UL 1029

STANDARD FOR SAFETY

High-Intensity-Discharge Lamp Ballasts

UL Standard for Safety for High-Intensity-Discharge Lamp Ballasts, UL 1029

Fifth Edition, Dated May 25, 1994

Summary of Topics

This revision of ANSI/UL 1029 dated October 11, 2024 includes the added new Section 27B, Risk of Electric Shock During Relamping, and Supplement SA, Requirements for Electronic High-Intensity-Discharge Lamp Ballasts.

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 requirements are substantially in accordance with Proposal(s) on this subject dated May 5, 2023, May 10, 2024, and August 16, 2024.

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UL 1029

Standard for High-Intensity-Discharge Lamp Ballasts

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Fifth Edition

May 25, 1994

This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through October 11, 2024.

The most recent designation of ANSI/UL 1029 as an American National Standard (ANSI) occurred on October 11, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 1029 on April 30, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 The requirements in this standard cover indoor and outdoor ballasts, including starting circuits for the operation of high-intensity-discharge lamps, and associated equipment, in accordance with the National Electrical Code, from an alternating-current power supply with nominal input ratings of 600 V rms or less. High-intensity-discharge lamps include mercury, metal halide, high-pressure sodium, and similar types. For convenience, although technically not HID lamps, low-pressure sodium lamps are included with the group.

1.2 The requirements for ballasts consisting of resistance only are excluded from this standard.

1.3 An open core and coil ballast is acceptable only for use when in a lighting fixture, sign, or other enclosure acceptable for its intended application.

1.4 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Glossary

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

2.2 BALLAST, NONRECESSED – A ballast intended to be mounted in a remote location, such as an equipment closet, that would not come in contact with building thermal insulation.

2.3 BALLAST, REACTANCE – A ballast, the impedance of which is provided by:

a) Inductive reactance,

b) Capacitive reactance, or

c) Both inductive and capacitive reactance.

2.4 BALLAST, REACTOR (SIMPLE REACTANCE) – A reactance type ballast in which the impedance (inductive reactance) is provided by a single coil and core– not a transformer.

2.5 BALLAST, RECESSED – A thermally protected ballast intended to be mounted in a recessed space and may be remote from a fixture. All insulation is intended to be spaced at least 3 inches (76.2 mm) from the sides of the ballast, however if insulation does come in contact with the ballast it is provided with thermal protection that will prevent it from overheating.

2.6 BALLAST, REMOTE – A ballast that is not intended to be mounted on a fixture or that is intended to be mounted on the fixture 18 inches (457 mm) or more from the housing as measured from the nearest point on the ballast to the nearest point (other than an incidental projection) on the housing. The ballast may be either recessed or nonrecessed.

2.7 GENERAL-USE – A ballast type that has been determined acceptable for direct installation in field applications in accordance with the National Electric Code. A ballast that complies with the requirements of this standard would be considered a General-Use ballast.

2.8 POWER CAPACITOR – A capacitor that is connected:

a) In series with a lamp or lamps and provides the ballast impedance for the lamp current; or

b) Across the input leads of the ballast or across an extension of the primary winding for power-factor correction.

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.

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.

CONSTRUCTION

6 General

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

6.2 An HID lamp ballast is categorized according to the use for which it is intended. A ballast in one category is acceptable, with respect to protection against corrosion, for use as a ballast in any category that precedes it in the following list:

a) An indoor ballast is acceptable only for use indoors.

b) A Type 1 outdoor ballast is acceptable for use in

1) Outdoor equipment,

2) A fixture intended for use in wet or damp locations, or

3) An outdoor sign if the ballast is within an overall electrical enclosure.

c) A Type 2 outdoor ballast is acceptable for use in

1) Outdoor equipment,

2) A fixture intended for use in wet or damp locations, or

3) An outdoor sign if the ballast, in addition to its own enclosure, is within an overall enclosure.

d) A weatherproof ballast is acceptable for exposure to the weather without an additional enclosure.

7 Enclosures

7.1 General

7.1.1 A ballast shall be provided with an enclosure of metal or a moisture-resistant polymeric material that has been investigated and found acceptable for the intended use. See Polymeric materials, Section 17, for requirements for a polymeric material used as an enclosure. Except as indicated in 7.1.2 and 7.1.3, the enclosure shall house all uninsulated live parts.

7.1.2 Terminals of a ballast intended for mounting on an outlet box need not be additionally enclosed if they are enclosed within the box when the ballast is mounted.

7.1.3 A ballast that is provided with interchangeable sections to adapt the ballast for different mounting means in the field is to have an enclosure that is complete except for that section. The ballast and the interchangeable sections are marked in accordance with 30.2.3.

7.1.4 The metal enclosure of a ballast shall have a thickness not less than as specified in Table 7.1.

7.1.5 The continuity of the grounding system shall not rely on the dimensional integrity of non-metallic material.

7.1.6 The cover of an enclosure shall be secured in place.

7.1.7 A cover that must be removed for the connection of circuit conductors shall not be provided with means for the connection of a wiring system.

Table 7.1
Enclosure thicknesses

Type enclosure	Material	Minimum thickness	
		Inches	mm
Sheet metal –	galvanized steel	0.029	0.74
other than	Uncoated steel	0.026 [c]	0.66 [c]
Weatherproof	nonferrous	0.036 [c]	0.91 [c]
Sheet metal –	galvanized steel	0.056	1.42
Weatherproof	uncoated steel	0.053	1.35
	Nonferrous	0.036	0.91
Cast metal	non-reinforced flat surface	1/8, 3/32[a]	3.2, 2.4[a]
	Malleable iron and permanent-mold cast aluminum	3/32, 1/16[a]	2.4, 1.6[a]
	Die-cast metal	5/64, 3/64[a]	2.0, 1.2[a]
Points of	galvanized steel	0.034[b]	0.86[b]
Wiring-system	uncoated steel	0.032[b]	0.81[b]
Connections	nonferrous	0.045	1.14

[a] Thickness meets the intent of the requirement when the shape or size of the surface is such that enough mechanical strength is provided.

[b] For a sheet–metal weatherproof enclosure not less than 0.056 inch (1.42 mm) for galvanized steel and 0.053 inch (1.35 mm) for uncoated steel.

[c] Uncoated sheet steel or nonferrous sheet metal with a minimum thickness of 0.020 inch (0.51 mm) meets the intent of the requirement when:

1) The ballast is intended to be used indoors only or marked for Type 1 outdoor use;

2) The overall weight is less than 8.8 pounds (4.0 kg); and

3) The ballast is completely compound filled, or the ballast complies with the Crushing Resistance and Resistance to Impact tests described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Note: These are minimum dimensions based on nominal metal gauge thicknesses, for example, 22 Manufacturer's Sheet Gauge, is 0.033 inch, nominal, 0.026 inch minimum. Because of the tolerance in metal gauge sizes it may be necessary to increase the metal thickness so the it is never less than the specified minimum.

7.2 Weatherproof enclosure

7.2.1 The enclosure of a weatherproof ballast shall be constructed to exclude a beating rain. Unless the enclosure is so constructed that it obviously excludes a beating rain, a weatherproof ballast is to be tested in accordance with Water Spray Test, Section 26.

7.2.2 A hole for rigid metal conduit in the enclosure of a weatherproof ballast shall be threaded, unless it is located wholly below the lowest live part of a ballast. Insulated wire leads are not to be considered live parts.

7.2.3 A threaded hole for rigid metal conduit in the enclosure of a weatherproof ballast shall be reinforced to provide metal not less than 1/4 inch (6.4 mm) in thickness, and the threads shall be tapered unless a conduit end stop is provided. See 11.1.4.

7.2.4 A bushed hole in a weatherproof ballast intended for open wiring shall not be located in the top or back of the enclosure unless a special hood fitting is provided. If a bushed hole is located in a side above live parts, it shall provide for a downward direction of the wire leaving the enclosure.

7.2.5 There shall be provision for drainage of the enclosure of a weatherproof ballast if knockouts or unthreaded conduit openings are provided. Drainage holes shall not be less than 1/8 inch (3.2 mm) or more than 1/4 inch (6.4 mm) in diameter.

7.2.6 The enclosure of a weatherproof ballast shall be provided with external means for mounting, except that internal means for mounting may be used if constructed to prevent water from entering the enclosure. See 7.2.1.

8 Ventilating Openings

8.1 Openings in an enclosure intended to provide ventilation – including holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers – shall be of such size or shape that no opening permits passage of a rod having a diameter of more than 1/2 inch (12.7 mm). If the distance between uninsulated live parts and the enclosure is more than 4 inches (102 mm), openings may be larger than those mentioned, provided that no opening permits passage of a rod having a diameter of more than 3/4 inch (19.0 mm).

8.2 The wires of a screen shall not be smaller than 16 AWG, not less than 0.045 inch (1.14 mm), if the screen openings are 1/2 square inch (322 mm^2) or less in area, and shall not be smaller than 12 AWG, not less than 0.075 inch (1.90 mm), for larger screen openings. Sheet metal used for expanded-metal mesh and perforated sheet metal shall have a thickness of not less than 0.042 inch (1.07 mm) if the mesh openings or perforations are 1/2 square inch (322 mm^2) or less in area, and shall have a thickness of not less than 0.093 inch (2.36 mm) for larger openings.

8.3 An opening into a wiring compartment shall be located or shielded that emission of molten metal, burning insulation or the like from the wiring compartment is unlikely under fault conditions.

9 Means for Mounting

9.1 A ballast shall be provided with means for mounting. The construction shall be such that, when the enclosure is mounted on a plane surface, it makes contact with such surface only at points of support. 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.

Exception: The 1/4 inch spacing need not be maintained if the ballast;

> *a) Is intended to be mounted on an outlet-box cover and it is rated at not more than 100 W,*
>
> *b) Is intended for use as an integral part of a fixture, sign, or other equipment, or*
>
> *c) Carries a marking that it must be mounted on a metal, brick, cement, or similar noncombustible surface. See 30.2.2.*

9.2 A ballast intended to be mounted on a standard outlet box shall include an outlet-box cover that, if of sheet steel, shall have a thickness of not less than 0.067 inch (1.70 mm) and shall be protected against corrosion on all surfaces.

9.3 A ballast intended to be supported only by rigid metal conduit, a fixture stud, or similar devices shall comply with the requirements in Section 25, Pullout, Bending, and Twisting Tests.

9.4 A ballast intended for permanent installation and provided with a single, threaded nipple meets the intent of the requirements when the nipple is a standard trade size long enough for two locknuts for assembly to a fixture enclosure. The ballast enclosure shall be evaluated for a construction with a ballast located outside a fixture enclosure.

10 Corrosion Protection

10.1 Type 1 outdoor

10.1.1 An indoor ballast and a Type 1 outdoor ballast enclosure of iron or steel shall be protected against corrosion.

10.1.2 An indoor ballast and a Type 1 outdoor ballast are considered to be protected against corrosion when completely coated with paint.

10.1.3 Both the inside and outside surfaces of an indoor ballast and a Type 1 outdoor ballast shall be protected against corrosion, except that corrosion protection need not be applied to:

a) The interior of an enclosure that is completely compound-filled.

b) Flat metal surfaces that are tightly clamped together.

c) Core surfaces that are not exposed.

d) Simple cut or sheared edges and punched holes.

10.2 Type 2 outdoor

10.2.1 A Type 2 outdoor ballast enclosure of iron or steel shall be protected against corrosion, except for the interior of a compound-filled section, by one of the methods specified in (a) – (c) or by other coatings that are shown to provide equivalent protection. Also see 10.2.2 – 10.2.4.

a) Hot-dip mill-galvanized sheet steel conforming with the coating designation G60 or A60 in Table I of the 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 specification. The weight of the zinc coating may be determined by any acceptable method; however, in case of a question, the weight of coating shall be established in accordance with the Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81.

b) For a zinc coating, other than that provided on hot-dip 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), the thickness of the coating shall be established by the metallic-coating thickness test (see 27.1). An annealed coating shall also comply with 10.2.2.

c) Two coats 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 test if considered necessary.

10.2.2 An annealed coating on sheet steel that is bent or similarly formed after annealing shall additionally be painted in the bent or formed area if the bending or forming process damages the zinc coating.

10.2.3 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible under 25-power magnification, the zinc coating is to be considered damaged. Simple sheared or cut edges and punched holes are not to be considered formed, but extruded and rolled edges and holes are to conform with 10.2.2.

10.2.4 With reference to 10.2.1 and 10.3.1, other finishes (including paints, special metallic finishes, and combinations of the two) may be accepted when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment), conforming with 10.2.1 (a) or 10.3.1 indicate that they provide equivalent protection. Among the factors that are to be taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide/sulphur dioxide/air mixtures, moist hydrogen sulphide/air mixtures, ultra-violet light, and water.

10.3 Weatherproof

10.3.1 A weatherproof ballast enclosure of iron or steel shall be protected against corrosion by one of the methods specified in item (a) – (e) or by other coatings that are shown to provide equivalent protection. See also 10.2.2 – 10.2.4.

a) Hot-dip mill-galvanized sheet steel conforming with the coating designation G90 in Table I of the 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 specification. The weight of zinc coating may be determined by any acceptable method; however, in case of a question, the weight of coating shall be established in accordance with the Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90-81.

b) For a zinc coating other than that provided on hot-dip mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm), the thickness of the coating shall be established by the metallic-coating thickness test (see 27.1). An annealed coating shall also comply with 10.2.2.

c) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the metallic-coating thickness test (see 27.1).

d) A zinc coating conforming with 10.2.1 (a) plus one coat of an organic finish of the epoxy 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 considered necessary.

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 thickness of the cadmium coating shall be established in accordance with the metallic-coating thickness test (see 27.1). The paint shall be as specified in 10.2.1 (c).

11 Power-Supply and Load Connections

11.1 Terminal and lead wire compartments

11.1.1 A terminal or splice compartment for the connection of the source of supply and lamp lead wire shall provide field wiring space for the incoming wires and splices to the ballast lead wires. See 11.1.2.1.

11.1.2 The field wiring compartment volume shall be at least the sum of the number of the specific wire volume allowances from Table 11.1, multiplied by the number of specific wire sizes. See Section 27A, Volume Method of Measurement for the procedure to determine the field wiring compartment volume.

Table 11.1
Conductor size for determination of the minimum terminal or splice compartment volume

Size of conductor, AWG	Conductor volume in	
	in^3	(cm^3)
18	0.5	(8.2)
16	0.6	(9.8)
14	0.75	(12.3)
12	1.0	(16.4)
10	1.7	(27.9)
Example: An autotransformer ballast has a 120/277 input. All ballast wires are 18 AWG. There is a 277 volt tap, a 120 volt tap, a common connection to the primary and secondary winding, and a lamp connection. There are two incoming 12 AWG supply wire connections, there are two incoming 18 AWG wires for the lamp connection Needed volume = 6 x 0.5 + 2 x 1.0 = 5 in^3 = 81.95 cm^3		

11.1.2.1 The wire count shall include:

a) Branch circuit wires entering a terminal or wire compartment;

b) Lamp wires entering a terminal or wire compartment;

c) Grounding wires provided with the ballast;

d) Ballast wires for the supply and alternate taps;

e) Ballast wires for the lamp;

f) Ballast wires for a capacitor, when the capacitor is externally connected; and

g) Any accessory control wires.

11.1.3 There shall be no openings in a terminal or splice compartment other than those required for drainage, ballast mounting, wiring, or ventilation.

11.1.4 If threads for the connection of conduit are tapped all the way through a hole in a box wall, or if an equivalent construction is used, there shall not be fewer than 3-1/2 or more than 5 threads in the metal. The construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in a box wall, conduit hub, or the like, there shall not be fewer than five full threads in the metal. There shall be a smooth well-rounded inlet hole for the conductors. The hole shall provide protection to the conductors equivalent to that provided by a standard conduit bushing. It shall have an internal diameter approximately the same as that of the corresponding trade size of rigid metal conduit. See 7.2.3.

11.1.5 If a knockout or hole is provided for the field connection of a wiring system, the knockout or hole shall be surrounded by a flat surface. The surface shall have enough area to permit the assembly to the ballast of a length of standard rigid steel conduit, of the largest size that the knockout or hole will accommodate, by means of a hexagon-shaped locknut.

11.1.6 The minimum diameter of the flat surface surrounding knockouts of the 1/2-, 3/4-, and 1-inch trade sizes shall be 1-5/32, 1-29/64, and 1-13/16 inches (30.4, 36.9, and 46.0 mm), respectively.

11.1.7 Knockouts shall be so secured in place that they can be removed readily without distortion of the enclosure and that they remain in place during regular handling.

11.1.8 A ballast intended for use with open wiring shall have a noncombustible, nonabsorptive insulating bushing secured in position in each opening for the entrance of a supply lead. The spacing between lead openings shall not be less than 1/4 inch (6.4 mm) and the spacing between lead openings and the plane of support shall not be less than 1/2 inch (12.7 mm).

11.1.9 The insulating bushings may be of porcelain, fiber, phenolic, or urea composition, or of other insulating material that is found by investigation to be acceptable for the purpose. A bushing of soft rubber or of hot-molded shellac and tar composition is not acceptable.

11.2 Wiring terminals

11.2.1 In these requirements, wiring terminals are those connections which are made in the field when a ballast is installed.

11.2.2 If a ballast is intended for mounting on an outlet box, wiring terminals that are inside the box after the ballast is installed shall be so located or recessed that contact between the terminals and wires inside the box is unlikely after the ballast is installed.

11.2.3 A wiring terminal shall be provided with a soldering lug, pressure wire connector, wire-binding screw, or wire-binding stud. A soldering lug or pressure wire connector shall be firmly held in place by a bolt or a screw.

11.2.4 The terminal plate and the wire-binding screw or stud and nut of a wiring terminal shall be of nonferrous metal. A No. 10 (4.8 mm diameter) or larger wire-binding screw may be of iron or steel if plated. Copper and brass are not acceptable for plating of a steel wire-binding screw. Cadmium or zinc is an acceptable plating.

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

11.2.6 A wire-binding screw or stud shall not be smaller than No. 8 (4.2 mm diameter) nor shall it have more than 32 threads per inch (per 25.4 mm).

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

11.2.8 A terminal intended for the connection of a grounded power-supply conductor shall be:

a) Identified by a plating substantially white in color (such as nickel);

b) Of a metal that is substantially white in color;

c) Otherwise colored white, marked with letters "WH" or "COM"; or

d) Identified on an attached wiring diagram in some manner. For example, the location of the terminal on the diagram directly corresponds with the terminal location in the unit itself.

11.3 Lead wires and splices

11.3.1 A ballast lead wire provided for the field supply connection or output connection shall be a copper conductor, with or without tinning, and either:

a) Acceptable for use as fixture wire in accordance with Article 402 of the National Electrical Code, NFPA 70, or

b) Have conductor insulation acceptable for the temperature and voltage involved, but not less than 90°C and 300 volts, respectively.

Fixture wire will be printed on its surface indicating its type. All other wire shall be considered rated 90°C and 300 volts, unless it is printed on its surface indicating a higher temperature or voltage.

11.3.2 In reference to the wire specification in 11.3.1 a wire with a rubber insulation, other than silicone rubber, shall have an overall braid.

11.3.3 Thermoplastic insulated wire shall not be used for a ballast lead wire unless its acceptability for the purpose is proven by an appropriate investigation. The investigation typically is to include a consideration of the strain-relief method used, as well as the effects of the varnishing and compounding operations on the insulation of the lead.

11.3.4 The lead wire integral to a General-Use ballast shall comply with the following:

a) A unit with an input current of 6 amperes or less shall have a conductor size of at least 18 AWG (0.82 mm^2);

b) A unit with an input current greater than 6 amperes and no more than 8 amperes shall have a conductor size of at least 16 AWG (1.3 mm^2); and

c) A unit with an input current of greater than 8 amperes, shall have a conductor size of at least 14 AWG (2.1 mm^2).

11.3.5 A ballast intended for open wiring shall have lead wires that are not smaller than 14 AWG (2.08 mm^2).

11.3.6 The free length of a ballast lead wire shall be 6 inches (152 mm) or longer.

11.3.7 The connection between a lead wire and the winding or other part of the ballast shall be soldered, welded, or otherwise securely connected within the enclosure. A soldered joint shall be made mechanically secure before being soldered.

Exception: A soldered joint need not be made mechanically secure before soldering provided that both sides of the joint are secured in such a manner that there is no strain on the connection either during manufacturing process or thereafter.

11.3.8 Strain relief shall be provided on a lead wire to prevent stress from being transmitted to the interior wiring or connections of a ballast.

Exception: Lead wires embedded in a compound filled enclosure are to be considered as providing the necessary strain relief.

11.3.9 **Relocated as 11.5.3**

11.3.10 A lead wire intended for the connection of a grounded power-supply conductor shall be:

a) Identified by white or gray color;

b) Marked with the letters "WH" or "COM"; or

c) Identified on an attached wiring diagram in some manner. For example, the location of the lead wire exit on the diagram directly corresponds with the lead wire exit location in the unit itself.

11.4 Bushings

11.4.1 A bushing shall be provided where a lead wire passes through a sheet-metal wall of a ballast, and it shall protect the wire insulation.

11.4.2 An insulating bushing used in a ballast intended for outdoor use shall be a moisture and heat resistant material.

11.4.3 A smooth metal grommet, a turned-over punched hole in sheet metal, an insulating bushing securely held in place, or a smooth hole in an end piece of insulating material is acceptable as a bushing.

11.5 Grounding means

11.5.1 A terminal or splice compartment shall have provision for grounding when the incoming supply is other than metallic conduit. The ground connection means shall be either a pig-tail lead wire or a wiring terminal. A pig-tail lead wire shall be green in color, at least 6 inches (152.4 mm) in length, and equal in gauge to the ballast primary lead wires. A wiring terminal shall comply with the requirements in 11.2. A sheet metal screw shall not be used.

11.5.2 A terminal intended for the connection of the earth grounding supply conductor shall be identified by one of the following methods:

a) Identified by a plating substantially green in color;

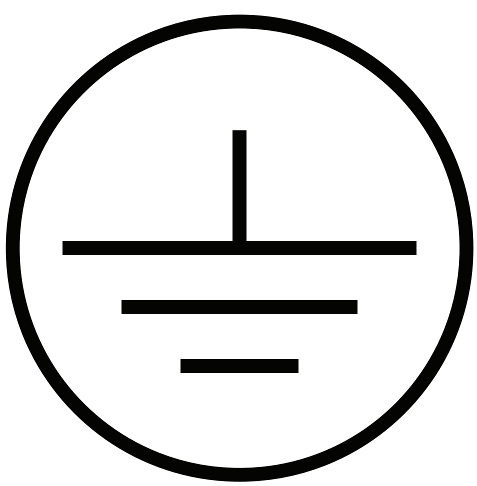
b) A machine thread screw, at least 8-32 thread, with a hexagonal head, green in color;

c) The word "ground", the letters "G" or "GR", or the symbol in Figure 11.1.; or

d) Identified on an attached wiring diagram in some manner. For example, the location of the grounding wire or terminal on the diagram directly corresponds with the grounding wire or terminal location in the unit itself.

Figure 11.1

Grounding symbol



11.5.3 The surface of an insulated lead wire intended for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

11.3.9 relocated as 11.5.3

12 Insulating Materials

12.1 Material for mounting of live parts shall be glass, porcelain, phenolic or cold-molded composition, or other insulation material acceptable for the particular application. Untreated fiber, rubber, wood, and hot-molded shellac or tar compositions shall not be used.

12.2 Coils shall be constructed to provide insulation between the various windings, between the windings and the core, and between the windings and the enclosure.

12.3 Coil insulation, unless inherently moisture-resistant, shall be treated to render it acceptably resistant to moisture. Most film-coated wire is not required to be additionally treated to prevent moisture absorption.

12.4 An insulating liner or barrier of vulcanized fiber or similar materials employed where spacings would otherwise be unacceptable shall not be less than 0.028 inch (0.71 mm) thick, and shall be so located or of such material that it is not likely to be adversely affected by arcing, except that vulcanized fiber not less than 0.013 inch (0.33 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception: Insulating material having a thickness less than that specified above, if upon investigation, it is found to be acceptable for the particular application.

13 Capacitors

13.1 A capacitor shall be provided with a positive means for draining the stored charge so that the difference in residual potential between the capacitor terminals is 50 V or less within 1 minute after the source of supply is disconnected from the ballast. This may be met if the capacitor is located in a closed loop of the circuit and if the loop is not opened by removal of the lamp. The potential is the peak voltage measured between capacitor terminals under any condition of ballast operation– including lamp starting, lamp operation and operation without a lamp.

Exception: A capacitor rated at no more than 1 µf and having a peak potential of not more than 500 V, need not comply with requirement. If the terminals of a capacitor rated more than 0.06 µf, are accessible during servicing, either the capacitor or an adjacent surface shall be marked as indicated in 30.2.8.

13.2 Regarding the discharge capacitor discharge described in 13.1, the value of resistance is determined from,

$$50\,volts = V_c * e^{\frac{-t}{RC}}$$

in which:

R is the resistance in ohms

C is the capacitance in farads

t is 60 seconds

V_c is the voltage on the capacitor

e is base e

13.3 The voltage rating of a capacitor shall not be less than the rms potential developed across its terminals under any condition of ballast operation as described in 13.1, except that the voltage across the terminals of a capacitor connected in series with the lamp may exceed the nominal voltage rating of the capacitor by 40 percent for the duration of the lamp starting cycle.

13.4 Capacitors shall be marked as indicated in 30.2.7. The peak voltage rating is to be considered 1.414 times the marked rms voltage.

13.5 A power capacitor employing a dielectric medium of wax or of liquid shall comply with the requirements for protected oil-filled capacitors in the Standard for Capacitors, UL 810, and shall be used within its rated voltage.

13.6 An oil-filled power capacitor shall be rated not less than the maximum available fault current (AFC) to which it may be subjected, as follows:

a) If connected across the ballast source of supply, 5000 amperes (AFC), or

b) The maximum current available to the capacitor under capacitor short circuit conditions or under ballast operation, which ever is greater, as determined by investigation. The ballast operating conditions are to include:

1) Normal operation with the lamp or lamps for which it is marked, and

2) Abnormal operations without the lamps.

In lieu of determining the maximum current by test when the capacitor is in series with the lamp, the fault current rating of three times the normal lamp current may be used.

13.6.1 A power capacitor employing a dry-metallized film construction and located outside the ballast enclosure shall comply with the construction requirements as described in the Standard for Capacitors, UL 810, and shall be used within its rated voltage.

13.7 A dry-metallized film capacitor operating at a voltage of 330 volts or less is not required to have a maximum available fault current rating. A dry-metallized film capacitor operating at a voltage of more than 330 volts and connected across the supply shall be subjected to a special investigation to determine the need for a fault current rating.

13.8 A dry-metallized film capacitor operating at a voltage of 600 volts or less is not required to have a maximum available fault current rating when the capacitor is connected in series with the lamp and secondary of a constant wattage autotransformer ballast circuit.

14 Wiring Devices

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

15 Spacings

15.1 Spacings through air (clearance) and over surface of insulating material (creepage distance) between:

a) Uninsulated live parts of opposite polarity, and

b) An uninsulated live part and a dead metal part that may be grounded, a metal part exposed to contact by persons, or a metal surface on which the ballast is mounted as intended, shall be not less than indicated in Table 15.1.

15.2 At terminal screws and studs to which connection may be made in the field as mentioned in 11.2.3, the spacings shall not be less than those shown in Table 15.1 when the connectors or lugs are in such position that minimum spacings – opposite polarity and to dead metal– exist when the terminals are turned 30 degrees toward each other, toward other uninsulated parts of opposite polarity, or toward grounded metal parts.

15.3 Requirements for insulation used in lieu of spacings are given in Section 12, Insulating Materials.

Table 15.1
Spacings

Potential in V RMS	Minimum spacings in inches (mm)[a]			
	Through air		Over surface	
0 – 50	1/16[b]	(1.6)[b]	1/16[b]	(1.6)[b]
51 – 125	1/8[b,c]	(3.2)[b,c]	1/4[c]	(6.4)[c]
126 – 250	1/4[c]	(6.4)[c]	3/8[c]	(9.5)[c]
251 – 600	3/8[c]	(9.5)[c]	3/8[c]	(9.5)[c]
601 – 1000	3/8	(9.5)	1/2	(12.7)
1001 – 2500	3/4	(19.0)	3/4	(19.0)

[a] Spacings may be less than indicated, provided that a conformal coating or encapsulation is used, but not less than 1/32 inch (0.8 mm) in any case.

[b] These spacings apply only at other than wiring terminals as defined in paragraph 11.2.1. At wiring terminals, the minimum spacings shall be 1/4 inch (6.4 mm).

[c] Film–coated wire is to be considered an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) measured over surface and through air between film–coated wire that is rigidly supported and held in place on a coil and a dead metal part is acceptable where the potential involved does not exceed 600 V rms.

16 Thermal Protection of Ballasts

16.1 A thermally protected ballast shall be provided with a protector that will open the power-supply circuit and shall be marked in accordance with 30.2.10.

16.2 A ballast that is intended for recessed installation shall:

a) Be provided with thermal protection,

b) Comply with the Recessed Use Abnormal Temperature Test, Section 22, and

c) Be marked in accordance with 30.2.10 and 30.2.11.

16.3 If a ballast has a supply lead or terminal intended to be grounded, the protector shall not open the side of the line intended to be grounded.

16.4 The thermal protector shall comply with all of the following:

a) Be either an automatically reset thermal protector or a thermal cut-out (thermal fuse).

b) Have a voltage rating not less than the input voltage rating of the ballast.

c) Have a current rating not less than the input current rating of the ballast.

d) Have a temperature rating not more than 20°C (36°F) above the ballast coil insulation system temperature rating.

16.5 An automatically reset thermal protector shall comply with the requirements for fluorescent-lamp-ballast protectors in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, including the 200-A Limited-Short-Circuit Test. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

16.6 A thermal cut-out shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691, including the Limited-Short-Circuit Test.

16.7 The protector or protectors shall be located within the ballast so as to be:

a) Protected against mechanical damage, and

b) Difficult to remove or tamper with without destroying the ballast.

17 Polymeric Materials

17.1 A polymeric material, thermoplastic or thermosetting, used to provide all or part of the enclosure for electrical parts shall comply with 17.2 – 17.4.

17.2 Insulating material used as any part of an enclosure shall comply with the requirements for classifying materials as V-0 in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

17.3 A nonmetallic enclosure shall have mechanical strength and durability and shall resist the abuses likely to be encountered during installation, intended use, and service. The mechanical strength shall be at least equivalent to a sheet-metal enclosure of the minimum specified in 7.1.4. The enclosure shall protect persons from a risk of electric shock and the material shall not create or contribute to a risk of fire or injury to persons.

17.4 Among the factors that are to be taken into consideration when judging the acceptability of a nonmetallic enclosure are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility,

e) Resistance to arcing,

f) Resistance to temperatures to which the material might be subjected under conditions of normal or abnormal use, and

g) Aging characteristics.

PERFORMANCE

18 General

18.1 For the purpose of these tests, rated voltage is to be considered 120, 208, 240, 277, or 480 V unless the ballast is intended for other system voltages, in which case, rated voltage is to be considered the marked voltage or the mid-point of a range.

18.2 To determine compliance with the requirements for leakage current, input, temperature, dielectric voltage-withstand, and burnout tests, a representative sample shall be subjected to the tests indicated in the order given, see Sections 19 – 24.

18.3 The load for the leakage current, input, and heating tests is to consist of a lamp(s) of the type for which the ballast is intended to be used. Any lamp ballast and capacitor required are to constitute a nominal system. A nominal system is to be considered to exist, with the system stabilized at rated voltage, when the lamp wattage and voltage are within ±5 percent of the ballast rating in accordance with the ANSI C78 series standards or the manufacturer's data sheet.

19 Leakage Current Tests

19.1 The leakage current of a ballast when tested in accordance with 19.3 – 19.7 shall not be more than 0.75 mA.

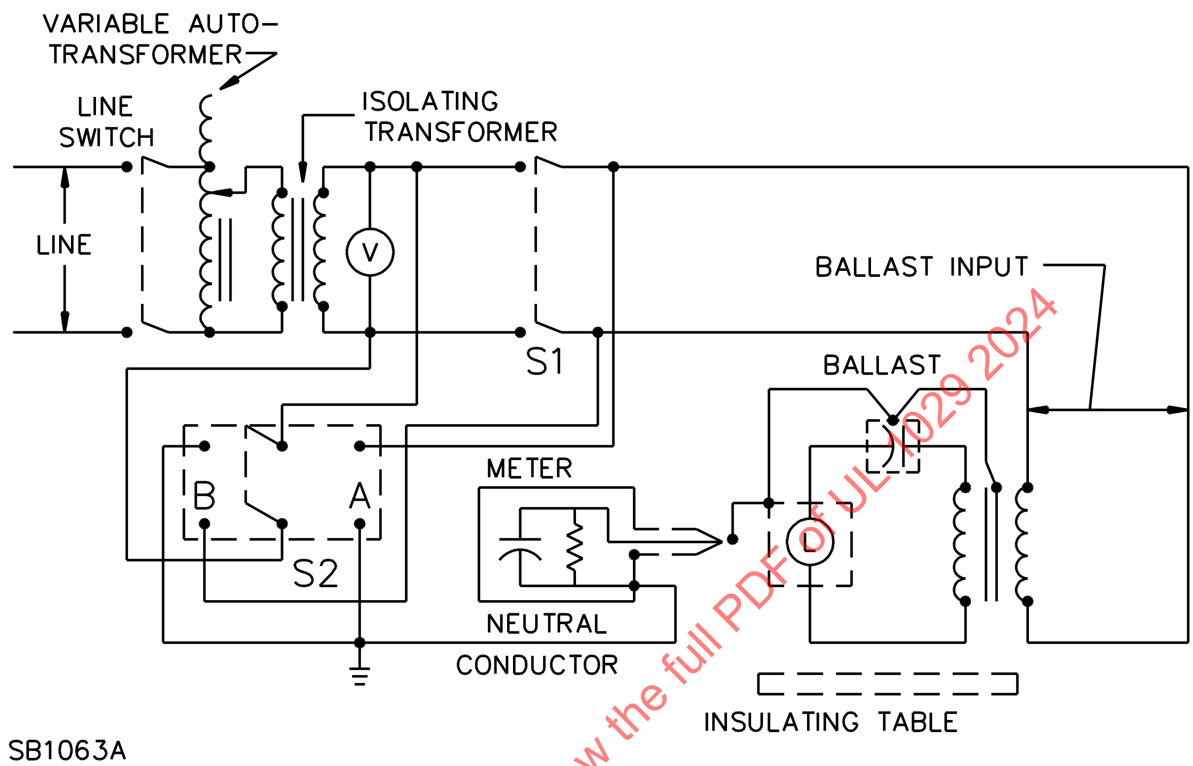
19.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of a ballast and ground.

19.3 A component ballast is to be tested as a separate unit, or mounted within a metal luminaire as intended. If tested as a separate unit, all metallic parts, including capacitors, that would usually be in contact with the luminaire enclosure shall be tied together electrically to form a common potential point to which the test probe is to be applied (see Figure 19.1). If the ballast is to be tested mounted in a metal luminaire, the luminaire enclosure is to serve as the common potential point for the test probe (see Figure 19.2).

19.4 An independent (component) ballast, which consists of an enclosure containing a core and coil assembly plus capacitors and other related ballast components, is to be tested as shown in Figure 19.2. An independent ballast with a nonmetallic enclosure is to be tested by using metal foil with an area of 10 by 20 cm in contact with the enclosure surface as an electrode for the test probe.

Figure 19.1

Circuit for leakage-current test component ballast tested separately



19.5 The measurement circuit for leakage current is to be as shown in Figure 19.1 or Figure 19.2. The defined measuring instrument is as described in items (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of 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 μf.

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

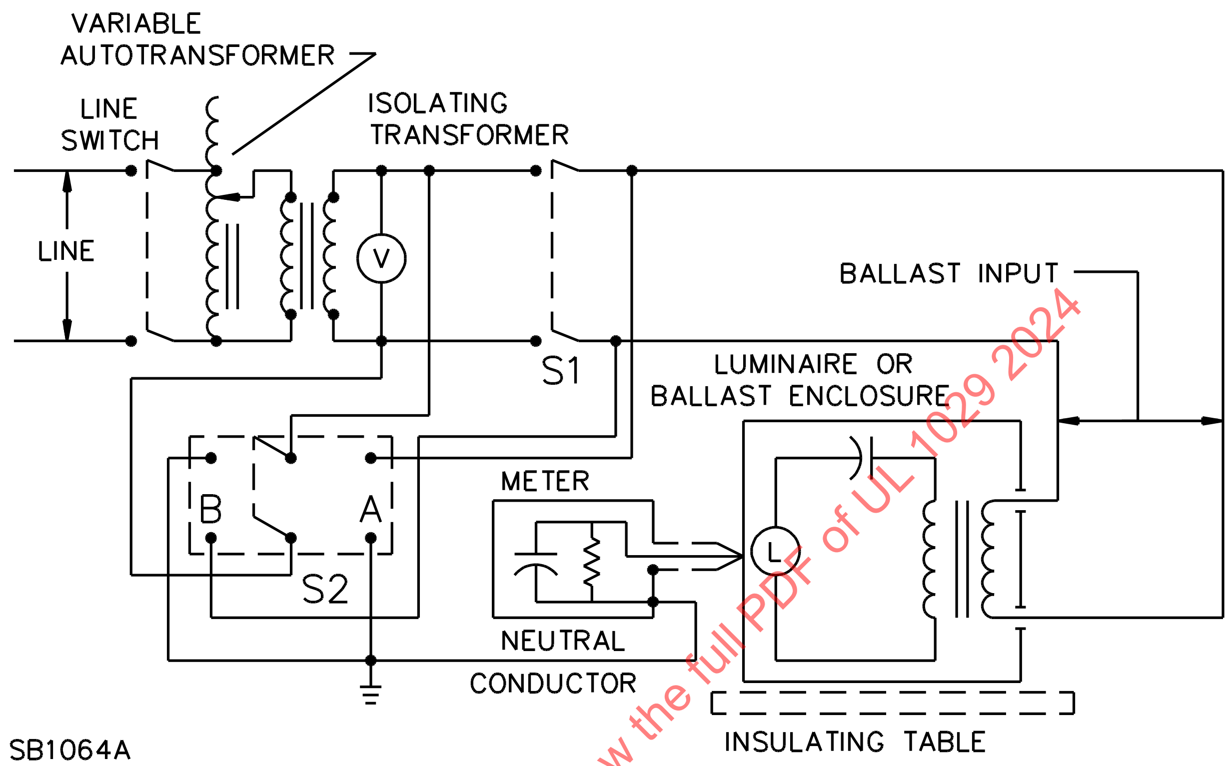
c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-μf capacitor to 1500 ohms. At an indication of 0.75 mA, the measurement is to have an error of not more than 5 percent at 60 Hz.

d) Unless the meter is being used to measure leakage from one part of a ballast to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

19.6 The test circuit is to employ an isolating transformer. The neutral conductor in Figure 19.1 and Figure 19.2 is to be connected to ground. The switch S2 is to have a neutral off position.

Figure 19.2

Circuit for leakage-current test ballasted luminaire or independent ballast



19.7 A sample of the ballast is to be tested for leakage current in a room ambient of 25 ±5°C (77 ±9°F). The supply voltage is to be adjusted to rated voltage and frequency. The test sequence with reference to the measuring circuit in Figure 19.1 or Figure 19.2 is to be as follows:

a) With switch S1 in the off position and switch S2 in the neutral position, close the line switch and adjust input voltage to rated ballast input voltage.

b) With switch S1 in the off position, switch S2 is to be transferred to position A and the leakage current is to be measured. Switch S2 is then to be transferred to position B and the leakage current measured.

c) Switch S2 is to be returned to the neutral off position and switch S1 is to be closed. Switch S2 is to be transferred to position A and the leakage current measured within 5 seconds. Switch S2 is then to be transferred to position B and the leakage current measured within 5 seconds after transfer.

d) With switch S2 in the neutral off position, the ballast is to be operated until constant temperatures are obtained. Switch S2 is to be transferred to position A and the leakage current measured. Switch S2 is then to be transferred to position B and the leakage current measured.

e) Switch S2 is to be returned to the neutral off position and switch S1 turned off. Switch S2 is to be transferred to position A and the leakage current measured. Switch S2 is then to be transferred to position B and the leakage current measured.

f) Switch S2 is to be returned to the neutral off position and switch S1 turned on. Before the lamp restarts, switch S2 is to be transferred to position A and the leakage current measured. Switch S2 is then to be transferred to position B and the leakage current measured.

20 Input Test

20.1 The current input, the measured output voltage, and the measured voltage to ground shall not be more than 110 percent of their respective marked ratings when the ballast is controlling lamps of any number and size for which it is marked, the ballast is energized at the input voltage and frequency in accordance with 18.1, and the lamp operation is in accordance with 18.3.

Exception: The current input measured during lamp starting and lamp out conditions shall be:

a) Not more than 125% of the marked current rating for normal ballast operation; or

b) Not more than 110% of the marked current rating for these lamp conditions.

21 Temperature Test

21.1 General

21.1.1 When operated as detailed in 21.1.2 – 21.2.4, the temperature on or within a ballast shall not be greater than the limits given in Table 21.1, except as indicated in 21.1.3 and 21.2.3.

21.1.2 Requirements relating to temperature are based on an ambient air temperature of 25°C (77°F). A temperature test may be performed at any ambient-air temperature within 20 – 30°C (68 – 86°F) and the variation from 25°C is to be added to or subtracted from the observed temperature readings. When an enclosed ballast is intended for high ambient temperature use [40, 55, 65, 75, or 90°C (104, 131, 149, 167, or 194°F) – see 30.2.6], it shall be tested in that ambient air condition if possible. If such a facility is not available, the full difference between the test ambient air and the rated ambient air is to be used to determine final temperature. An open core-and-coil type ballast is also subject to a temperature test for the purpose of determining the temperature code designation that is explained in Table 30.2, although the ballast is in an ambient air temperature of 25°C.

21.1.3 In reference to Table 21.1, the following explanation pertains to coil insulation temperatures. The insulation class is the internal hot spot temperature limit. The average coil temperature is obtained by means of the change of resistance method. The outer surface of the ballast coil is obtained by means of thermocouples. The outer surface will be lower than the average temperature because of cooling to the ambient air. The outer surface temperature may exceed the value given in Table 21.1 provided the average temperature is not exceeded. At the point on the surface of a coil of a ballast where the temperature is affected by another source of heat, the temperature shall be measured by thermocouples mounted on the outer coil surface. The maximum surface temperature shall not exceed the insulation class hot spot temperature – 105, 130, 155, 180, 200, 220, or 250°C (221, 266, 311, 356, 392, 428, or 482°F) for a Class 105, 130, 155, 180, 200, 220, or 250 insulating system, respectively.

Table 21.1
Maximum acceptable temperature

Component or location	°C	°F
1. Point of connection of supply wires[a]	60	140
2. Sealing Compound	f	f
3. Coils of ballast[b]		
Class 105 insulation systems		
Thermocouple method	90	194

Table 21.1 Continued on Next Page

Table 21.1 Continued

Component or location	°C	°F
Resistance method	95	203
Class 130 insulation systems		
Thermocouple method	110	230
Resistance method	120	248
Class 155 insulation systems		
Thermocouple method	135	275
Resistance method	140	284
Class 180 insulation systems		
Thermocouple method	150	302
Resistance method	165	329
Class 200 insulation systems		
Thermocouple method	170	338
Resistance method	185	365
Class 220 insulation systems		
Thermocouple method	185	365
Resistance method	200	392
Class 250 insulation systems		
Thermocouple method	215	419
Resistance method	230	446
4. Enclosure of enclosed ballast[c]	90	194
5. Case of capacitor	d	d
6. Internal wiring[e]	60	140

[a] The temperature at the point of connection of supply wires may exceed the limit shown if the ballast is marked in accordance with 30.2.4.

[b] Some types of coil construction may have a smaller difference of temperature between the thermocouple method and the resistance method than conventional types of coil winding. In such cases, the limiting values shown may be exceeded if an investigation shows that the hottest-spot (limiting) temperature for the insulating system class is not exceeded.

[c] See 21.2.3.

[d] The marked temperature rating of a capacitor of a ballast, but not more than 90°C (194°F) unless the capacitor is found to be acceptable for a higher temperature by appropriate investigation.

[e] The limitation on rubber or thermoplastic insulation does not apply to wires that are investigated and found to have appropriate heat-resistance properties.

[f] For other than a thermosetting material, the maximum sealing-compound temperature, when corrected to a 25°C (77°F) ambient temperature, is not to be higher than 15°C (27°F) less than the softening point of the compound as determined by the ball and ring method, ASTM E28-67(1982).

21.1.4 The temperature of a winding is to be calculated by the following formula:

$$T_H = \frac{R_H}{R_C}(T_C + k) - k + (T_{AT} - T_A)$$

in which:

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

T_H is the temperature of the coil in degrees C at the end of the test, normalized as specified in 21.1.2 for the target ambient temperature;

R_H is the resistance of the coil, in ohms, at the end of the test;

R_C is the resistance of the coil, in ohms, at the beginning of the test;

T_{AT} is the target ambient temperature, normally 25 degrees C, unless the device is being tested for a higher ambient rating as discussed in 21.1.2, and then T_{AT} would be 40, 55, 65, etc. degrees C;

T_A is the temperature of the ambient air in degrees C at the end of the test when RH is measured; and

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

As it is generally necessary to de-energize the winding before measuring R_H, the value of R_H 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 showing the resistance values as a function of time may then be extrapolated to give a value of R_H at shutdown.

21.1.5 Except in those cases in which it is specifically stated that temperature determinations are to be made by the resistance method, temperatures are to be measured by means of thermocouples.

21.1.6 A thermocouple-measured temperature is to be considered constant if three successive readings, taken at not less than 15-minute intervals, indicate no upward change.

21.1.7 The junction of the thermocouple is to be firmly secured with the point on the surface on which the temperature is to be measured. The thermocouple is to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). Thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan (Type J) wires, and a potentiometer- or electronic-type instrument; and such equipment is to be used whenever a referee temperature measurement by thermocouples is necessary. Thermocouples consisting of chromel-alumel (Type K) or copper-constantan (Type T) wires may be used if it is determined that high frequency ballast operation results in eddy current heating of iron and constantan thermocouples.

21.2 Methods

21.2.1 The ballast is to be operated continuously at rated primary voltage (see 18.1) or at any voltage within a marked voltage range and rated frequency with the intended lamp or lamps, with the frame or enclosure grounded, and until constant temperatures are attained. For examples of various methods of installation that would simulate actual usage, see 21.2.2 – 21.2.4 and 22.1.1 – 22.1.10. Marking on the ballast or intended mounting of the ballast indicates which method is to be used.

21.2.2 A ballast is to be supported in the intended manner of use. If the position of mounting is marked on the ballast, that position is to be used. Otherwise, the ballast is to be mounted in the position that results in the maximum heating – considering wiring compartments, capacitors, and the like.

Exception: A ballast that is intended to be an integral part of a fixture or marked for mounting only on a metal surface is to be bench tested while supported on two wooden cleats that provide edge support only and that are not less than 2 inches (51 mm) high.

21.2.3 The temperature on the enclosure of a ballast intended for wall mounting may exceed 90°C (194°F) as specified in Table 21.1 provided it is not greater than 105°C (221°F) during the temperature test if:

a) The temperature test is conducted with the ballast mounted in an alcove as defined in 21.2.4 and Figure 21.1,

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

c) The ballast is marked in accordance with 30.2.5.

21.2.4 The side wall and top of the test alcove depicted in Figure 21.1 are to be of 3/8-inch (10-mm) fir plywood, and the rear wall on which the ballast is mounted is to be of 3/4-inch (19-mm) plywood. The inner surfaces of the test alcove are to be painted dull black, and the ballast is to be mounted in the intended manner. The horizontal dimensions of the walls and top are to be large enough so that the temperatures attained closely approach those that would result if the dimensions were indefinitely large.

Figure 21.1

Temperature test setup

B – Ballast.

X – Marked minimum spacing between top of ballast enclosure and surface above ballast.

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

22 Recessed Use Abnormal Temperature Test

22.1 General

22.1.1 With reference to 16.2, a ballast intended for recessed installation and operated in the test box described in 22.2.1 – 22.2.3, shall not exceed the limits described in 22.2.4 – 22.2.10.

Exception: A ballast provided with a thermal protector rated at 120 ±5°C (248 ±9°F) or less, need not be subjected to the Recessed Use Test.

22.2 Method

22.2.1 The ballast is to be operated as specified in Section 18, General, and mounted in the test box as described in 22.2.2.

22.2.2 A ballast is to be mounted in a rectangular box built of 1/2-inch (12.7-mm) thick fir plywood, A – D grade or better. The plywood test box is to have dimensions such that each wall is 8-1/2 inches (216 mm) from the nearest point of the ballast enclosure and the top edge of each wall is 8-1/2 inches above the height of the installed ballast enclosure. The top of the box is to be open.

22.2.3 The vertical depth of the insulation shall be 4 inches (102 mm) measured from the inside bottom surface of the test box.

Exception: The initial depth of insulation shall not exceed the height of the top of the ballast.

22.2.4 The test box is initially to be filled with the thermal insulation rated, conditioned, and placed as specified in 22.3.1 – 22.3.4 to a vertical depth as specified in 22.2.3. The test is to be conducted with the ballast, test box, and insulation starting at room ambient air temperature. The ballast is to be operated until the thermal protector trips at least once or the ballast has operated for 7-1/2 hours, whichever occurs first.

22.2.5 If the thermal protector trips within 3 hours of the start of the test, the results are acceptable if the maximum temperature during the 3 hours does not exceed 160°C (320°F) on any part of the ballast in contact with the test box or thermal insulation.

22.2.6 If the thermal protector trips after 3 hours, or does not trip within the 7-1/2 hour test period, the maximum temperatures during ballast operation shall not exceed the temperatures specified in Table 21.1.

22.2.7 If the thermal protector trips after 3 hours, or does not trip within the 7-1/2 hour test period, the thermal insulation vertical depth is to be increased 2 inches (50.8 mm) and the test described in 22.2.4 is to be repeated with the ballast, test box, and the insulation starting at room ambient air temperature.

22.2.8 Retesting with increased depths of insulation is to continue until:

a) The thermal protector trips within 3 hours of the start of the test to determine compliance with 22.2.5,

b) The temperatures in Table 21.1 are exceeded, or

c) The test is conducted with the thermal insulation at a depth of 8-1/2 inches (216 mm) above the highest projection of the ballast.

22.2.9 If it is necessary to increase the depth of insulation to 8-1/2 inches, the thermal protector shall trip within 3 hours of the start of the test to determine compliance with 22.2.5, or the temperature limits of Table 21.1 shall not be exceeded within 7-1/2 hours of the start of the test.

22.2.10 The depth of insulation is to be increased in 2-inch increments except the last increase may be less than 2 inches as required to increase the depth of the insulation to the maximum of 8-1/2 inches above the highest projection of the ballast.

22.3 Insulation

22.3.1 Thermal insulation of the loose-fill type shall be conditioned to the density specified by the insulation manufacturer to obtain a required rated thermal resistance of Rsi 0.56 to 0.678 (R3.2 to R3.85) per inch.

22.3.2 Thermal insulation shall be conditioned, if required, by a blowing or vacuum machine before it is placed around the test ballast. Density shall be verified by placing insulation into a box of known volume and weight, and then weighing the filled box. The difference in weight between the empty and full box, divided by the volume, shall be the insulation density.

22.3.3 The insulation is to be poured into the test box around the ballast enclosure without applying any compacting procedure.

22.3.4 The insulation is to be placed in the space between the test box and ballast enclosure in a uniform manner such that all areas surrounding the mounting brackets, incidental projections on the fixture, and the like, are free of large air pockets or cavities. Small cavities such as 1/2 inch (12.7 mm) high spaces between the brackets and the test box are not required to be filled other than through natural filling as a result of placing the insulation around the area.

23 Dielectric Voltage-Withstand Test

23.1 A high-intensity discharge lamp ballast other than an auto-transformer, while hot from normal operation, shall be capable of withstanding without breakdown, for a period of 1 minute, the application of a 60 Hz essentially sinusoidal potential of:

a) 1000 V plus twice the maximum rated rms voltage of the primary, or 1000 V plus twice the maximum rated rms voltage of the secondary, whichever is larger, between primary and secondary windings.

b) 1000 V plus twice the maximum voltage of that winding, between each winding and dead metal parts that are exposed or are likely to become grounded.

23.2 A high-intensity discharge lamp ballast of the auto-transformer type, while hot from normal operation, shall be capable of withstanding for a period of 1 minute the application of a 60 Hz essentially sinusoidal potential of 1000 V plus twice the maximum rated input rms voltage, or 1000 V plus twice the maximum rated output rms voltage, whichever is larger, between the windings and dead metal parts that are exposed or are likely to become grounded.

23.3 The test potential is to be supplied from a 500 VA or larger capacity testing transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased gradually from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapidly as is consistent with the voltage being correctly indicated by a voltmeter.

24 Burnout Test

24.1 There shall not be any damage to the enclosure nor shall there be emission of flame or molten metal when a high-intensity discharge lamp ballast is operated under the conditions described in 24.2.

24.2 The ballast is to be operated continuously at rated input voltage and frequency with the enclosure and core solidly connected to ground. The condition of operation shall be with the output (lamp) terminals or lead wires open and shorted, in turn. Operation is to be continued for 7 hours or until burnout occurs. The circuit on which the ballast is tested is to be protected by Class H non-renewable fuses at ten times the input current rating of the ballast or the next higher ampere fuse rating but in no case less than 20 amperes. If accessible fuses are provided on the ballast, they are to be replaced with dummy fuses; but inaccessible fuses and thermal-sensitive or current-sensitive protective devices are to remain in the circuit. Opening of the line fuse is considered an acceptable result.

25 Pullout, Bending, and Twisting Tests

25.1 Conduit and fixture connections of a ballast intended for support by rigid metal conduit shall be capable of withstanding, without pulling apart, a pull of 200 lbf (890 N), a bending moment of 600 lbf-in (67.8 N·m), and a torque of 600 lbf-in (67.8 N·m), each applied in turn for a period of 5 minutes.

25.2 The pullout test is to be conducted with the ballast supported by rigid metal conduit in its intended manner of use. The ballast is to support a weight exerting 200 lbf (890 N) for 5 minutes, or if a fixture stud or similar fitting is provided, the weight is to be supported from rigid metal conduit or the equivalent threaded onto this fitting so that the stud and conduit connection are tested simultaneously.

25.3 The bending test is to be conducted with the ballast rigidly supported by means other than conduit fittings. A bending moment of 600 lbf-in (67.8 N·m) is to be applied, for 5 minutes, to the conduit at right angles to its axis. The lever arm is to be measured from the inner end of the threaded section in a conduit-hub or stud-type connection to the point of application of the bending force.

25.4 The twisting test is to be conducted with the ballast rigidly supported by means other than conduit fittings. A torque of 600 lbf-in (67.8 N·m) is to be applied, for 5 minutes, to the conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

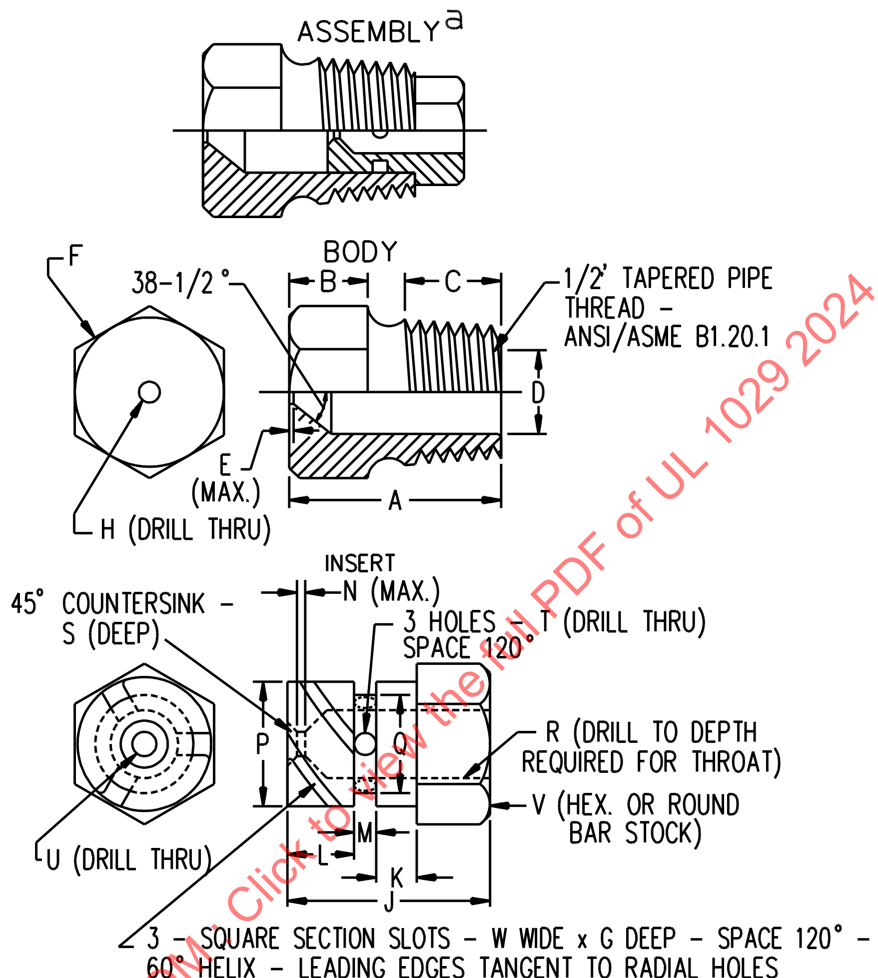
26 Water Spray

26.1 Unless the enclosure of a weatherproof ballast is so constructed that it is obvious that the construction would exclude water when subjected to a water-spray test, the ballast is to be subjected to a water-spray test. The complete enclosure with a short section of the intended wiring system – that is, conduit, EMT, or the like – is to be installed and assembled in the intended manner. The end of the wireway not connected to the ballast is to be plugged and waxed or otherwise treated to prevent the entrance of water. The ballast enclosure is to be mounted and oriented in the intended manner at the focal point of the artificial-rain test equipment illustrated in Figure 26.1 and Figure 26.2. The water pressure is to be adjusted to 5 lbf/in^2 (3.4 N/cm^2) at each spray head.

26.2 The assembly is to be subjected to artificial rain for a period of 1 hour. Upon completion of the test, the ballast is to be wiped dry and examined. There shall not be any significant accumulation of water within the enclosure and water shall not enter the enclosure at a level higher than the lowest live part. Insulated lead wires are not to be considered to be live parts.

Figure 26.1

Rain-test spray head



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

[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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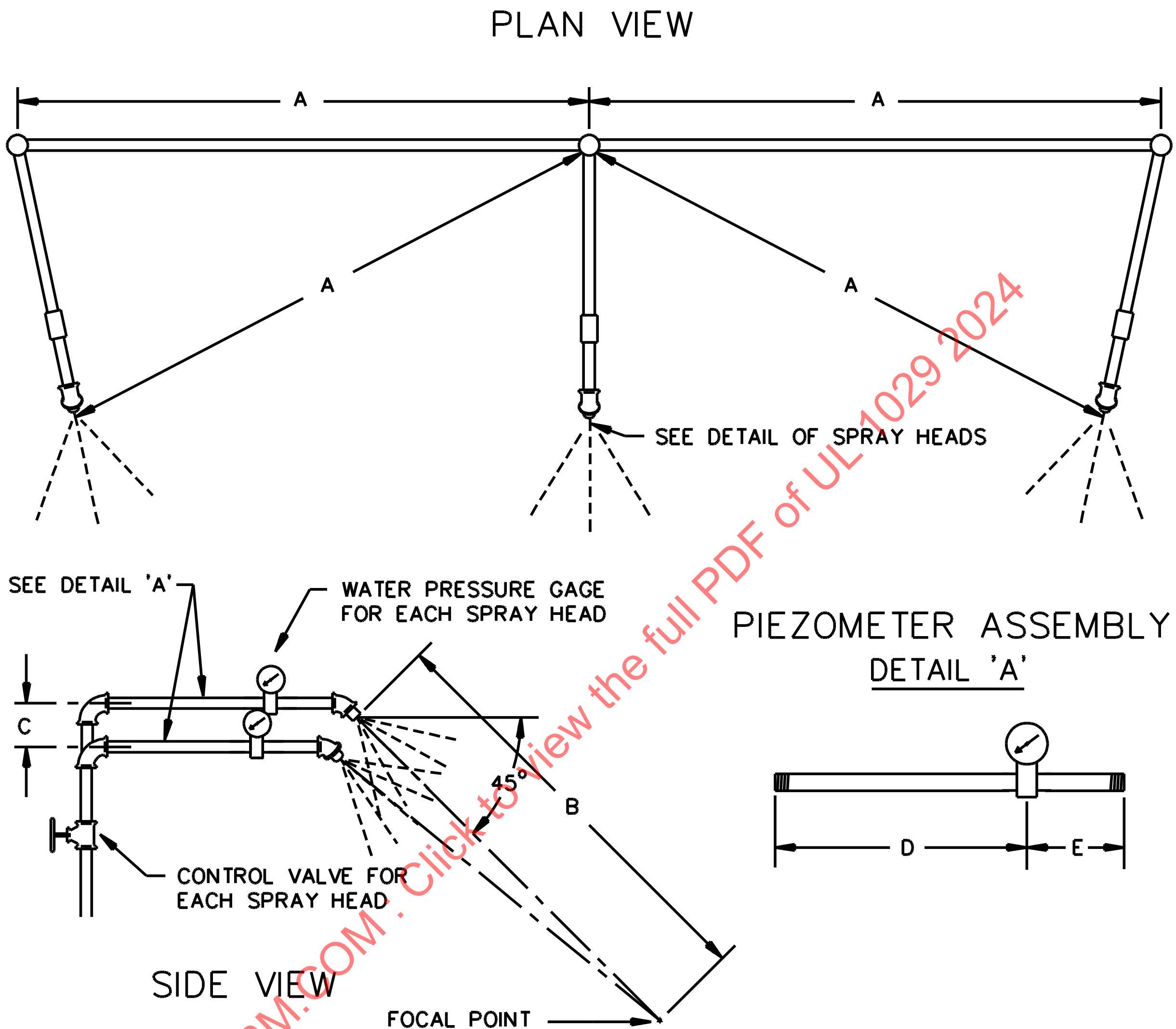
Figure 26.2

Rain-test spray-head piping



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

RT101E

27 Metallic Coating Thickness Test

27.1 The method of determining the thickness of zinc or cadmium coatings by the metallic-coating thickness test is as indicated in items (a) – (h):

a) The solution to be used for the metallic-coating thickness test is to be made from distilled water and 200 g/L of the American Chemical Society reagent grade of chromic acid (CrO^3) and 50 g/L of the American Chemical Society reagent grade of concentrated sulphuric acid (H_2SO_4). The latter is equivalent to 27 mL/L of the American Chemical Society reagent grade of concentrated sulphuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

b) The test solution is to be contained in a glass vessel, such as a separatory funnel, with the outlet equipped with a stopcock and a capillary tube of approximately a 0.025 inch (0.64 mm) inside bore and of a length of approximately 5.5 inches (140 mm). The lower end of the capillary tube is to be tapered to form a tip, the drops from which are to be approximately 0.05 mL each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of drip is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of drip.

c) The sample and the test solution should be kept in the test room long enough to acquire the temperature of the room, which should be noted and recorded. The test is to be conducted at a room temperature of 70 – 90°F (21 – 32°C).

d) Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of appropriate solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care should be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

e) The sample to be tested is to be supported from 0.7 – 1 inch (18 – 25 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested should be inclined approximately 45 degrees from horizontal.

f) After cleaning, the sample to be tested is to be put in place under the orifice. The stopcock is to be opened and the time in seconds is to be measured with a stop watch until the dripping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

g) Each sample of a test lot is to be subjected to the test at three or more points (excluding cut, stenciled, and threaded surfaces) on the inside surface and at an equal number of points on the outside surface at places at which the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

h) To calculate the thickness of the coating being tested, select from Table 27.1 the thickness factor appropriate for the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as noted in (f).

Table 27.1
Coating – thickness factors

Temperature		Thickness factor in 0.00001 inch (0.00025 mm) per second	
°F	(°C)	Cadmium plating	Zinc plating
70	(21.1)	1.331	0.980
71	(21.7)	1.340	0.990
72	(22.2)	1.352	1.000
73	(22.8)	1.362	1.010
74	(23.3)	1.372	1.015
75	(23.9)	1.383	1.025
76	(24.4)	1.395	1.033
77	(25.0)	1.405	1.042
78	(25.6)	1.416	1.050
79	(26.1)	1.427	1.060
80	(26.7)	1.438	1.070
81	(27.2)	1.450	1.080
82	(27.8)	1.460	1.085
83	(28.3)	1.470	1.095
84	(28.9)	1.480	1.100
85	(29.4)	1.490	1.110
86	(30.0)	1.501	1.120
87	(30.6)	1.513	1.130
88	(31.1)	1.524	1.141
89	(31.7)	1.534	1.150
90	(32.2)	1.546	1.160

27A Volume Method of Measurement

27A.1 Unless it is obvious the required volume is exceeded, the volume of a field wiring space for a ballast shall be determined by the amount of water needed to fill the volume of the wiring space. Small amounts of putty are to be used to close any seams or small openings observed in the test sample. The sample is to be positioned so that only a single opening from the field wiring compartment is upward and level. A clean, graduated vessel (pipette or the equivalent) having a volume equal to or greater than the volume of the sample is to be filled with water at room temperature. The water is then to be transferred from the vessel to the sample. The following relationship is to be used:

$$1\ in^3 = 16.39\ cm^3 = 16.39\ ml\ of\ water$$

27B Risk of Electric Shock During Relamping

27B.1 HID lamp ballasts employing double-ended HID lamps shall comply with this test. This test shall be conducted with each lamp for which the ballast is marked, in turn.

27B.2 Prior to energization, the lamps shall be new (e.g., less than 5 hours of operation) and at room temperature (25 ±5 °C). All measurements shall be made using each lamp for which the ballast is marked, in turn.

27B.3 For the tests described in 27B.4, the ballast is to be energized with the input voltage and frequency in accordance with 21.6 of UL 935.

27B.4 One end of the lamp base shall be connected to its intended lampholder contact while the other end of the lamp base shall be considered accessible and shall be connected to the shock hazard measurement meter circuit and, in turn, to earth ground. The test shall be conducted using the following two methods, in turn, that simulate likely contact scenarios.

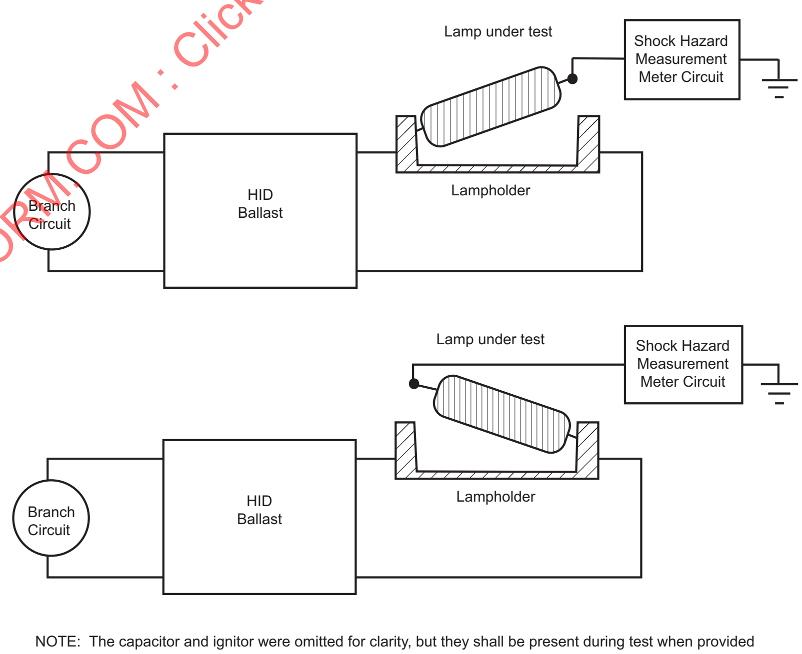
a) Method A – Contact during insertion into a live circuit. The ballast shall be energized with no lamp in the circuit. One end of the lamp shall then be connected to the supply source while the other end of the lamp is connected to the shock hazard measurement meter circuit. Readings shall be monitored for a minimum of 30 seconds, starting immediately after device connection (insertion). The highest reading shall be recorded. If a ballast produces a periodic or transient output outside of this initial 30 second window, then the measurement interval shall be extended as needed to capture and measure this output as well.

b) Method B – Contact during removal from a live circuit. The supply source shall be energized with the lamp in the circuit. One end of the lamp shall then be disconnected from its lampholder and connected to the shock hazard measurement meter circuit. Readings shall be monitored for a minimum of 30 seconds, starting at 1 second after disconnection (removal) from the lampholder. The highest reading shall be recorded. If a ballast produces a periodic or transient output outside of this 30 initial second window, then the measurement interval shall be extended as needed to capture and measure this output as well.

These methods shall be repeated with the lamp connected to the opposite lampholder contact, resulting in four sets of test results for each lamp/ballast combination. See Figure 27B.1.

Figure 27B.1

Risk of Shock During Relamping



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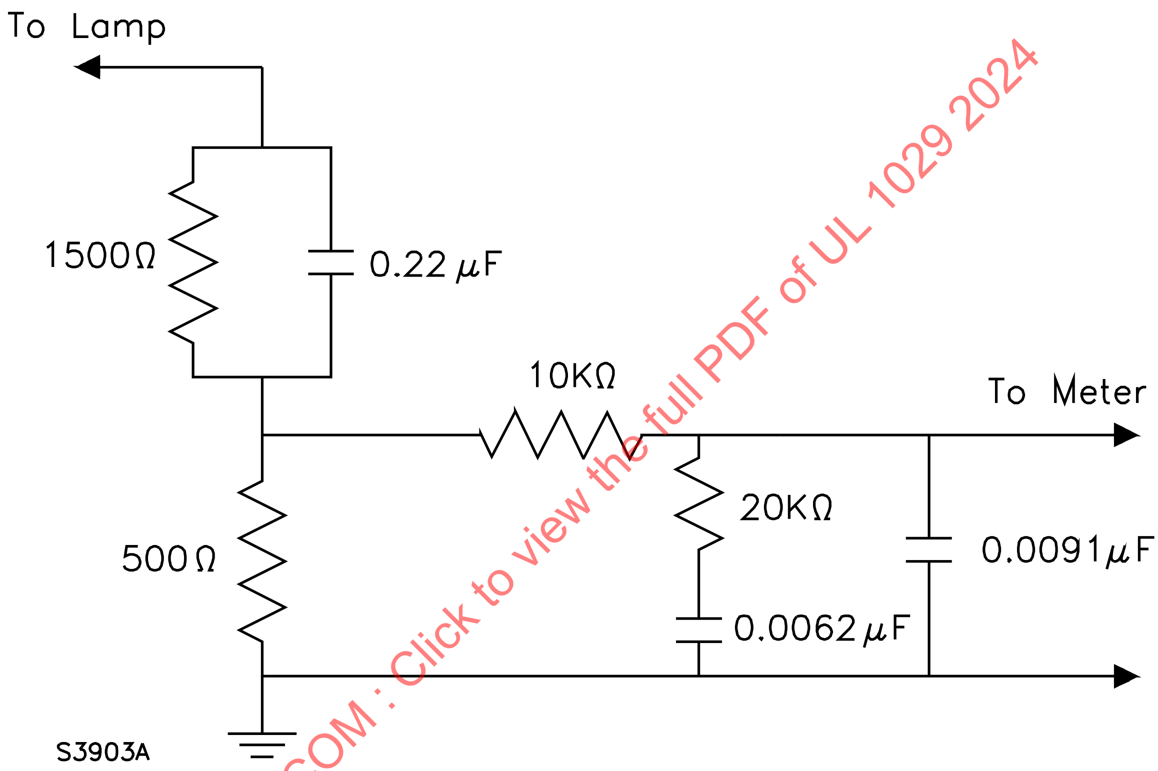
27B.5 The shock hazard measurement meter circuit shall be the let-go response network shown in Figure 27B.2. Alternatively, the let-go response network may be replaced by a noninductive 500 ohm resistor.

27B.6 If the 500 ohm resistor described in 27B.5 causes a "shut-down" mode of operation of an electronic ballast, the value of resistance may be increased, but not more than 2000 ohms, total.

Figure 27B.2

Let-go Response Network



27B.7 The measured values of current shall not exceed the values specified in Table 27B.1, or 27B.8 and Table 27B.2.

Table 27B.1
Shock-current measurements

Frequency (hertz)	Maximum peak M.I.U.[e] when using the network in Figure 27B.2	Maximum current when using a 500 ohm resistor as described in 27B.5[a,b] (milliamperes peak)
		Pin
60 or less	7.07	7.07
180	7.07	8.17
500	7.07	8.64
1000	7.07	10.76

Table 27B.1 Continued on Next Page

Table 27B.1 Continued

Frequency (hertz)	Maximum peak M.I.U.[e] when using the network in Figure 27B.2	Maximum current when using a 500 ohm resistor as described in 27B.5[a,b] (milliamperes peak)
		Pin
2500	7.07	15.71
5000	7.07	23.02
10,000 or more	7.07	43.45[c,d]

[a] Straight-line interpolation between adjacent values in the table is to be used to determine the maximum current values corresponding to frequencies not shown.

[b] To be calculated by determining the peak voltage across a noninductive 500 ohm resistor when using an oscilloscope.

[c] Impulses greater than 43.45 milliamperes peak at the lamp pin are in compliance after further investigation as indicated in note d has been conducted. However, for a rapid determination, a wide-band true rms indicating meter is to be used to determine when a complex waveshape is below 30.7 milliamperes (rms) at the lamp pin. When a spectrum analyzer and a 1000X attenuator probe are used, the analyzer displays the rms voltage of the various component frequencies. For frequencies of 10 Khz and above the maximum values of voltage across the 500-ohm resistor is 15.3 millivolts (-36.3 dBV) at the lamp pin.

[d] Impulse peaks greater than 43.45 milliamperes peak at the lamp pin, including dynamic modes of operation such as starting, are in compliance when after further oscilloscope evaluation, the waveform has been determined to meet the intent of the requirement. Consideration is to include pulse width, height, repetition and rms equivalent, minimum off time such as in a starting sequence and method of body contact for the particular shock-current measurement.

[e] M.I.U. stands for meter indicating units and is the millivolt peak from the meter divided by 500. It is the peak value of a 60 Hz sinusoidal current in mA. It is not a direct indication of the peak leakage current when the frequency is other than 60 Hz. In making the calculation for M.I.U., the meter reading in millivolts is always divided by 500 regardless of frequency.

27B.8 For pulsed waveforms, an oscilloscope shall be used to determine the maximum RMS value for the pulse while taken over the interval of the pulse. To be a pulsed waveform, the pulse must have an "off" time of at least one second. Compliance of the pulse output is to be determined using the time and current limits described in Table 27B.2.

Table 27B.2
Time and current limits

Pulse time duration, seconds (T)	Current limit (rms), mA when using a 500 ohm resistor as described in 27B.5
0.000 001 to 0.004	$I=6.3T^{-0.7}$
0.004 to 0.021	I=300
0.021 to 0.55	$I=20T^{-0.7}$
greater than 0.55	$I=20T^{-0.7}$ or Table 27B.1 whichever gives the greater limit

MANUFACTURING AND PRODUCTION TESTS

28 Production-Line Dielectric Voltage-Withstand Test

28.1 Each ballast shall withstand without electrical breakdown, as a routine production line-test, the application of a potential described in 28.2 and at a frequency within the range of 40 – 70 hertz between:

a) Live parts of the primary winding and dead metal parts that are exposed or are likely to become grounded, and

b) Live parts of the secondary windings and dead metal parts that are exposed or are likely to become grounded.

Exception: Ballasts having no accessible metal parts need not be tested.