UL 379

STANDARD FOR SAFETY

Power Units for Fountain, Swimming Pool, and Spa Luminaires

UL Standard for Safety for Power Units for Fountain, Swimming Pool, and Spa Luminaires, UL 379

First Edition, Dated June 19, 2013

Summary of Topics

This revision of ANSI/UL 379 dated November 4, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated September 16, 2022.

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UL 379

Standard for Power Units for Fountain, Swimming Pool, and Spa Luminaires

First Edition

June 19, 2013

This ANSI/UL Standard for Safety consists of the First Edition including revisions through November 4, 2022.

The most recent designation of ANSI/UL 379 as a Reaffirmed American National Standard (ANS) occurred on November 4, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

PART I – ALL POWER UNITS FOR FOUNTAIN, SWIMMING POOL, AND SPA LUMINAIRES

INTRODUCTION

CONSTRUCTION

PERFORMANCE

PART II – POWER UNITS INTENDED FOR DIRECT CONDUIT CONNECTION TO A WET-NICHE OR NO-NICHE LUMINAIRE

PART I – ALL POWER UNITS FOR FOUNTAIN, SWIMMING POOL, AND SPA LUMINAIRES

INTRODUCTION

1 Scope

1.1 These requirements cover field-installed air-cooled transformers and dc output power supplies intended to supply fountain, swimming pool, and spa luminaires in accordance with Article 680 of the National Electrical Code, NFPA 70.

1.2 These requirements do not address designs that vary the magnitude of voltage or current on the output for signal or control purposes. Designs that superimpose a signal on the output for control purposes area also not addressed.

2 General

2.1 Power units

2.1.1 These power units are not intended for installation in specific luminaires.

2.2 Undated references

2.2.1 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.

2.3 Units of measurement

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

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

2.4 Electrical rating

2.4.1 The input is to be rated a nominal 120 volts; the secondary shall be rated 15 volts ac or less or 30 volts dc or less and 1000 volt-amperes or less.

2.5 DC output units

2.5.1 Each output of a direct current (DC) power unit for supply of underwater luminaires for fountains, pools, and spas shall comply with items (a) and (b) below.

a) The circuit shall be rated 30 VDC or less. The maximum output voltage in normal use and under any single fault condition shall not exceed 30 VDC.

b) Under all combinations of constant resistive load and single fault conditions, the peak-to-peak value of ripple voltage and ripple current measured on the circuit shall be not more than 10 percent of the measured DC value.

3 Components

3.1 General

3.1.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Section;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability; and

d) Comply with the applicable requirements of this end product Standard.

3.1.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

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

b) Is superseded by a requirement in this Standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

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

3.1.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL standard(s) that cover devices that provide those functions.

3.1.5 Any component used shall not present the risk of fire, electric shock or casualty hazards.

3.1.6 Components shall be suitable for the intended use and installation environment. This suitability shall assume the following installation parameters:

a) Outdoor, Pollution Degree 3 installations.

b) Overvoltage Category III as specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

3.2 Fuseholders

3.2.1 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and:

a) The Standard for Fuseholders – Part 4: Class CC, UL 4248-4, or

b) The Standard for Fuseholders – Part 5: Class G, UL 4248-5, or

c) The Standard for Fuseholders – Part 6: Class H, UL 4248-6, or

d) The Standard for Fuseholders – Part 8: Class J, UL 4248-8, or

e) The Standard for Fuseholders – Part 9: Class K, UL 4248-9, or

f) The Standard for Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse, UL 4248-11, or

g) The Standard for Fuseholders – Part 12: Class R, UL 4248-12, or

h) The Standard for Fuseholders – Part 15: Class T, UL 4248-15.

3.3 Fuses

3.3.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and:

a) The Standard for Low-Voltage Fuses – Part 2: Class C Fuses: UL 248-2, or

b) The Standard for Low-Voltage Fuses – Part 3: Class CA and CB Fuses: UL 248-3, or

c) The Standard for Low-Voltage Fuses – Part 4: Class CC Fuses: UL 248-4, or

d) The Standard for Low-Voltage Fuses – Part 5: Class G Fuses: UL 248-5, or

e) The Standard for Low-Voltage Fuses – Part 6: Class H Non-Renewable Fuses: UL 248-6, or

f) The Standard for Low-Voltage Fuses – Part 7: Class H Renewable Fuses: UL 248-7, or

g) The Standard for Low-Voltage Fuses – Part 8: Class J Fuses: UL 248-8, or

h) The Standard for Low-Voltage Fuses – Part 9: Class K Fuses: UL 248-9, or

i) The Standard for Low-Voltage Fuses – Part 10: Class L Fuses: UL 248-10, or

j) The Standard for Low-Voltage Fuses – Part 11: Plug Fuses: UL 248-11, or

k) The Standard for Low-Voltage Fuses – Part 12: Class R Fuses: UL 248-12, or

l) The Standard for Low-Voltage Fuses – Part 15: Class T Fuses: UL 248-15, or

3.4 Printed wiring boards

3.4.1 Printed wiring boards shall comply with the Standard for Printed-Wiring Boards, UL 796. A printed wiring board shall have a temperature rating corresponding to the maximum temperature on the board during the Heating Test, Section 23. Unless wholly in a Class 2 circuit, it shall comply with the direct support of live parts requirements in UL 796.

3.5 Terminal blocks

3.5.1 Terminal blocks shall comply with:

a) The Standard for Terminal Blocks, UL 1059, or

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-1: Ancillary Equipment – Terminal Blocks for Copper Conductors, UL 60947-7-1, or

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-2: Ancillary Equipment – Protective Conductor Terminal Blocks for Copper Conductors, UL 60947-7-2, or

d) The Standard for Low-Voltage Switchgear and Controlgear – Part 7-3: Ancillary Equipment – Safety Requirements for Fuse Terminal Blocks, UL 60947-7-3.

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

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

3.5.3 Terminal blocks intended for field wiring shall comply with the Standard for Wire Connectors, UL 486A-486B, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

3.6 Wire connectors

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

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

3.7 Quick-connect wire connectors

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

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

CONSTRUCTION

4 Output Circuit Isolation

4.1 Each output circuit shall be electrically isolated from the power unit supply circuit. Each output circuit shall not be bonded to the supply circuit equipment grounding conductor or to dead metal bonded to the supply circuit equipment grounding conductor.

4.2 Where a transformer is being used to provide isolation, the primary and secondary windings shall be:

a) Separated by a shield of copper that is at least 0.002 inch (0.051 mm) thick or brass minimum 0.005 inch (0.127 mm); or

b) Comply with the Standard for Low-Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; or

c) Comply with the Standard for Class 2 Power Units, UL 1310.

4.3 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 shall be no smaller than 18 AWG (0.82 mm^2).

4.4 The shield dimensions and placement shall leave no unshielded electrical fault path between windings through any bobbin wall, winding insulation, or both.

4.5 A power supply circuit complying with the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, and the Standard for Information Technology Equipment – Safety – Part 22: Equipment to be Installed Outdoors, UL 60950-22, and the following specifications is considered to meet the dc output limitations specified in 2.5 and the isolation requirements specified in 4.1 and 4.2.

a) The power supply has an Output Category (OC) rating of SELV suitable for outdoor locations as specified in UL 60950-22.

b) The power unit was evaluated for use in Pollution Degree 3 environments

Exception: Power units with additional means to create a micro environment suitable for that of the power supply.

c) The power unit is suitable for Overvoltage Category III installations.

Exception: Supplies suitable for Overvoltage Category II environments with supply side transient voltage surge suppression that meets the following: Complies with Standard for Surge Protective Devices, UL 1449, 6kV impulse and limiting the transient voltages to the power supply to 2500 volts maximum for 240 volt rated units 1500 maximum for 120 volt units.

d) The power unit has an ambient temperature rating appropriate for the installation. The ambient temperature in an outer enclosure intended for a non-high ambient temperature installation shall be considered a 40°C (104°F) environment.

5 Class 2 Circuits Within Power Unit

5.1 Except for compliance with the requirements identified in items (a) and (b) below, components of a Class 2 Circuit within the power unit enclosure are not required to comply with the requirements in PART 1 of this standard.

a) Electrical Spacings, Section 15; and

b) Dielectric Strength Test, Section 24.

5.2 Components of a Class 2 circuit functioning as part of or mounted on the power unit enclosure need to comply with the applicable requirements in PART I of this standard.

6 Mechanical Assembly

6.1.1 A power unit shall be formed and assembled so that it possesses the strength and rigidity required to resist the abuses to which it is subjected, without increasing its fire hazard due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

7 Enclosures

7.1 General

7.1.1 A power unit shall be provided with an enclosure of noncombustible, moisture-resistant material. The enclosure shall house all uninsulated live parts.

7.1.2 An enclosure shall be provided with means for mounting in a reliable manner. The design shall be such that, when the enclosure is mounted on a plane surface, it will make contact with such surface at points of support only; and when so mounted there shall be a spacing through air of not less than 1/4 inch (6.4 mm) between the supporting surface and the enclosure.

7.1.3 A sheet-steel enclosure shall be formed from stock having an average thickness of not less than 0.026 inch (0.66 mm) (No. 22 Manufacturer's Standard Gauge – MSG), except that sheet steel having an average thickness of not less than 0.021 inch (0.53 mm) (No. 24 MSG) may be used for drawn end bells having maximum dimensions of 2-1/4 inches (57 mm) on the flat portion and 1-1/2 inches (38 mm) at the base of the drawn portion. The thickness of an enclosure of nonferrous steel metal shall be such as to provide strength and rigidity not less than that of an enclosure of sheet steel having the specified thickness.

7.1.4 Sheet aluminum used for an enclosure shall have an AWG number that is four units higher than the MSG number for the required thickness of uncoated sheet steel.

7.1.5 The average thickness of a steel sheet is determined by taking the average of five micrometer readings equally spaced across the full width of the sheet as rolled.

7.1.6 An enclosure of cast iron shall not be less than 1/8 inch (3.2 mm) thick at any point, and of greater thickness at reinforcing ribs and edges of doors or covers.

7.1.7 The cover of an enclosure shall be secured in place in a reliable manner.

7.1.8 A cover which must be removed to permit the connection of circuit conductors shall not be provided with means for the connection of conduit.

7.1.9 A hinged cover shall be provided when access is required to the interior of the power unit to reset protective devices or replace fuses.

7.2 Resistance to corrosion

7.2.1 An iron or steel part shall be resistant to corrosion by enameling, galvanizing, plating, or equivalent means, if the corrosion of such a part would be likely to result in a risk condition.

Exception No. 1: In certain instances where the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet steel and cast iron parts within an enclosure may not be required to be corrosion resistant.

Exception No. 2: The requirement does not apply to bearings, laminations, or to minor parts of iron or steel such as washers and screws.

Exception No. 3: Stainless steel requires no corrosion-resistant coating.

7.2.2 Copper or copper alloy with zinc content not in excess of 15 percent may be used without additional resistance to corrosion.

7.2.3 Aluminum may be used without additional resistance to corrosion.

7.2.4 Metal shall not be used in combinations to cause galvanic action.

7.2.5 A sheet steel enclosure and other parts, including hinges and other attachments, of a power unit intended for outdoor use shall be resistant to corrosion as described in 7.2.6 and 7.2.7.

7.2.6 The outer sheet steel enclosure shall be resistant to corrosion by one of the following:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M REV A.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each side, with a minimum thickness of 0.00054 inch (0.014 mm). An annealed coating shall also comply with 7.2.7.

c) A coating conforming with subitem (1) or (2) and with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.

1) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G60 or A60 in Table I of ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM standard. The weight of the zinc coating may be determined by any method; however, in case of question the weight of coating shall be established in accordance with the test method of ASTM A90/A90M REV A. An annealed coating shall also comply with 7.2.7.

2) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). An annealed coating shall also comply with 7.2.7.

d) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The paint shall be as described in 7.2.6(c).

f) Other finishes, including paints, special metallic finishes, and combinations of the two may be accepted when comparative test with galvanized sheet steel (without annealing, wiping, or other surface treatment) conforming with 7.2.6(a) indicate that they provide equivalent resistance to corrosion. Among the factors that are taken into consideration when evaluating such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light, and water. Organic coatings shall comply with the Standard for Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment, UL 1332.

7.2.7 An annealed coating on sheet steel that is bent or similarly formed or extruded, or rolled at edges of holes after annealing shall be additionally painted in the affected areas if the process damages the zinc coating. When flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Sheared or cut edges and punched holes are not required to be additionally treated.

7.3 Conduit connection provisions

7.3.1 Provision shall be made for separate conduit connection for the input and output circuits.

7.3.2 When threads for the connection of conduit are tapped all the way through a hole in a power unit enclosure, or when an equivalent construction is used, there shall not be less than 3-1/2 nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing is capable of being properly attached.

7.3.3 When threads for the connection of conduit are tapped only part of the way through a hole in the enclosure, there shall not be less than five full threads in the metal and there shall be a smooth, well-rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

7.3.4 A power unit designed to be supported by rigid conduit shall have substantial conduit hubs with not less than five full threads or other equivalent supporting means of such strength that these parts will comply with the requirements in the Pullout, Bending, and Twisting Tests, Section 27.

7.3.5 An enclosure of cast iron shall not be less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

7.3.6 A knockout for the connection of conduit to a terminal or wiring compartment of a power unit shall have a diameter in accordance with the requirements of the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

7.3.7 There shall be adequate space within a terminal or wiring compartment to permit a standard conduit bushing to be properly mounted on conduit connected to the compartment.

7.4 Openings

7.4.1 Openings in an enclosure intended to provide ventilation, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be sized and shaped so that no opening permits passage of a rod having a diameter of more than 1/2 inch (12.7 mm); except that when the distance between uninsulated live-metal parts and the enclosure is more than 4 inches (102 mm), openings are not prohibited from being larger than those previously specified, when no opening permits passage of a rod having a diameter of more than 3/4 inch (19.1 mm).

7.4.2 The wires of a screen shall not be less than 16 AWG (1.31 mm^2) when the screen openings are 1/2 square inch (12.7 mm square) or less in area, and not less than 12 AWG (3.31 mm^2) for larger screen openings. Sheet metal used for expanded-metal mesh, and perforated sheet metal shall have an average thickness of not less than 0.043 inch (1.1 mm) (No. 18 MSG) when the mesh openings or perforations are 1/2 square inch or less in area, and shall have an average thickness of not less than 0.095 inch (2.4 mm) (No. 12 MSG) for larger openings.

7.4.3 An opening into a wiring compartment shall be located or shielded so that emission of molten metal, burning insulation, etc., from the wiring compartment under fault conditions is unlikely to occur.

7.5 Rain-tight enclosures

7.5.1 A power unit intended for installation outdoors shall be marked "Suitable For Outdoor Use" as specified in 18.9 and shall comply with 7.5.2 – 7.5.7.

7.5.2 A rain-tight sheet-steel enclosure shall have an average thickness of not less than 0.054 inch (1.37 mm) (No. 16 MSG).

7.5.3 A hole for conduit in a rain-tight enclosure shall be threaded, unless it is located wholly below the lowest live-metal part of a power unit. (Insulated wire leads are not considered to be live-metal parts).

7.5.4 A threaded hole for conduit shall be reinforced to provide metal not less than 1/4 inch (6.4 mm) in thickness, and shall be tapered unless a conduit end stop is provided.

7.5.5 There shall be provision for drainage of the enclosure when knockouts or unthreaded conduit openings are provided.

7.5.6 The enclosure shall be provided with external means for mounting, except that internal means for mounting are not prohibited from being used when the construction prevents water from entering the enclosure.

7.5.7 A rain-tight enclosure shall be constructed to resist leakage during a beating rain as specified in the Rain Test, Section 30.

8 Splices and Connections

8.1 A splice or connection shall be made mechanically secure and shall provide continuity of electrical contact.

8.2 A splice shall be provided with insulation equivalent to that on the spliced wires when permanence of spacing between the splice and uninsulated metal parts is not provided.

8.3 A soldered connection shall be made mechanically secure before being soldered.

Exception: When the conductors of a soldered connection are rigidly held in place without the use of solder, or when it will be retained in place by compound or other suitable means so as not to be subjected to appreciable motion, no additional mechanical security is required.

9 Separation of Circuits

9.1 The primary and secondary leads shall be separated internally and shall terminate in separate wiring compartments for field wiring connections.

10 Field-Wiring Connections

10.1 General

10.1.1 A power unit shall be provided with pigtail leads or terminals for field wiring connections.

10.1.2 The primary leads or terminals shall be color coded and the lead or terminal intended to be connected to the grounded supply conductor shall be connected within the power unit to the winding end closest to the grounded shield.

10.2 Terminals

10.2.1 The set-screw form of wiring terminal shall not be used.

10.2.2 Terminal plates and the wire-binding screws, studs, and nuts shall be of nonferrous metal.

10.2.3 A No. 10 (4.8 mm) or larger wire-binding screw is not prohibited from being made of iron or steel when suitably plated. Copper and brass are not to be used for plating of a steel wire-binding screw; however, a plating of cadmium or zinc is not prohibited from being used.

10.2.4 The thickness of a terminal plate for a wire-binding screw shall be not less than 0.030 inch (0.76 mm); and there shall not be less than two full threads in the metal for the binding screw.

10.2.5 A wire-binding screw or stud shall not be smaller than No. 6 (3.5 mm) nor have more than 32 threads per inch (1.3 threads per mm).

10.2.6 Wiring terminals shall be provided with cupped washers, upturned lugs, or the equivalent to retain the wires under the heads of screws or nuts.

10.3 Pigtail leads

10.3.1 A power unit lead shall be of stranded wire. The lead shall have an ampacity, in accordance with the National Electrical Code, ANSI/NFPA 70, not less than the rated full-load current of the winding to which it is connected and shall not be smaller than 14 AWG (2.08 mm^2).

10.3.2 A power unit lead shall be suitable for the voltage involved.

10.3.3 A power unit lead shall be a wire type suitable for the voltage and temperature involved, be for use in wet locations and, except as specified in 10.3.4, be a thermoset wire type such as types RHW, RHW-2, XHHW, or XHHW-2.

10.3.4 A thermoplastic wire type power unit lead shall suitable for use in wet locations, such as wire types TW, THW, THW-2, THHW, THHW-2, THWN, THWN-2, or ZW. The wire's electrical insulation and the lead's strain relief means, as specified in 10.3.7 and 10.3.8, shall not be damaged as a result of temperatures encountered during any power unit varnishing and compounding operations completed in production.

10.3.5 To permit connections to be made, the free length of a lead shall be 6 inches (15 cm) or longer.

10.3.6 The connection between a lead and the winding or other part of the power unit shall be soldered, welded, or otherwise securely connected.

10.3.7 Strain relief shall be provided so that a stress on a lead will not be transmitted to the connection inside the power unit.

10.3.8 A strain relief means which depends solely on adhesion between the conductor and compound is not to be used.

10.3.9 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be green with or without a yellow stripe, and no other lead shall be so identified.

11 Bushings for Wiring

11.1 A bushing which is used in a power unit intended for outdoor use shall be of porcelain, cold-molded or phenolic composition, fiber which has been so treated as to render it suitably resistant to moisture, or other insulating material recognized as being suitable for the particular application.

11.2 An untreated fiber bushing is to be used in a power unit intended only for indoor-use.

11.3 A fiber bushing shall have a wall thickness of not less than 1/16 inch (1.6 mm) [with a minus tolerance of 1/64 inch (0.4 mm) for manufacturing variations], and shall be formed and secured in place so that it is not affected adversely by conditions of ordinary moisture or by normal use. A fiber plate not less than 1/32 inch (0.8 mm) in thickness, with a punched hole, may be used in place of a bushing when the wire is tightly bushed and is rigidly held in position.

11.4 Bushings of rubber, wood, or so-called hot-molded shellac or tar compositions shall not be used.

11.5 A wire-entry hole in an enclosure, in a partition, or in a bushing shall be smooth and well-rounded, without burrs or fins which are capable of damaging the conductor insulation.

11.6 A bushing shall be securely held in place.

11.7 An insulating bushing is not required at a point where a low-voltage wire passes through a hole in an interior metal wall or barrier, through a hole in insulating material, through a conduit nipple or hub, or through an armored-cable connector or the equivalent.

12 Insulating Material for Mounting Live-Metal Parts

12.1 Material for the mounting of live-metal parts shall be glass, porcelain, phenolic or cold-molded composition, or polymeric material that complies with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Untreated fiber, rubber, wood, and so-called hot-molded shellac or tar compositions shall not be used.

12.2 Enameled wire is not required to be additionally treated to prevent moisture absorption.

13 Coil Insulation

13.1 The transformer shall meet the constructional requirements specified in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and either the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, or the Standard for Class 2 Power Units, UL 1310.

14 Wiring Devices

14.1 A switch or other wiring device shall be mounted so that it will not turn with regard to the mounting surface.

15 Electrical Spacings

15.1 The electrical spacings at wiring terminals, between uninsulated live-metal parts of opposite polarity, and between an uninsulated live-metal part and a dead-metal part which may be grounded when the power unit is installed, shall not be less than as specified in Table 15.1.

Table 15.1
Electrical spacings at wiring terminals

Voltage involved	Electrical spacings in inches (mm)	
	Through-air	Over-surface
0 – 50	1/8 (3.2)	1/4 (6.4)
51 – 250	1/2 (12.7)	1/2 (12.7)

15.2 The electrical spacings at points other than wiring terminals, between uninsulated live-metal parts of opposite polarity, and between an uninsulated live-metal part and a dead-metal part, shall not be less than those indicated in Table 15.2. These spacing requirements do not apply between turns of the same winding.

Table 15.2
Electrical spacings at other than wiring terminals

Voltage involved	Electrical spacings in inches (mm)	
	Through-air	Over-surface
0 – 50	1/16 (1.6)	1/16 (1.6)
51 – 125	1/8 (3.2)	1/4 (6.4)
126 – 250	1/4 (6.4)	3/8 (9.5)

15.3 The spacing between secondary parts and primary parts shall not be less than required for the voltage of the primary parts. The spacing between secondary parts and dead-metal parts shall not be less than required for the voltage of the secondary parts. The spacing between two secondary windings of a power unit shall not be less than that for uninsulated live-metal secondary parts of opposite polarity.

16 Output Overload Protection

16.1 Integral overload protection shall be provided for the outputs. The protection means shall comply with the Abnormal Heating Test followed by the Dielectric Strength Test, Section 24. The protective device shall be located so that internal wiring is not disturbed when attempting to reset a protective device or replace a fuse.

Exception No. 1: Transformers or power units that comply with the Standard for Class 2 Power Units, UL 1310.

Exception No. 2: Transformers that comply with the Standard for Low-Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

Exception No. 3: Power supply circuits that comply with 4.5.

17 Grounding

17.1 A terminal solely for connection of an equipment grounding conductor shall be provided in both the primary and secondary wiring compartments. In lieu of these two separate terminals, a single wire-binding screw, stud, or lay-in connector which permits connection of a continuous unbroken grounding conductor, is not prohibited from being used. These terminals shall be capable of securing a conductor of a size suitable for the particular application in accordance with the National Electrical Code, ANSI/NFPA 70, and not smaller than 12 AWG (3.31 mm^2).

17.2 A wire-binding screw intended for the connection of an equipment grounding conductor shall have a slotted, hexagonal, green-colored head. Means shall be provided for retaining the conductor under the head of the screw. A pressure wire connector intended for this use shall be plainly identified by being marked "G", "GR", "Ground", or "Grounding".

17.3 A wire-binding screw or pressure wire connector shall be located so that it does not have to be removed during normal servicing of the power unit.

17.4 Suitable instructions shall be supplied to indicate the proper connection of the grounding conductor to a lay-in connector to insure that it remains unbroken.

17.5 A wireway spaced between the edge of the power unit shell and the enclosure, or a tube through potting compound where such is used, or any other convenient means to permit passage of an unbroken grounding wire through the power unit enclosure, shall be provided. This wireway shall be constructed so that the primary and secondary wiring does not enter the other wiring compartment.

18 Marking

18.1 A power unit shall have a plain legible marking which is readily visible after the power unit has been installed as intended, and which includes the manufacturer's name or trademark, catalog number or the equivalent, and the electrical rating.

18.2 The electrical rating of a power unit shall include the primary voltage or voltages and frequency, all secondary voltages, and the secondary capacity in amperes or volt-amperes.

18.3 A terminal for the connection of a grounded conductor shall be identified by means of a metallic plated coating substantially white in color, and shall be readily distinguishable from the other materials; or when wire leads are provided and serve in place of terminals for the power unit, the identified lead shall have a white or gray color and shall be readily distinguishable from the other leads.

18.4 When a manufacturer produces power units at more than one factory, each finished power unit shall have a distinctive marking, which is not prohibited from being in code, by which it may be identified as the product of a particular factory.

18.5 Special markings concerning the use of the power unit and the requirement for grounding the case are required.

18.6 When, during the Heating Test, Section 23, the temperature on a field-installed lead or on a surface of the wiring compartment which the lead is capable of contacting is more than 60°C (140°F), the power unit shall be marked at or near the points where field connections will be made, and located so that it is readily visible during installation, with the following (or equivalent) statement: "FOR FIELD CONNECTIONS, USE WIRES SUITABLE FOR AT LEAST ___°C (___°F)." The temperature value to be used in the preceding statement shall be in accordance with Table 18.1.

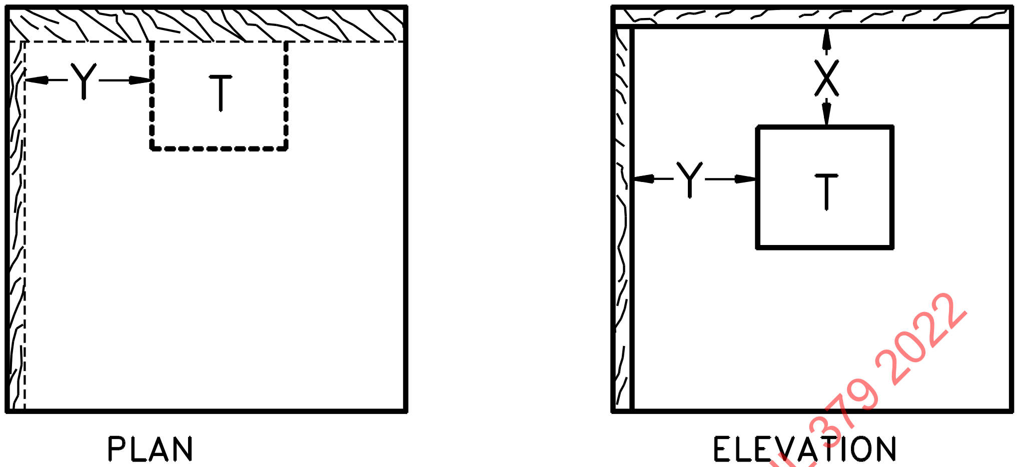
Table 18.1
Wiring compartment marking

Temperature attained during test		Value to be used in marking indicated in 18.6
More than	**But not more than**	
60°C (140°F)	75°C (167°F)	75°C (167°F)
75°C (167°F)	90°C (194°F)	90°C (194°F)

18.7 When the temperature rise on a power unit enclosure is more than 65°C (117°F), the power unit shall be clearly marked to indicate the minimum separations (the distances X and Y in Figure 18.1) between the enclosure and the adjacent surfaces required to prevent attainment of temperatures of more than 90°C (194°F) on the latter. The marking shall be located so that it is plainly visible after the power unit has been installed as intended.

Figure 18.1

Power unit test set-up



SA0599

T is the power unit.

X is the minimum spacing between the top of the power unit enclosure and the surface above the power unit.

Y is the minimum spacing between the hotter end of the power unit and the adjacent side wall. If the temperature of the right end of the power unit is higher than that of the left end, the side wall is to be to the right instead of to the left as shown.

18.8 The side wall and the top of the test alcove represented in Figure 18.1 are of 3/8-inch (9.5-mm) thick fir plywood, and the rear wall (on which the power unit is mounted) is of 3/4-inch (19-mm) thick plywood. The inner surfaces of the test alcove are to be painted dull black, and the power unit is to be mounted in the intended manner. The horizontal dimensions of the walls and top are to be large enough to ensure that the temperatures attained closely approach those which would result if the dimensions were indefinitely large.

18.9 A power unit intended for installation outdoors shall be marked "Suitable for Outdoor Use" where visible after installation.

18.10 Unless the power unit complies with the requirements in Part II, markings and installation instructions shall not describe or portray the power unit as suitable for connection to a conduit which extends directly to an underwater pool light forming shell.

18.11 Outputs that comply with 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, shall be marked “Class 2 transformer” or “Class 2 Power Unit” or with some equivalent marking.

PERFORMANCE

19 General

19.1 A power unit shall be subjected to the tests specified in Sections 19 – 30. Unless otherwise specified, a different sample for each test is not prohibited from being used.

19.2 The primary voltage for each test shall be as indicated in the description of that test, except that the primary voltage shall be 120 volts when the primary-voltage rating is 110 – 120 volts.

19.3 When a power unit has its output rated in volt-amperes, the full-load secondary current is to be determined by taking the quotient of the rated secondary volt-amperes and the rated secondary voltage.

19.4 Requirements relating to heating are based on an ambient-air temperature of 25°C (77°F). A temperature test may be conducted in any ambient-air temperature and the variation from 25°C (77°F) added to or subtracted from the observed temperature readings.

19.5 Except in those cases where it is specifically stated that temperature determinations are to be made by the resistance method, temperatures are to be measured by means of thermocouples. A thermocouple-measured temperature is considered to be constant if three successive readings, taken at intervals of ten percent of the previously elapsed duration of the test, but at not less than five-minute intervals, indicate no change. The junction of the thermocouple is to be secured in intimate contact with the point of the surface at which the temperature is to be measured; and the thermocouple is to consist of wires not larger than 24 AWG (0.205 mm^2).

19.6 When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is standard practice to use thermocouples consisting of 30 AWG (0.0511 mm^2) iron and constantan wires, and a potentiometer-type of indicating instrument; and such equipment is to be used whenever referee temperature measurements are necessary.

19.7 The temperature rise of a copper or aluminum winding is to be determined by the resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature, according to the following formula:

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

in which:

Δ t is the temperature rise,

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

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

k is 234.5 for copper and 225.0 for aluminum,

t_1 is the room temperature in °C at the beginning of the test, and

t_2 is the room temperature in °C at the end of the test.

As it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve plotted between the resistance values and time may then be extrapolated to give the value of R at shutdown.

19.8 A wall-mounted power unit shall be mounted in a corner alcove described in 18.8 and Figure 18.1 during the Heating Test, Section 23.

20 Leakage Current Test

20.1 The power unit enclosure is to be isolated from ground with the primary connected to a source of rated primary voltage. The leakage current shall be measured with the power unit in a well-heated condition.

20.2 Leakage current from the enclosure and other accessible surfaces to each supply circuit conductor through a 500-ohm resistor is not to exceed 5 mA.

20.3 For accessible nonmetallic surfaces, leakage current is to be measured using metal foil with an area of 10 by 20 centimeters in contact with the surface. When the conductive surface has an area less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is to conform to the shape of the surface but is not to remain in place long enough to affect the temperature of the product.

21 Open-Circuit Voltage Test

21.1 The open circuit secondary voltage shall be 15 volts AC or less or 30 volts DC or less when connected to a source of maximum rated primary voltage.

22 Input Test

22.1 The input in amperes or volt-amperes to a power unit shall not be more than 110 percent of the rated primary value, when the power unit is delivering its rated secondary output, with the primary connected to a circuit of maximum rated voltage and rated frequency.

23 Heating Test

23.1 When operated continuously at maximum rated primary voltage and rated frequency, with the secondary delivering full-load secondary current, with the frame or enclosure grounded, and until constant temperatures are attained, the temperature on or within a power unit shall not be such as to affect injuriously any of the material used in its construction. The temperature at any point on the enclosure shall not be more than 90°C (194°F); the temperature of winding insulation shall not be more than specified in Table 23.1; the temperature of other components and materials shall not be more specified in Table 23.2.

Exception: The temperature rise on the enclosure is not prohibited from exceeding 90°C (194°F) when the power unit is tested as described in 23.5 and marked in accordance with 18.7.

Table 23.1
Maximum temperature for winding insulation

Insulation system	Hot spot[a] differential, °C	(°F)	Maximum temperature rise, °C	(°F)	Maximum temperature[b], °C	(°F)
Class 105 (A)	10	18	70	126	95	203
Class 130 (B)	10	18	95	171	120	248
Class 155 (F)	15	27	115	207	140	284
Class 180 (H)	20	36	135	243	160	320
Class 200 (N)	25	45	150	270	175	347
Class 220 (R)	30	54	165	297	190	374

[a] The assumed difference between the average coil temperature determined by the change-of-resistance method and the hottest point somewhere within the coil.

[b] See 23.6.

Table 23.2
Maximum temperature rises for materials and components

Materials and components	°C	(°F)
A. COMPONENTS		
1. Capacitors:		
a. Electrolytic[a]	40	72
b. Other types[b]	65	117
2. Fuses:		
a. Class G, J, L, T, and CC:		
Tube	100	180
Ferrule or blade	85	153
b. Others[c]	65	117
3. Coils of a Class 2 transformer:		
a. Class 105 insulation systems:		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulation systems:		
Thermocouple method	85	153
Resistance method	95	171
B. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords[c, d]	35	63
2. Copper		
a. Tinned or bare strands having:		
i. A diameter less than 0.015 inch (0.38 mm)	125	225
ii. A diameter of 0.015 inch (0.38 mm) or more	175	315
b. Plated with nickel, gold, silver, or a combination of these	225	405
C. ELECTRICAL INSULATION – GENERAL		
1. Fiber used as electrical insulation	65	117
2. Phenolic composition used as electrical insulation or as a part the deterioration of which is capable of resulting in a risk of fire or electric shock[c]:		
a. Laminated	100	180
b. Molded	125	225
3. Varnished-cloth insulation	60	108

[a] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum temperature rise on insulating material integral with the capacitor enclosure shall not be more than 65°C (117°F).

[b] A capacitor that operates at a temperature of more than 65°C (149°F) complies with the intent of this requirement when evaluated on the basis of its marked temperature limit.

[c] These limitations do not apply to compounds and components that have been investigated and rated for use at higher temperatures.

[d] A rubber-insulated conductor with a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor that is subjected to a higher temperature complies with the intent of this requirement when the conductor is provided with sleeving or a braid that has been investigated and rated for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.

23.2 In a wiring compartment, the temperature attained on a field-installed conductor and temperature of any surface which such lead is capable of contacting, shall not be more than 90°C (194°F). If the temperature exceeds 60°C (140°F), the marking specified in 18.7 shall be provided.

23.3 In the performance of the test specified in 23.1, the load is to consist of resistance. The load is to be adjusted until full-load secondary current flows; after two minutes of operation, the load is to be readjusted, if necessary, to restore the current to full-load value, but no further adjustment is to be made thereafter. Winding temperatures (for determining the temperatures on the winding insulation) are to be measured by the resistance method. See 18.7.

23.4 When a fuseholder is provided, a fuse of proper rating is to be used during this test.

23.5 The temperature rise on the enclosure of a power unit intended for wall mounting shall not be more than 80°C (144°F) during the heating test when:

a) The temperature test is conducted with the power unit mounted in an alcove as described in 18.8 and Figure 18.1;

b) The temperature at any point on the inner surfaces of the alcove is not more than 90°C (194°F); and

c) The power unit is marked in accordance with 18.7.

23.6 The test shall be conducted in an ambient temperature of 25°C ± 5°C (77°F ± 9°F). Ambient temperature variations above or below 25°C (77°F) shall be respectively subtracted from or added to temperatures recorded at points on the product. Temperature limits specified above are based on a 25°C (77°F) ambient.

23.7 Where a power unit has more than one voltage tap for a winding, the test shall be completed for all voltage tap configurations unless the voltage tap configuration producing the greatest temperatures can otherwise be established.

23.8 Prior to energization, the resistive load shall be adjusted to the value anticipated to draw the required load current. The power unit shall be energized and the resistive load immediately readjusted as necessary to draw involved load current and then readjusted again after two minutes of operation if necessary. No further adjustment of the resistive load shall be made during the test.

24 Dielectric Strength Test

24.1 A power unit, while hot from the testing previously specified, shall be capable of withstanding without breakdown, for a period of one minute, the application of an alternating period of:

a) 2500 volts between primary and secondary windings and

b) For each winding, except as specified in 24.2, 1000 volts plus twice the maximum voltage of that winding, between:

1) The winding and

2) The core, enclosure, and grounded shield.

24.2 The voltage to be applied in 24.1(b) shall be 500 volts for Class 2 circuits.

24.3 When the power unit has an extended winding, the "maximum voltage" specified in the preceding paragraph is to include the voltage of the extended portion of the winding, even though both terminals of the extended portion are not available for external connection.

24.4 The test potential is to be supplied from a suitable 500 volt-ampere or larger testing power unit, the output voltage of which can be regulated; and the wave form of the voltage should approximate a sine wave as closely as possible. The applied potential is to be increased gradually from zero until the required test value is reached, and is to be held at that value for one minute.