circuit shall be tested in the same manner.

29 Overload Test

29.1 A power unit shall comply with the overload test described in this section.

29.2 The power unit is to be mounted in accordance with the manufacturer's instructions. A single layer of cheesecloth is to be placed around the power unit. The rated load plus 15 percent of the rated secondary wattage is to be connected to the unit. If a 15% overload cannot be sustained, the highest stable overload condition shall be the starting point for the test. For a unit with multiple output connections, the total load (including each 15% increase, if required by Figure 29.1) shall be balanced, to the extent practical, between the outputs.

29.3 The power unit is to be operated according to the procedure shown in Figure 29.1.

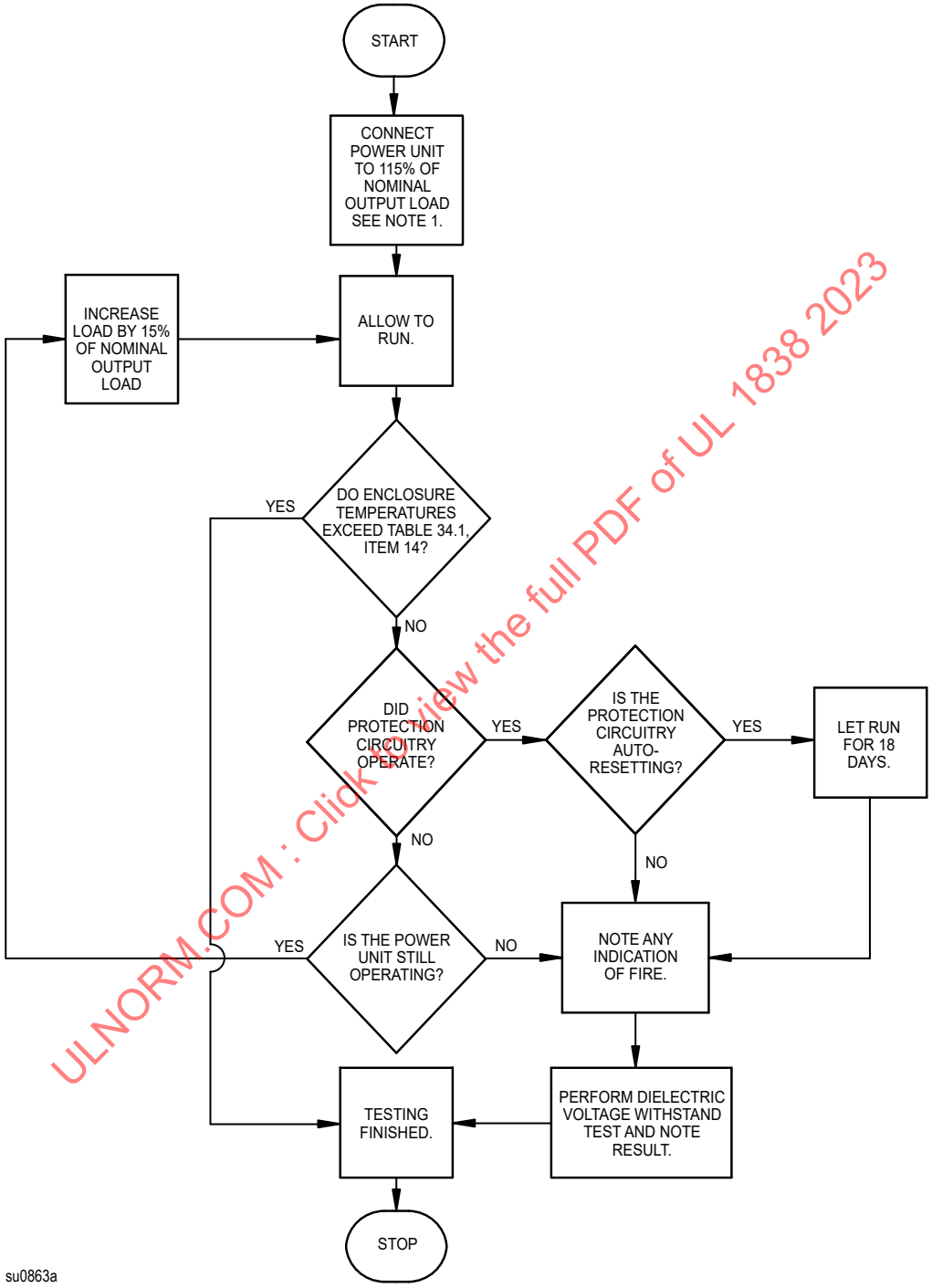
29.4 There shall be no ignition of the cheesecloth, the unit shall comply with the Dielectric Voltage Withstand Test specified in Section 32 and the outside of the enclosure that contacts combustible materials shall comply with Table 33.1.

Exception: A recessed power unit shall not exceed 160°C (320°F) on the enclosure if the protector operates within 3 h, or 90°C (194°F) after 3 h of operation.

29.5 *Deleted*

Figure 29.1

Overload test flow chart



Note – Refer to 29.2

30 Burnout Test

Section 30 deleted

31 Endurance Test

Section 31 deleted

32 Dielectric Voltage Withstand Test

32.1 The power unit shall successfully withstand without electrical breakdown for a period of 1 minute a voltage of 1000 volts plus twice the rated voltage between the primary winding and exposed grounded dead metal of the enclosure, and between the primary and secondary windings. If the power unit incorporates double insulation, the test voltage shall be 2 × (1000 Volts + 2V) where V is the rated voltage.

NOTE: Surge protective devices bridging the circuit locations under test may be removed for this test.

32.2 The test equipment shall include a transformer having sinusoidal output, a means of indicating the test potential, and an audible or visible indication of breakdown. The current trip level of the equipment shall be 5 mA.

32.3 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

32.4 If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential is to be identified by a voltmeter in the primary circuit or in a tertiary winding circuit, by a selector switch marked to indicate the test potential, by a marking in a readily visible location to indicate the test potential of equipment having a single test potential output. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as a power-on lamp to indicate that the manually reset switch has been reset following a trip-out.

32.5 During the test, any switch is to be in the on position, both sides of the primary circuit of the unit are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

33 Temperature Test

33.1 A power unit shall be tested as specified in this section with the output circuits loaded with a resistive load corresponding to the nominal rated output power as specified by the manufacturer. The power unit shall not attain a temperature at any point sufficiently high to present the risk of fire, to damage any materials employed in the system or unit, or to exhibit higher temperatures at specific points than indicated in Table 33.1. The following conditions shall apply during the temperature test:

a) Unless marked for use with a specific dimmer control or unless marked “Not for use with a dimmer,” a power unit shall be tested with a 2-volt dc offset as described in 33.10.

b) If marked for use with a specific dimmer control, a power unit shall be tested with the control adjusted to result in maximum temperature.

c) If marked "Not for use with a dimmer," that test shall not be conducted with a 2-V dc offset nor with a dimmer.

Exception: If the power unit is marked in accordance with 50.18 to indicate the specific lamps that are to be used with the power unit, the test load shall consist of the minimum length of cord as specified by the instructions and the number of lamps determined by dividing the rated secondary wattage by the lamp

wattage. The cord size shall be one size larger than required for the rated load. If more than one type of lamp is specified then the lamp that will be the higher load shall be used.

Table 33.1
Maximum acceptable temperature

	Component location	°C	°F
1.	Any point in power unit field wiring compartment	a	a
2.	Coil of open coil type device employing Class 105 insulation system:		
	Thermocouple method	90	194
	Change of resistance method	100	212
3.	Coil of device employing Class 130 insulation systems:		
	Thermocouple method	110	230
	Resistance method	120	248
4.	Class 155 insulation systems:		
	Thermocouple method	135	275
	Resistance method	140	284
5.	Class 180 insulation systems:		
	Thermocouple method	150	302
	Resistance method	165	329
6.	Class 200 insulation systems:		
	Thermocouple method	170	338
	Resistance method	185	365
7.	Class 220 insulation systems:		
	Thermocouple method	185	365
	Resistance method	200	392
8.	Class 250 insulation systems:		
	Thermocouple method	215	419
	Resistance method	230	446
9.	Varnished cloth insulation[b]	85	185
10.	Fuse Body	90	194
11.	Fiber employed as electrical insulation[b]	90	194
12.	Wood	90	194
13.	Copper conductor (bare or insulated) without a nickel coating or equivalent protection	150	302
14.	Termination of copper conductor and pressure terminal connectors without a nickel coating or equivalent protection	150	302
15.	Polymeric material used for enclosure or structural parts	c	c
16.	Surface to which a marking label is attached	d	d
17.	Wire or cord	e	e
18.	Points of support on external surfaces	90[g]	194[g]
19.	On gaskets	f	f
20.	On any point of an exposed surface of a luminaire (except lens):		
	Indoor	90	194
	Outdoor	150	302

Table 33.1 Continued on Next Page

Table 33.1 Continued

Component location	°C	°F
[a] Any temperature up to 90°C (194°F) meets the intent of the requirements consistent with the marking on the power unit as specified in 50.5.		
[b] These limitations do not apply to compounds or components that have been investigated and found to meet the intent of the requirements for a higher temperature.		
[c] The investigation of a polymeric material shall comply with the requirements in Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.		
[d] The maximum temperature, when corrected to a 25°C (77°F) ambient temperature, is the temperature rating of a label that is specified in Table 50.1.		
[e] The maximum temperature, when corrected to a 25°C (77°F) ambient temperature, is the temperature rating of the wire or cord used as specified in Wiring and Conductors, Section 19.		
[f] The maximum temperature of the material meets the intent of the requirements if the material complies with 37.7.1.		
[g] The maximum temperature rise is 125°C (225°F) when the power unit or luminaire is marked for installation in or on non-combustible materials only.		

33.2 The values for temperature in Table 33.1 are based on an assumed ambient temperature of 25°C (77°F), and tests are to be conducted at an ambient temperature of 25 ±5°C (77 ±9°F). Ambient temperature variations above or below 25°C shall be respectively subtracted from or added to temperatures recorded at points on the luminaire. The ambient temperature is to be measured by means of a thermocouple immersed in a bath of mineral oil in a glass container, or other means equivalently immune to air turbulence or convection currents.

Exception: The test is able to be conducted at a higher ambient temperature if agreeable to all concerned.

33.3 Temperature readings to determine compliance with Table 33.1 are to be obtained by thermocouples or change-of-resistance for coils or windings. A temperature is determined to be constant when:

a) The test has been running for a minimum of 7.5 hours; or

b) The test has been running for a minimum of 3 hours; and

c) Three successive readings taken at 15 minute intervals are within 1°C (1.8°F) of one another and are not rising.

33.4 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). It is standard procedure to employ thermocouples consisting of 30 AWG iron and constantan wires and a potentiometer-type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouple wires are to conform with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

33.5 A thermocouple junction and the adjacent thermocouple lead wire are to be held securely in good thermal contact with the surface of the material of which the temperature is being measured, and are to be placed at locations of the hottest accessible parts.

33.6 Conditions for the performance of temperature tests for a system are to be as indicated in 33.7 – 33.12.

33.7 A power unit provided with more than one opening intended for supply connection shall comply with the point of connection of supply wire temperature limits specified in Table 33.1 at each opening. The unit marking specified in 50.5 shall be based on the highest temperature recorded at all openings on the unit available for possible supply connection.

33.8 If a system utilizes a polymeric part required by this standard (such as a thermoplastic enclosure, watershield, lens, diffuser, or similar part), temperatures are to be measured by placing one or more thermocouples in contact with the part in such a manner that the thermocouple is wedged between the part and any metallic material or other source of conducted heat. For a source of radiated or convected heat, thermocouples are to be inserted from the outside surface through holes drilled in the polymeric material, such that the thermocouple tips are located in the plane of the inside surface and are sealed in place.

33.9 The temperature measured on any component (timer, switch, and similar component) shall not exceed that component's temperature rating.

33.10 In accordance with 33.1(a), a power unit not marked for use with a specific dimmer or not marked "Not for use with a dimmer" shall be tested with a 2-volt dc offset potential applied to the power unit input voltage. The 2-volt dc offset potential is able to be obtained by using any suitable means. The 2-volt dc bias is measured on the switched ac output waveform by a dc volt meter having a frequency damped response in the range of 0 – 120 hertz.

33.11 The Change of Resistance Method is to be performed by:

a) Turning the power off to the unit;

b) Measuring the resistance of the coils in 5 second intervals;

c) Taking a minimum of six readings;

d) Either using a graphical method or linear regression. The resistance shall be calculated at the time the circuit is opened.

e) Using the following equation, the temperature of the windings shall be calculated:

$$dT(temperature\ rise) = \frac{R_H}{R_C}[k + T_C] - [k + T_H]$$

in which:

dT is the temperature of the coil in degrees C at the end of the test;

R_H is the resistance of the coil at the end of the test;

R_C is the resistance of the coil at the beginning of the test;

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant for other grades must be determined;

T_C is the room temperature of the coil in degrees C at the beginning of the test when R_C is measured;

T_H is the room temperature of the coil in degrees C when the power is turned off and the resistance measurement begins.

33.12 A power unit intended for use only in-ground is to be buried in 30 mesh dry builders sand. The sand is to surround the power unit on all sides by at least 8 inches (203 mm).

33.13 During the Temperature Test, no protective device provided shall operate.

34 Grounding Continuity Test

34.1 To determine compliance with 25.1.14 or 25.2.2, each design provided with a grounding means is to be tested for grounding continuity between the grounding means and the accessible dead metal that is required to be grounded.

34.2 Any indicating instrument is able to be used, but if the results obtained do not meet the requirements, either an alternating or direct current of at least 25 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit, and the resulting drop in voltage is to be measured between the two points. The resistance in ohms is then to then be calculated by dividing the drop in potential (in volts) by the current (in amperes). The results meet the intent of the requirement if the resistance does not exceed 0.1 ohm.

35 Leakage Current Test

35.1 Cord connected and direct plug-in electronic power units shall be subjected to the test described in this section. The leakage current shall not exceed 0.5 milliampere.

35.2 Leakage current refers to all currents, including capacitively coupled currents, that are conveyed between exposed conductive surfaces of the power unit and ground or other exposed surfaces of the power unit.

35.2.1 The electronic power unit sample is to be heated in an air-circulating oven to a temperature just above 34°C (93°F) to reduce the risk of condensation of moisture during conditioning. The heated sample is to be placed in a humidity chamber maintained at 88 ±5 percent relative humidity at a temperature of 32 ±2°C (90 ±4°F) for 48 hours. Following the conditioning, the sample is to be tested unenergized as described in 35.7(a). The sample is then to be energized and tested as described in 35.7 (b) and (c). The test to be discontinued when the leakage current stabilizes or decreases.

35.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively when simultaneously accessible, and from one surface to another when simultaneously accessible. Parts are determined to be exposed surfaces unless guarded by an enclosure determined to reduce the risk of electric shock as defined in 2.16. Surfaces are determined to be simultaneously accessible when they able to be contacted by one or both hands of a person at the same time. These measurements do not apply to output terminals operating at voltages less than 15 volts (21.2 volts peak). When all accessible surfaces are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current is able to be measured between the grounding conductor and the grounded supply conductor.

35.4 When a conductive surface other than metal is used for the enclosure or a part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters in contact with the surface. When the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the power unit.

35.5 The circuit for the leakage current measurement is to be as illustrated in Figure 35.1. The measurement instrument is defined in 35.5 (a) – (c). The meter that is actually used for a measurement is only required to indicate the same numerical value for a particular measurement as the defined instrument. The meter used is not required to have all the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

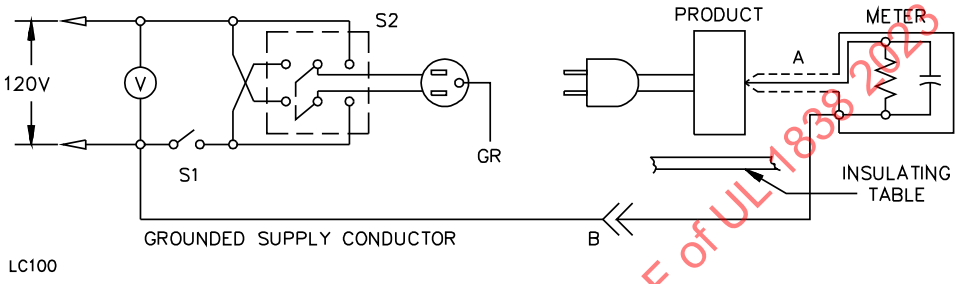
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuit is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is not to have an error of more than 5 percent at 60 hertz.

35.6 Unless the meter is being used to measure leakage from one part of a power unit to another, the meter is to be connected between an accessible part and the grounded supply conductor.

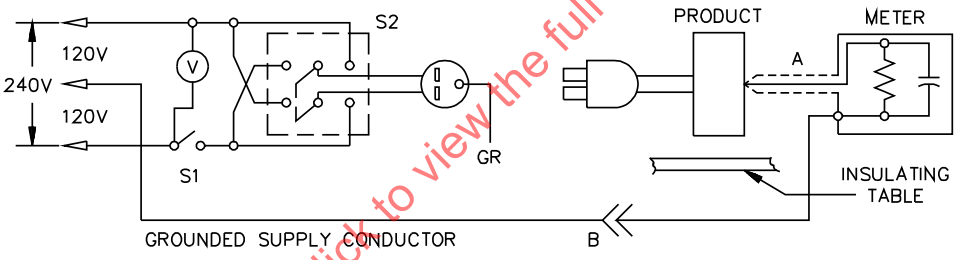
Figure 35.1

Leakage current measurement circuit



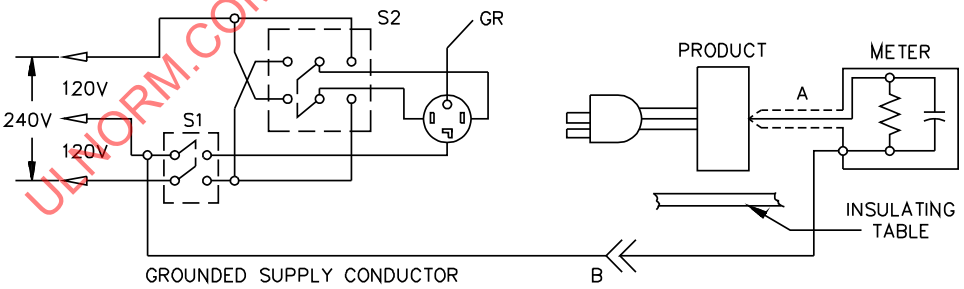
LC100

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



LC200

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



LC300

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

NOTE:

a) Probe with shielded lead.

b) Separated and used as clip with measuring currents from one part of device to another.

35.7 A sample of the electronic power unit is to be tested for leakage current starting with the as-received condition – the as-received condition is without prior energization except as occurs as part of the production-line testing and with the grounding conductor, when provided, open at the attachment plug. The supply voltage is to be adjusted to the test voltage specified in Table 27.1. The test sequence, with reference to the measuring circuit, Figure 35.1, is to be as follows:

a) With switch S1 open, the power unit is to be without load and connected to the measuring circuit. The leakage current is to be measured using both positions of switch S2 and with the power unit switching devices, when provided, in all their operating positions.

b) Switch S1 is then to be closed, energizing the power unit, and within 5 seconds the leakage current is to be measured using both positions of switch S2, and with the power unit switching devices, when provided, in all their operating positions.

c) The leakage current is to be monitored until thermal stabilization occurs. Both positions of switch S2 are to be used in making this measurement. Thermal stabilization is determined to be obtained by operation as in the rated output heating test.

35.8 Normally the complete leakage current test program as described in 35.7 is to be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current tests are interruptible to conduct other nondestructive tests.

36 Leakage Current Test Following Humidity Conditioning

Section 36 deleted

37 Weather Tests

37.1 General

37.1.1 A power unit shall be subjected to a sprinkler test described in 37.5; and a rain test described in 37.9.

Exception No. 1: A power unit marked for indoor use only need not be subjected to a sprinkler test and rain test.

Exception No. 2: The sprinkler test and rain test is not required if the construction features of the unit are such that it is readily apparent water will not enter it when it is used in the intended manner.

37.1.2 A power unit which is intended to be mounted within 1 foot (0.305 m) of the ground or below grade level shall be subjected to the immersion test described in 37.6.1.

Exception: A power unit marked for indoor use only need not be subjected to the immersion test.

37.2 Impact conditioning

37.2.1 Before being subject to the sprinkler test, rain test, or immersion test, a power unit having a nonmetallic enclosure shall be subjected to the applicable impact tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

37.3 General – test conditions

37.3.1 Before a sprinkler, rain, or immersion test is conducted, an enclosure containing an opening for supply connections is to be fitted with the intended supply connection means.

37.3.2 A power unit shall be subjected to a sprinkler test and a rain test in accordance with the requirements in 37.5.1 and 37.5.2 and to a rain test in accordance with 37.9. The test is to be conducted in accordance with Table 37.1. The unit shall be loaded to its maximum output rating when designated “on” in Table 37.1.

Table 37.1
Operating sequence

Duration in hours	Unit	Water
1	on	off
1/2	off	on
2	on	on
1/2	off	on

37.3.3 Any doors are to be left opened, unless provided with the means such as a spring or gravity to automatically shut the door or unless the door is attached in such a manner as to be opened only by the use of tools.

Exception: The door is not required to be left open during the test when marked in accordance with 50.21.

37.3.4 A power unit provided with a receptacle shall withstand the Rain Test of 37.9.1 and the Sprinkler Test of 37.5.1 and 37.5.2 with the cover open, closed, with and without an attachment plug in place.

37.3.5 A gasketed power unit shall be tested after the temperature test, followed by removal and replacement of rings, frames, or other replaceable parts serving to compress the gasket.

37.4 General – test results

37.4.1 Test results meet the intent of the requirements if, after the impact conditioning (if applicable) and the sprinkler, rain, or immersion tests, no water has entered the unit.

Exception: Water is able to enter if the water does not cause wetting of any primary wiring, or other electrical parts that are not inherently waterproof and if the unit is provided with a drain hole as required in 12.1.

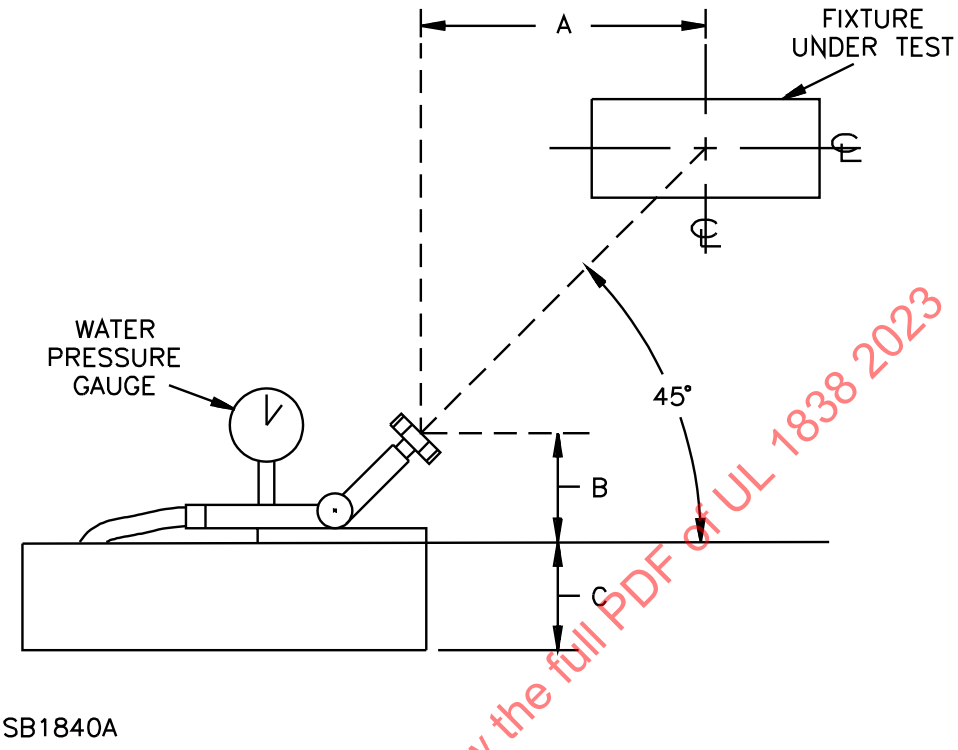
37.5 Sprinkler test

37.5.1 A power unit is to be mounted with adjustable parts arranged for maximum vulnerability to the water spray.

37.5.2 The power unit is to be positioned as shown in Figure 37.1 in front of a standard water spray head of the type shown in Figure 37.2, to which the water pressure is maintained at a gage pressure of 20 pounds per square inch (137.9 kPa).

Figure 37.1

Representative sprinkler test setup



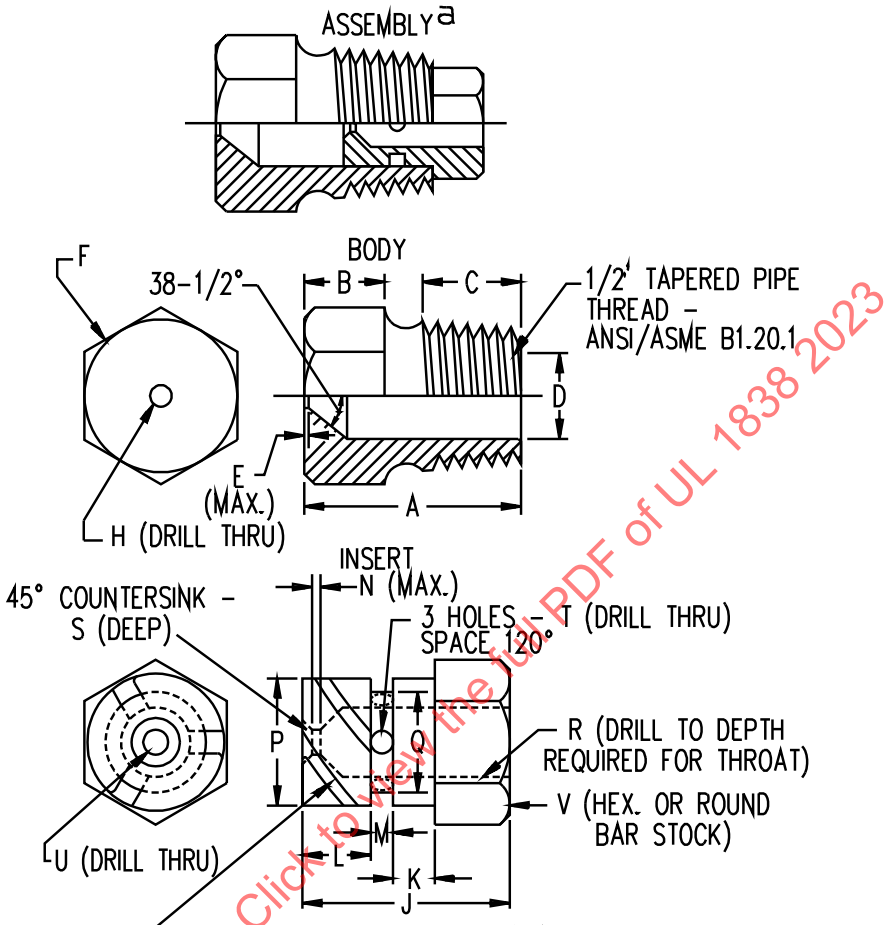
A – 36 inches (914 mm).

B – 3 – 6 inches (76.2 – 152 mm).

C – Height necessary for the unit to be mounted as intended with the dimensional center of the unit on a line projected from the center line of the nozzle head.

Figure 37.2

Spray head



Item	mm	inch	Item	mm	inch
A	31.0	1-7/32	N	0.80	1/32
B	11.0	7/16	P	14.61	.575
C	14.0	9/16		14.63	.576
D	14.68	.578	Q	11.51	.453
	14.73	.580		11.53	.454
E	0.40	1/64	R	6.35	1/4
F	c	c	S	0.80	1/32
G	1.52	.06	T	2.80	(No. 35) [b]
H	5.0	(No.9) [b]	U	2.50	(No. 40) [b]
J	18.3	23/32	V	16.0	5/8
K	3.97	5/32	W	1.52	0.06
L	6.35	1/4			
M	2.38	3/32			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

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37.6 Immersion test

37.6.1 A power unit as described in 37.1.2 shall be subjected to the immersion test in accordance with Table 37.2, with or without an auxiliary well form and mounted face-up, with the screws that attach the face torqued to the manufacturer's specified values.

Table 37.2
Immersion test operating sequence

Test duration in hours	Test period in hours	Lamp	Location
0 to 3.5	3.5	On	Dry
3.5 to 7.5	4.0	Off	Submerged
7.5 to 24.0	16.5	Off	Dry
24.0 to 27.5	3.5	On	Dry
27.5 to 31.5	4.0	Off	Submerged
31.5 to 48.0	16.5	Off	Dry
48.0 to 51.5	3.5	On	Dry
51.5 to 55.5	4.0	Off	Submerged

37.6.2 The power unit shall be conditioned by being operated in a dry location at room temperature for 3.5 hours.

37.6.3 The power unit shall be de-energized and immediately submerged under at least 12 in (300 mm) of water. The temperature of the water before submersion shall be 41°F (5°C) or lower. The power unit shall remain under water for at least 4 hours and then be removed from the water.

37.6.4 The procedure of 37.6.2 and 37.6.3 shall be conducted three times. Before the second sequence and the third sequence, the power unit shall be conditioned by placing it in a dry location at room temperature for no less than 16.5 hours.

37.6.5 Following the third sequence, the power unit shall be removed from the water and subjected to the Dielectric Voltage-Withstand Test of Section 32. There shall be no dielectric breakdown, and no water shall have entered the power unit.

37.7 Gasket tests

37.7.1 A gasket or bushing employed to comply with the weather test requirements shall, after conditioning for 168 hours in a circulating air oven at a temperature 20°C (36°F) above the temperature measured on the gasket or bushing during the temperature test, have a tensile strength and elongation of not less than 60 percent of the values determined before conditioning.

Exception: This test need not be conducted if a gasket or bushing is tested while installed in the unit as described in 37.7.2.

37.7.2 As an alternative to the test described in 37.7.1, a gasket or bushing shall be tested as follows. With the gasket(s) or bushing(s) in place, the power unit is to be conditioned in a circulating air oven for 240 hours at 20°C (36°F) above the temperature measured on the gasket(s) or bushing(s) during the Temperature Test described in Section 33. After the conditioning, any panels which depend on the gasket or bushing for sealing are to be opened. The results meet the intent of the requirement if a visual inspection shows no damage to the gasket and the gasket has remained in place. The power unit panels are then to be closed and the unit subjected to the applicable weather test.

37.7.3 In regard to 37.7.2, if the power unit is provided with more than one gasket and if the temperature rise measured on the gasket material during the temperature test is not the same for all gaskets, then the test described in 37.7.2 is able to be conducted at the accelerated aging condition corresponding to the highest temperature rise for the gaskets. Otherwise, a separate power unit will need to be tested at each measured temperature rise on the gaskets.

37.8 Gasket adhesion test

37.8.1 In accordance with 14.3, a gasket secured by an adhesive shall be tested as follows. Three gasket assemblies shall be used to determine the average initial force required to remove the gasket from its mounting surface. The force shall be applied to the edge of the gasket in a plane perpendicular to the surface on which the gasket is mounted. Two additional sets of three gasket assembly samples shall be conditioned as described in 37.7.1. The force required to remove the gaskets from the mounting surface is to be measured within 1/2 hour after completion of the conditioning for one set of samples, and 24 hours after the conditioning for the other set of samples. The average force to remove the gaskets from their mounting surface for each conditioned sample set shall be at least 60 percent of the average value measured of the unconditioned sample set.

37.9 Rain test

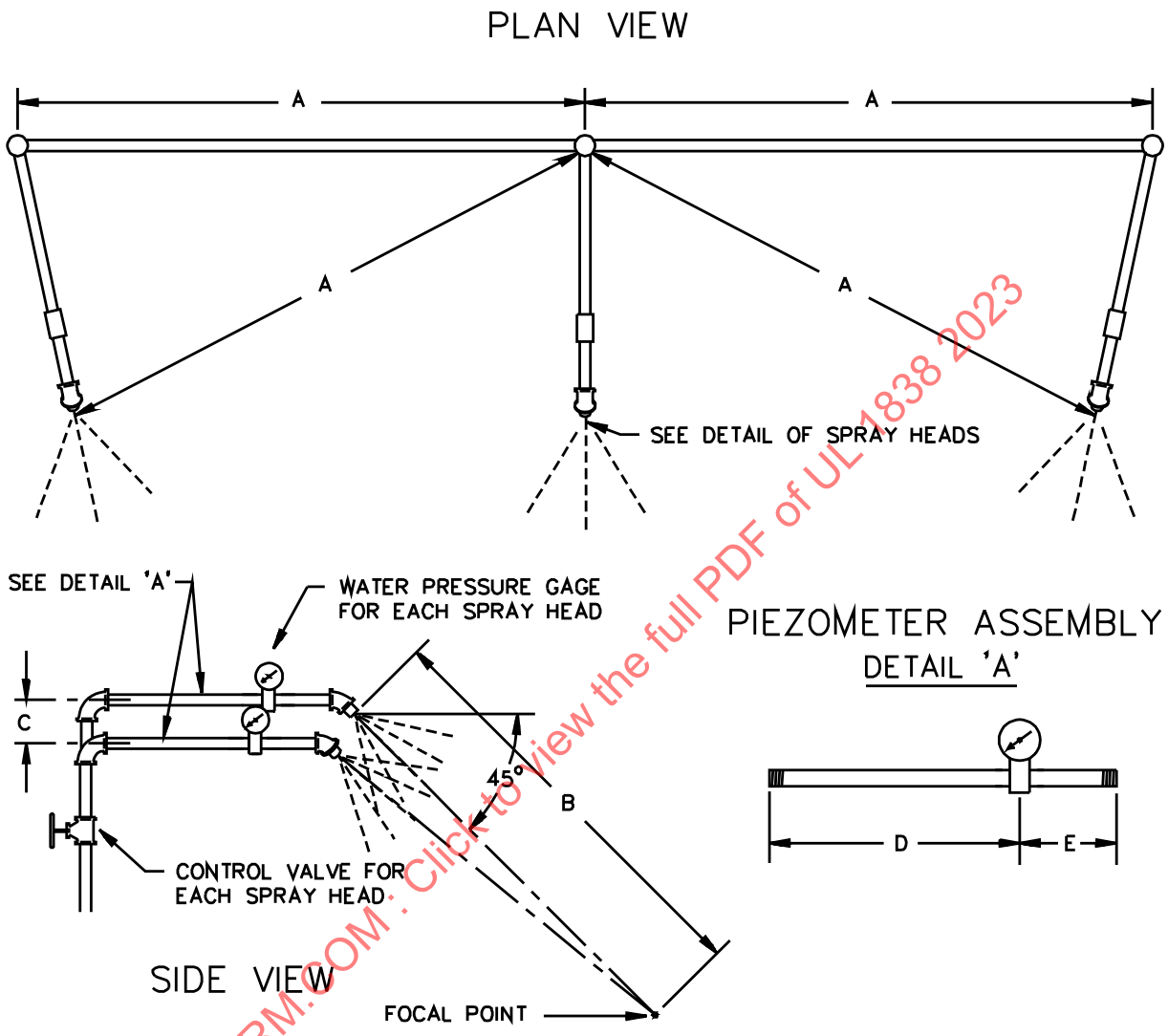
37.9.1 A power unit required to be subjected to a rain test in accordance with 37.1.1 shall comply with the requirements in 37.9.2.

37.9.2 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 37.3. Spray heads are to be constructed in accordance with the details shown in Figure 37.2. The power unit is to be set up as in a normal installation with conduit – without pipe compound – if so intended. The enclosure is to be positioned in the focal area of the spray heads so that the greatest quantity of water enters the enclosure. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each spray head.

37.9.3 *Deleted*

Figure 37.3

Rain test apparatus



Item	mm	inch
A	710	28
B	1400	55
C	55	2–1/4
D	230	9
E	75	3

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38 Strain Relief Test

38.1 A strain relief device is to be tested by the application of a 35 pound (156 N) pulling force on the cord for 1 minute. The result meets the intent of the requirements if the pull is not transmitted to terminals, splices, or internal wiring.

38.2 In testing in accordance with 38.1, the conductors are to be severed immediately adjacent to the terminals or splices. The pull is to be applied to the cord or wire in a direction perpendicular to the plane of the entrance to the unit. Movement of the cord of more than 1/16 inch (1.6 mm) at the point where it is severed does not meet the intent of the requirement.

39 Screw Torque Test

39.1 To determine compliance with 7.1, self-threading or sheet metal screws shall be tightened with a torque of 30 pound force inches (3.39 N·m) and the part, supported by the screw is then subjected to a force equal to four times the weight of the part applied in a direction coincident with the axis of the screw.

40 Polymeric Enclosure Conduit Connection Tests

40.1 General

40.1.1 A polymeric enclosure intended for connection to a rigid metallic conduit system shall not pull apart or sustain damage such as cracking and breaking as a result of the pullout, torque, and bending procedures described in 40.2 – 40.4. If knockouts are incorporated in the enclosure, they shall remain in place as a result of the procedure described in Tests on Knockouts, Section 41.

Exception: The torque test need not be conducted on an enclosure that is not provided with a preassembled hub if instructions are provided that state that the hub is to be connected to the conduit before the hub is connected to the enclosure.

40.2 Pullout

40.2.1 The enclosure is to be suspended by a length of a rigid conduit installed in one wall of the enclosure or mounted as intended in service and a pulling force of 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit installed in the opposite wall.

40.3 Torque

40.3.1 The enclosure is to be securely mounted as intended in service. A torque in accordance with Table 40.1 is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

Exception: An end-of-line enclosure – an enclosure that is intended to be connected at the end of a run of conduit and has only one 3/4-inch maximum trade size opening for the connection of conduit – need only be subjected to a tightening torque of 200 pound-inches (22.6 N·m).

Table 40.1
Tightening torque

Trade size of conduit hub, inches	Tightening torque, pound-inches (N·m)	
3/4 and smaller	800	(90.4)
1, 1-1/4, and 1-1/2	1000	(113)
2 and larger	1600	(181)

40.4 Bending

40.4.1 A length of conduit at least 1 foot (305 mm) long of the intended size is to be installed:

a) In the center of the largest unreinforced surface; or

b) In a hub or an opening if provided as part of the enclosure.

The enclosure is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. A weight is to be suspended from the end of the conduit to produce the bending moment specified in Table 40.2. The magnitude of the weight is to be determined from the equation:

$$W = \frac{M - 0.5CL}{L}$$

in which:

W is the weight, in pounds, to be hung at the end of the conduit;

L is the length of the conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended;

C is the weight of the conduit, in pounds; and

M is the bending moment required, in pound-inches.

40.4.2 For the SI system of units, the equation is:

$$W = \frac{0.1M - 4.9CL}{L}$$

in which:

W and C are measured in kilograms;

M is in newton-meters; and

L is in meters.

Table 40.2
Bending moment

Normal mounting plane of enclosure surface[a]	Conduit size, inches	Bending moment pound-inches[b,c] (N·m)	
		Metallic conduit	
Horizontal	All	300	(33.9)
Vertical	1/2 – 3/4	300	(33.9)
	1 – up	600	(67.8)

[a] If the enclosure surface is installed in either a horizontal or a vertical plane, the vertical bending moment value is to be used.

[b] The test procedure is able to be terminated prior to attaining the values specified if the deflection of the conduit exceeds 10 inches (254 mm) for a 10 foot (3.05 m) length of conduit.

[c] For an end-of-line enclosure as defined in the Exception to 40.3.1, the bending moment is to be 150 pound-inches (17.0 N·m).

41 Tests on knockouts

41.1 A force of 10 lbs (4.5 kg) shall be applied to a knockout for 1 minute by means of a 1/4 in (6.4 mm) diameter mandrel with a flat end. The force is to be applied in a direction perpendicular to the plane of the knockout and at the point causing movement. The knockout shall remain in place and the clearance between the knockout and the opening shall be no more than 0.063 in (1.6 mm) measured after the force has been removed.

41.2 A knockout is also to be subjected to a force sufficient to remove the knockout applied at right angles by means of a mandrel with a 1/4-inch (6.4 mm) diameter flat end. The mandrel is to be applied at the point causing movement of the knockout. The test results meet the intent of the requirements if the knockout is removed and there is no distortion of the enclosure.

42 Impact Test on Units With Open Holes

42.1 As an alternative to the limitation on open holes specified in 11.3, a power unit shall be subjected to 5 foot-pound (6.8 J) impact on the surface that exceeds the open hole limitation. This impact is to be produced by dropping a steel sphere, 2 inches (51 mm) in diameter and weighing approximately 1.18 pounds (535 g), from a height of 51 inches (1.29 m). For surfaces other than the top, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum, dropping through a vertical distance of 51 inches to strike the surface.

42.2 The results meet the intent of the requirements if there is no reduction of spacings below the values specified in Electrical Spacings, Section 23 and if the articulate probe shown in Figure 11.1 does not contact uninsulated current carrying parts.

43 Component Fault Test

43.1 For power units with electronics there shall be no emission of flame or molten metal nor ignition of cheesecloth loosely placed over all openings or totally around open devices when capacitors, diodes, or other solid state components are short- or open-circuited.

Exception: The test is not required:

a) If circuit analysis indicates that no other component or portion of the circuit will be seriously overloaded as a result of the assumed open circuiting or short circuiting of another component.

b) For components in Class 2 circuits.

c) For components complying with requirements applicable to the component.

43.2 For electronic power units the Maximum Output Test of 28.2.1 shall be conducted at the conclusion of the test in 43.1.

43.3 After the test in 43.1, a Dielectric Voltage Withstand Test, Section 32, and a Leakage Current Test, Section 35, shall be conducted and shall be found to comply.

44 Short Circuit Test

44.1 The power unit is to be:

a) Placed on a soft pine board;

b) Covered with a single layer of cheesecloth;

c) Connected to a circuit of rated voltage that is protected by a 20-ampere branch circuit fuse; and

d) For a power unit with multiple output circuits, the output circuits not being subjected to the Short Circuit Test shall be loaded to the level that represents the worst case condition. If necessary to determine compliance, each output circuit shall be tested individually.

For grounded units, a 3-ampere nonrenewable, non-time-delay plug fuse is to be connected between the case and earth ground. The power unit is then to be operated with the output circuit short circuited at the power unit for a period of 7 hours. Any protective device provided with the transformer is to remain in the test circuit. When the circuit is opened by the protective device or by the branch circuit fuse, the test is to be terminated. Ungrounded, double insulated units shall be subject to the Dielectric Voltage Withstand Test, Section 32.

44.2 Results are considered compliant if the cheesecloth does not glow or flame, there is no emission of molten metal, the 3-ampere fuse does not open (for grounded units) and there is no dielectric breakdown (for ungrounded and double-insulated units).

45 Limited Short Circuit Test

45.1 *Deleted*

45.2 *Deleted*

MANUFACTURING AND PRODUCTION TESTS

46 Dielectric Voltage Withstand Test

Section 46 relocated to Appendix B

47 Polarity Test

Section 47 relocated to Appendix B

48 Continuity of Grounding Connection Test

Section 48 relocated to Appendix B

RATINGS

49 Details

49.1 A power unit shall be rated for input voltage, frequency, and current (or wattage). Each output circuit shall have a rated voltage (identified as ac or dc) and current (or wattage).

MARKING

50 Details

50.1 A required marking shall be legible, shall be one of the types designated by form letter in Table 50.1, and shall be in one of the locations designated by form numbers in Table 50.2. The wording, form letter, and form number shall be in accordance with specifications elsewhere in this standard for the particular case.

Table 50.1
Form designations for type of marking

Form letter of marking	Type
A	Permanent – Paint-stenciled, die-stamped, indelibly printed lettering[a], or indelibly printed pressure-sensitive label.[b]
B	Temporary – Pressure-sensitive label, decalcomania transfer, paper label, paint-ink or die-stamped lettering, or equivalent.
C	Instructions – Tie-on tag, stuffer sheet, carton marking, or equivalent.

[a] Indelibly printed lettering shall be applied by a stamping device (other than a rubber ink stamp) that results in consistent and even pressure applied to the printing process regardless of operator.

[b] Pressure-sensitive labels shall be rated for the type of surface to which it will be affixed and shall comply with the Standard for Marking and Labeling Systems, UL 969.

[c] Instructions are permitted to be abbreviated if they include a website reference or QR code where the full set of instructions can be accessed without need for password or registration.

Table 50.2
Form designations for location of marking

Form number of marking	Location
1	Visible after installation.
2	Visible during relamping.
3	Visible during installation.
4	On smallest unit packaging.

50.1.1 When the words of a particular marking are given within quotation marks in this standard, the actual wording must be used. Words within parentheses are optional.

50.1.2 The minimum letter height for markings in Table 50.1 shall be 1/8 inch (3.2 mm) unless specified otherwise.

Exception: For small products where 1/8 inch lettering does not physically fit, a minimum letter height of 1/16 inch (1.6 mm) is permitted, except the words "WARNING" or "CAUTION" shall be no less than 3/32 inch (2.4 mm) high.

50.2 A power unit shall be marked in Form A-1 with the manufacturer's name, the catalog or model number, the electrical ratings specified in 49.1, and the date or other dating period of manufacture not exceeding any three consecutive months.

Exception: The date of manufacture is able to be abbreviated or may be in a nationally recognized conventional code or in a code affirmed by the manufacturer, provided that the code:

a) Does not repeat in less than 10 years; and

b) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.

50.3 If a manufacturer produces or assembles one model at more than one factory, it shall have a distinctive marking, such as a code, by which it is identified as the product of a particular factory. The code of one factory is able to be the absence of a factory identification marking.

50.4 A power unit intended for installation less than 1 foot (0.3 m) aboveground, in the ground, or below grade level and that complies with the requirements of the immersion test shall be marked in Form A-1 with the following or equivalent wording: "Suitable for Ground Installation." The fixture shall be provided with installation instructions.

50.5 A permanently connected power unit shall be marked in Form A-3 " For supply connections use wire rated for at least ____°C (____°F)," in which the "(____°F)" is optional and the blank space is filled with the temperature rating of the wire based on the temperature measured in item 1 of Table 33.1.

Exception No. 1: If the temperature measured in Table 33.1 for a power unit is 90°C (194°F) or less, the marking is able to be in Form B-3.

Exception No. 2: If the temperature measured in Table 33.1 for a power unit is 60°C (140°F), the marking need not be provided.

Exception No. 3: If the power unit is provided with tap conductors, the unit is able to be marked in Form A-3 "For supply connections, use wire rated at least ____°C (if supply connections are made inside the unit) or 60°C (if supply connections are made at the ends of the tap conductors and are located at least 1 foot from the unit)." The blank is to be filled in with the temperature measured at the supply connection point inside the power unit during the temperature test.

50.6 The marking described in 50.5 shall also be provided in Form B on the carton or package in which the power unit is packed. The wording of the marking shall be a minimum 1/4 inch (6.4 mm) in height.

50.7 A unit having a pressure wire terminal for the connection of an equipment grounding conductor shall be marked, in Form B-1, adjacent to the terminal or screw "GROUND," "GRND," or "GND." The electrical symbol for grounding alone does not meet the intent of the requirement.

50.8 If a replaceable fuse is provided there shall be a marking located near the fuseholder that states "CAUTION" and the following or equivalent wording "Disconnect power before replacing fuse. Replace only with same type _____ A, _____ V fuse." The blanks are to be filled in with the applicable fuse ratings.

50.9 *Deleted*

50.10 A power unit provided with a convenience receptacle that is not a GFCI type (see 18.4) shall be marked in Form A-1 with the word " WARNING" and the following or equivalent wording "To reduce the risk of electric shock, install only on a circuit protected by a GFCI."

50.11 A power unit not temperature tested with a 2-volt dc offset or with a specific dimmer shall be marked in Form B-3 with either:

a) “Not for use with dimmers” or

b) “Dimmer, if used, must be a magnetic low-voltage dimmer” if the power unit is magnetic, or “Dimmer, if used, must be an electronic low-voltage dimmer” if the power unit is electronic.

Equivalent wording shall be permitted.

50.12 A power unit evaluated for indoor use only shall be marked in Form A-1 “Suitable for Indoor Use Only” in minimum 1/4 in (6.4 mm) letters. In addition, the power unit shall be marked in Form B-3 with the word “WARNING” and the following or equivalent wording: “Risk of Fire. Installation involves special wiring methods to run wiring through a building structure. Consult a qualified electrician.” There shall be no literature, carton markings, or illustrations depicting or implying outdoor installation of the power unit.

50.13 A power unit evaluated for outdoor use only shall be marked in Form A-1 “Suitable for Outdoor Use Only” in minimum 1/4 in (6.4 mm) letters. There shall be no literature, carton markings, or illustrations depicting or implying indoor use.

50.14 A power unit evaluated for either indoor or outdoor use shall be marked in Form A-1 “Suitable for Indoor or Outdoor Use” in minimum 1/4 in (6.4 mm) letters. In addition, the power unit shall be marked in Form B-3 with the word “WARNING” and the following or equivalent wording “Risk of Fire. If installation involves running wiring through a building structure, special wiring methods are needed. Consult a qualified electrician.”

50.14.1 A power unit evaluated for installation in or on non-combustible materials only shall be marked in Form A-3 “For Installation in or on non-combustible materials only.”

50.15 *Deleted*

50.16 A power unit is permitted to be marked, in Forms A-3 and C-4, “Suitable for Use with Submersible Luminaires or Submersible Pumps,” or equivalent.

50.17 A power unit shall be marked, in Form C-4, that it is only for use with low voltage landscape luminaires and fittings, unless evaluated for other uses.

50.18 A power unit tested in accordance with the Exception to 33.1 shall have the following or equivalent marking, in Forms A-1 and C-4; “Caution – Use only with maximum ____-watt lamp load” or equivalent, where the blank shall identify the maximum tested lamp load. In addition, the installation instructions shall include a statement informing the user how to calculate the total lamp wattage.

50.19 A power unit that employs double insulation shall be marked in Form B-3 “Double Insulated” or the equivalent. The double-insulation symbol – a square within a square – is permitted to be used in addition to but not in place of the words “Double Insulation.”

50.20 *Deleted*

50.21 A power unit tested in accordance with the Exception to 37.3.3 shall be provided with a marking on the door in Form A1 stating that the door must be closed.

50.22 In accordance with 24.4.7, visible at the point of secondary wire connections, a marking shall be provided in 1/8 inch (3.2 mm) high lettering, "Read Installation Instructions before Wiring" or equivalent.

50.23 A power unit whose output is limited to Class 2 levels, in accordance with 15.1A.1, is permitted to be marked “Class 2.”

50.24 When the temperature measured on the supporting surface during the Temperature Test, Section 33, exceeds 90°C (194°F) but is not greater than 150°C (302°F), the power unit shall be marked in Form A-4 “For Installation In or On Non-Combustible Materials Only.”

50.25 A direct plug-in power unit shall be marked in Form C-4 “WARNING: Not for use with receptacles that are weatherproof only when the receptacle cover is closed and the power unit is not inserted.”

51 Installation Instructions

51.1 Installation instructions shall be provided with the power unit. Specific instructions for mounting, proper wiring, grounding, and servicing shall be included. Instructions for power units with a flexible cord and plug shall include guidance for selecting a mounting location sufficiently close to an available receptacle. The instructions shall inform the installer that the main secondary wiring is intended for shallow burial – less than 6 inches (152 mm) – unless the manufacturer has provided wiring intended for direct burial.

51.1.1 The instructions for a conduit-connected power unit shall include the statements "WARNING – Risk of Electric Shock. Install power unit 5 feet (1.5 m) or more from a pool or spa and 10 feet (3.05 m) or more from a fountain. Where the power unit is installed within 10 feet (3.05 m) of a pool or spa connect power unit to a GFCI protected branch circuit."

51.1.2 The instructions for a power-supply cord connected power unit shall include the statements "WARNING – Risk of Electric Shock. Install power unit 5 feet (1.5 m) or more from a pool, spa, or fountain. Where the power unit is installed (a) indoors within 10 feet (3.0 m) of a pool, spa, or fountain or (b) outdoors, connect power unit to a receptacle protected by a GFCI.”

51.1.3 The instructions for a power unit marked in accordance with 50.14.1 shall include the following statement, or equivalent: “WARNING – install power unit in or on non-combustible materials only.”

51.2 The installation instructions shall state how to order additional lengths of wire for connection in the secondary or state the proper accessory kit to purchase.

51.3 The instructions shall provide information to the user on how to determine the number of luminaires and the lamp wattages to be used with the power unit.

51.4 The installation instructions for a cord-connected power unit shall warn the user not to use an extension cord and shall also state that an outdoor power unit shall be connected to a GFCI protected hooded flush type cover plate receptacle marked "Wet Location" while in use.

51.5 When the temperature measured on the supporting surface during the Temperature Test, Section 33, exceeds 90°C (194°F) but is not greater than 150°C (302°F), the installation instructions shall be provided with a WARNING to the installer to mount the power unit in or on non-combustible mounting surfaces only.

51.6 The installation instructions for a direct plug-in unit shall include the following statement: “WARNING: Risk of Electric Shock. When used outdoors, install only to a covered Class A GFCI protected receptacle that is weatherproof with the power unit connected to the receptacle. If one is not provided, contact a qualified electrician for proper installation. Ensure that the power unit and cord do not interfere with completely closing the receptacle cover.”

PART 2 – EQUIPMENT CONNECTED TO THE POWER UNIT OUTPUT

CONSTRUCTION

52 General

52.1 In addition to the other construction requirements in this section, a luminaire and fittings shall comply with the following construction requirements in Part 1: 15.1, 15.2, 15.3, 15.5, 16.1.1, 16.2.1, 16.2.2(a), 19.1, 19.2, and Switches and Relays, Section 17 and Printed Wiring Boards, Section 21.

52.2 The minimum thickness for a metal enclosure of a luminaire shall be 0.016 inch (0.41 mm).

52.3 A luminaire or fitting using a polymeric material shall have minimum ratings as shown in Table 52.1.

Table 52.1
Polymeric requirements

Use	Examples	RTI[a]	Min. HB	HWI[b]	UV[c,e]
In contact with an uninsulated current carrying part.	Contact support material in a lampholder or insulation piercing connector.	Yes	Yes	Yes[g]	Yes[g]
Lamp enclosing parts.	Lens, reflector, globes, lamp enclosure.	Yes [f]	Yes [f]	No	No[d]
Parts not enclosing the lamp.	Stakes, decorative tops, tiers.	No	No	No	No

[a] RTI is Relative Thermal Index.

[b] For HWI PLC levels see Table 52.2. As an alternative to the values in Table 52.2, the Glow-Wire End Product Test or Abnormal Overload Test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is to be conducted.

[c] UV is Exposure to Ultraviolet Light Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[d] A lamp containment barrier shall comply with the UL 746C UV requirements.

[e] UV testing required when lamp holder is exposed to direct sunlight or a tungsten halogen lamp is used.

[f] Not required if results from temperature test yield no visual signs of deformation or reduction in overall dimensions.

[g] Not applicable where the current carrying parts operate within class 2 power limits.

Table 52.2
Hot wire resistance to ignition

Flammability rating	HWI PLC
HB	2
V-2	2
V-1	3
V-0	4
5V	4

52.4 All inside and outside surfaces of sheet steel or other mechanical parts of iron or steel shall be zinc-coated, cadmium-plated, enameled, painted, or provided with equivalent protection against corrosion on all surfaces.

Exception: Punched holes and cut edges inferrous material need not be corrosion protected.

52.5 A luminaire and other type of output circuit component intended to be recessed into a building structure shall comply with the enclosure requirements specified in 8.1 and 8.2 and with the conduit connection provision requirements in 24.2.

53 Output Circuit Wiring and Connections

53.1 General

53.1.1 For installation of the luminaires and other output circuit components, the required length of main low voltage cable and unit low voltage cable and connectors shall be provided unless instructions on how to obtain cable and connectors from the manufacturer are provided.

53.1.2 *Deleted*

53.2 Internal wiring

53.2.1 A conductor shall have insulation rated for the voltage, temperature, and condition of service to which it will be subjected under conditions of intended use. The flammability rating shall be VW-1. A wire or each insulated conductor of a cord that is rated for 90°C (194°F), 105°C (221°F), or 125°C (257°F) is evaluated as rated 150°C (302°F) when each wire is individually provided with supplementary insulation that consists of snugly fitting woven glass sleeving or tape at least 0.010 inch (0.25 mm) thick.

53.3 Main low voltage cable

53.3.1 Main low voltage cable shall be sized in accordance with Table 53.1 and shall be one of the following:

a) Underground low energy circuit cable,

b) SPT-3 or SPT-2W,

c) Any junior hard service cord specified in 24.3.1.2,

d) Any other wire rated as sunlight resistant, suitable for wet locations, and intended for direct burial as defined in the Standard for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables, UL 493.

Exception: Cable connected to a Class 2 power unit is permitted to be sized in accordance with Table 53.2.

Table 53.1
Maximum ampacities of secondary wires and cords with copper conductors

Wire gauge (AWG)	18	16	14	12	10
SI equivalent, mm^2 sectional area	0.82	1.3	2.1	3.3	5.3
	Ampacity (amperes)				
	7[a] (10)	10[a] (13)	15[a] (18)	20[a] (25)	25[a] (30)

[a] These ampacities are applicable to 3-conductor cords and 4-conductor cords with three conductors carrying current. The corresponding ampacities for these sizes of 2-conductor cords and 3-conductor cords with two conductors carrying current are shown in parentheses.

Table 53.2
Minimum Size of Cable Connected to Class 2 Power Unit

Class 2 power unit maximum output rating, amps	Minimum cable size
	Wire gauge, AWG (mm^2)
3.5	20 (0.52)
1.8	22 (0.32)

53.4 Unit low voltage cable

53.4.1 Unit low voltage cable used to connect the luminaire or fitting to the main low voltage cable shall be one of the following:

a) Any wire suitable for the main voltage cable, per 53.3.1,

b) SPT-1W,

c) XTW or CXTW, or

d) AWM with minimum 22 AWG conductors and minimum 105 C, 300 V, 30 mil thick insulation.

53.4.2 When the unit low voltage cable is not of a type suitable for use as main low voltage cable, installation instructions in accordance with 57.5 shall be provided.

53.4.3 The connectors used to connect a luminaire or output circuit component to the main low voltage cable shall be copper or copper alloy, or the equivalent. When installed the connection shall guard against inadvertent shorting of current carrying parts. Wire nuts are not to be used unless provided with corrosion protection and intended for outdoor use.

53.4.4 Connectors with insulation-piercing terminals shall comply with the Insulation-Piercing Terminal Temperature Test, Section 55.

PERFORMANCE

54 Temperature

54.1 A luminaire shall be subjected to the temperature test described in 33.2 – 33.5, 33.8, and 33.9.

54.1.1 If rated for a reflector type lamp, a "flood" lamp shall be used for testing.

54.1.2 The luminaire shall be connected to a supply source adjusted to cause the luminaire to operate at rated wattage. For lamp types that do not have a wattage, the supply source will be adjusted to the marked voltage rating.

54.1.3 A luminaire fitting designed to be adjustable by the user shall be positioned or adjusted to cause maximum heating of the fitting.

54.1.4 The luminaire shall not attain a temperature at any point sufficiently high to present the risk of fire or damage any materials employed in the luminaire, or higher than as specified in Table 33.1.

Exception: A polymeric material, not including wood, used as a luminaire housing is able to exceed its lowest temperature index (Electrical or Mechanical with Impact) if it complies with 54.2.

54.2 A polymeric material, not including wood, used as a luminaire housing that is subjected to an operating temperature in excess of its lowest temperature index (Electrical or Mechanical with Impact) as determined by the temperature test shall retain its original dimensions and shape after exposure for 1000 hours to a temperature in accordance with Table 54.1. Exposure time is able to be reduced by one-half for each increase in oven temperature of 10°C (18°F). If the measured temperature is above 95°C (203°F), the oven temperature is able to be determined by extrapolation.

Table 54.1
1000-hour exposure temperature

Normal temperature on polymeric material				Oven test temperature	
Higher than		Not higher than			
°C	°F	°C	°F	°C	°F
65	149	75	167	85	185
76	167	85	185	95	203
86	185	95	203	105	221

54.3 In-ground recessed luminaires or units intended for poured concrete are to be buried in 30 mesh dry builder sand. The sand is to surround the luminaire on all sides, except where the light is emitted by at least 6 inches (153 mm). See 56.7.

54.4 Recessed luminaires intended for mounting in a wall (a building wall or a deck) are to be totally enclosed within a wood box built of 1/2 inch thick fir plywood, A-D grade, that is reasonably airtight, but not sealed. The box is to be rectangular or square in shape and have four sides, and a bottom. The box is to be dimensioned so that the wood is in contact with the luminaires housing.

55 Insulation-Piercing Terminal Temperature Test

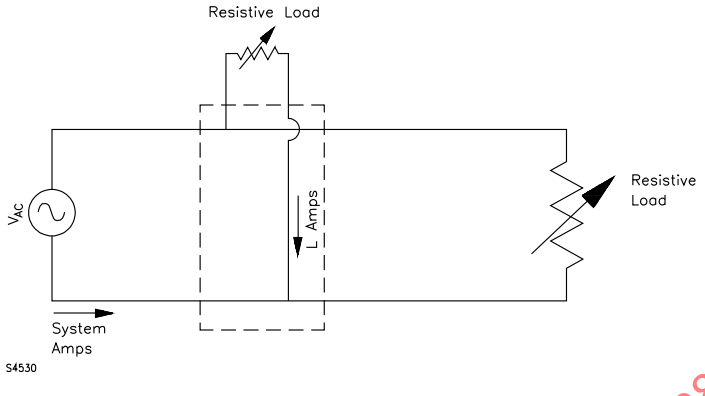
55.1 As specified in 53.4.4, connectors with insulation-piercing terminals shall be tested in accordance with 55.2 – 55.6.

55.2 Thermocouples are to be placed on the wire insulation as close to the terminal connections as construction permits. Thermocouples are to be placed in the same location on six previously untested connectors.

55.3 The connectors are to be installed in accordance with the installation instructions in the position and under the conditions that cause maximum temperatures to be reached. Connectors not integral to the luminaires are to be buried in 30 mesh dry builders sand; surrounded by minimum 6 inches of sand. The test is to be performed at rated current installed as intended. Each connector shall have its own load as obtained by use of an adjustable resistor so that the connector is being subjected to the current from the supply to the luminaire load. See Figure 55.1 and Figure 55.2 for further details.

Figure 55.1

Cable-to-luminaire test circuit



Notes:

1. Luminaire amps shall be at the maximum current based on the lamp wattage (for incandescent lamps), the power unit output (for constant current LED luminaires), or based on the size of the conductor marked on the connector.

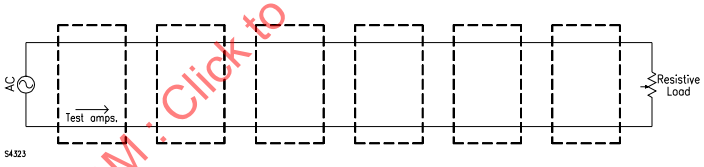
2. System amps shall be the current based on the size of the conductor, but shall not exceed 25 amps. It is produced by adjusting the resistive load to obtain the system amps.

3. The power source shall be located within 1 foot of the connector under test, unless otherwise specified in the installation instructions.

4. Minimum supply conductor length (from supply source to source load) shall be 25 feet.

Figure 55.2

Cable-to-cable test circuit



Notes:

1. Test amps is determined by the size of the cable, and shall not exceed 25 amps. It is produced by adjusting the resistive load to obtain the correct current.

2. The distance between connectors shall not be less than 1 foot in order to reduce the risk of heat from one connector effecting another.

3. Minimum supply conductor length (from source to source load) shall be 25 feet.

55.4 Six previously untested connectors are to be assembled to conductors of the size and type for which they are intended. Multiple tests are required if the connector is designed for several types of wire sized or types. The connectors are to be connected to the test load. For "line-to-line" connectors, the test circuit has capability of consisting of all six connectors in series with one power source and one load. For "line-to-luminaire" connectors, the test circuit has capability of consisting of the six connectors each connected to its lamp load and the main secondary load with one power source. The temperature of the insulation piercing terminal connections is to be monitored continuously. The connectors are to be operated for a period of seven hours and the temperature of the insulation piercing terminal connections recorded.

Exception: When multiple tests are to be conducted, testing the maximum and minimum of a particular conductor type represents intermediate wire gauge sizes.