UL 935

STANDARD FOR SAFETY

Fluorescent-Lamp Ballasts

UL Standard for Safety for Fluorescent-Lamp Ballasts, UL 935

Tenth Edition, Dated May 21, 2001

Summary of Topics

This revision to ANSI/UL 935 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 October 19, 2018.

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Standard for Fluorescent-Lamp Ballasts

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The most recent designation of ANSI/UL 935 as a Reaffirmed American National Standard (ANS) occurred on December 18, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 935 on February 17, 1983. 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 UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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PART 1 – ALL PRODUCTS

INTRODUCTION

1 Scope

1.1 These requirements cover ballasts of the resistance, reactance, and electronic (high frequency) types for use with fluorescent lamps involving a potential of 2500 volts or less in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 A fluorescent-lamp ballast may be determined by investigation to be acceptable for use, in a fixture or other device, with electric-discharge lamps of other than the fluorescent type.

1.3 Fluorescent self ballasted lamps and ballast adaptors are evaluated using the Standard for Self-Ballasted Lamps and Lamp Adapters, UL 1993. The component ballast is evaluated to requirements in this Standard.

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 – A device that by means of reactance or resistance, singly or in combination, limits the current of a lamp to the required value for proper operation and, where necessary, provides adequate starting voltage; and in the case of rapid start circuits, provides for low-voltage lamp filament heating.

2.3 CHEESECLOTH – Used in abnormal condition tests as an indicator of a fire hazard. Bleached cheesecloth is to be 36 inches (910 mm) wide, running 14 – 15 yards per pound (28 – 30 m/kg), and have what is known to the trade as a count of 32 X 28; that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction).

2.4 CLASS P PROTECTED BALLAST – A ballast that is integrally protected from overheating, where the ballast and protection combination comply with the requirements in this standard.

2.5 COMPACT FLUORESCENT LAMP – A fluorescent lamp of a small compact shape (such as a folded construction) with all contacts terminating in a single base that performs the entire mechanical support function.

2.6 CONDITIONED LAMP – A new lamp that has been operated for a minimum of 100 hours.

2.7 CONVENTIONAL MAGNETIC BALLAST – A ballast that consists of a coil of wire wound on a core and operates at the supply line frequency. A conventional magnetic ballast is either a transformer type or simple reactance type. A power capacitor is able to be provided with the magnetic ballast.

2.8 DEACTIVATED LAMP – A lamp end-of-life failure mode, that is caused by the depletion of the filament emission material so that the lamp cannot be ionized.

2.9 ELECTRONIC BALLAST – A ballast involving high frequency switching that is controlled by active components (transistors, thyristors, and the like), and with the lamp ballasting impedance provided by a series capacitive or inductive reactance appropriate for the high switching frequency. The lamps and ballasting impedance may be connected either directly or by means of an isolating transformer to the switching transistors.

2.10 FIXED BALLAST – A ballast intended to be permanently connected electrically.

2.11 INSTANT-START CIRCUIT – A circuit that employs a high open-circuit voltage to start lamps that usually have a single contact at each end.

2.12 LEAD-LAG CIRCUIT – A two-lamp circuit that has one lamp in series with an inductor and the other lamp in series with a capacitor to attain a high power factor. Generally, it may be part of either an instant-start or preheat circuit.

2.13 LIVE PARTS – Metallic parts intended to carry voltage or current. A part that is connected to a grounded (neutral) supply conductor is determined to be a live part.

2.14 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in millivolts RMS, in the measurement instrument in Figure 23.2, divided by 500 ohms. The instrument indication is equal to the RMS value in milliamperes when the frequency is 60 Hz (sinusoidal current). The reading is not always a direct indication of the RMS or other common amplitude quantifier of leakage current when the leakage current is of complex waveform or frequency other than 50 or 60 Hz.

2.15 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.

2.16 PREHEAT CIRCUIT – A circuit with a ballast connected in series with a lamp, and having a manual or automatic starter that functions to cause an initial heating of the lamp filaments prior to ionizing the lamp. The starter, when closed, connects the two lamp filaments in series in the ballast circuit.

2.17 RAPID-START CIRCUIT – A circuit employing continuously heated lamp filaments, along with an open-circuit voltage for the ballast to start a lamp without a starter. The lamps usually have miniature or medium bi-pin contacts or specific sockets (for example, circular lamps) for sizes smaller than 40 watts or recessed contacts for the larger 800 and 1500 milliampere sizes. A metal reflector connected to ground is needed near the lamps to ensure starting.

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

a) Inductive reactance;

b) Capacitive reactance; or

c) Both inductive and capacitive reactance.

2.19 REACTOR (SIMPLE REACTANCE) BALLAST – A reactance type ballast in which the lamp ballasting impedance is provided by a single coil inductor – not a transformer or inductor with additional components.

2.20 RESISTANCE BALLAST – A ballast in which the impedance is provided by a resistor or resistance wire.

2.21 TWO-WINDING TRANSFORMER (ISOLATING TYPE) BALLAST – A ballast having independent, insulated primary and secondary windings with no common connection between them, except that a minimum resistor of 470,000 ohm may be connected between the windings to aid in lamp starting.

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 generally used in the products covered by this standard.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

4 Units of Measurement

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

4.2 All values of voltage and current are true rms values unless otherwise indicated.

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 fluorescent-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 the category that precedes it in the following list:

a) An indoor ballast is only intended for use indoor, dry location.

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 intended 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 intended for exposure to the weather without an additional enclosure.

6.2 Materials employed in a ballast shall not be adversely affected by the temperatures to which they are subjected during normal operation. See 11.2, 13.2.4, and 13.2.5.

7 Mechanical Assembly

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

8 Enclosure

8.1 General

8.1.1 A ballast shall be provided with an enclosure of metal or of a polymeric material that has been investigated and found to be evaluated for the intended use. See Polymeric Materials, Section 20, for requirements for a polymeric material used as an enclosure.

Exception: A reactor ballast intended for use within the enclosure of other equipment may be an open core-and-coil ballast.

8.1.2 A ballast is determined to be enclosed when:

a) All seams are overlapped, except that a total length of not more than 3 inches (76.2 mm) of butt seam meets the intent of this requirement when no opening in such seam is more than 0.005 square inch (3.23 mm^2) in area and the total area of such openings is no more than 0.250 square inch (161.29 mm^2); and

b) The perimeter of each opening for a lead wire fits closely around the wire that it encircles. An opening of 1/8 inch (3.2 mm) diameter or less complies with this requirement.

Exception No. 1: Laminated core sections are not required to be enclosed.

Exception No. 2: A Class P ballast without potting is not required to have lapped seams where parts of the enclosure are joined.

8.1.3 A Class P electronic ballast is able to have openings for ventilation when:

a) The ballast is provided with an overcurrent protective device rated 5 A or less or is provided with a foil trace that meets the requirements of this standard;

b) Circular openings have a diameter not exceeding 3 mm (0.12 inch) and minimum spacing between circular openings is 3 mm (0.12 inch);

c) Rectangular (or square) openings have dimensions not exceeding 3 mm (0.12 inch) across and 30 mm (1.18 inch) in length; and

d) The pattern of openings for metal enclosures is such that the through air spacings (clearance) between live parts and the dead metal enclosure is not reduced below the values specified in Spacings, Section 19, when the enclosure is subjected to the Rod Pressure Loading Test, Section 41. (The pattern of openings for plastic enclosures is not specified).

A Class P electronic ballast shall be marked in accordance with 45.5.10.

8.1.4 The thickness of a cast- or sheet-metal enclosure shall be in accordance with Table 8.1.

Table 8.1
Thickness of metal enclosures

Metal	Minimum thickness, inch (mm)	
	At small, flat, non-reinforced surfaces and at surfaces that are reinforced by curving, ribbing, or the like	At relatively large non-reinforced flat surfaces
Die-cast metal	3/64 (1.2)	5/64 (2.0)
Cast malleable iron	1/16 (1.6)	3/32 (2.4)
Other cast metal	3/32 (2.4)	1/8 (3.2)
Uncoated sheet steel	0.026 (0.66)[a,b]	0.026 (0.66)[a,b]
Galvanized sheet steel	0.029 (0.74)[a]	0.029 (0.74)[a]
Nonferrous sheet metal (including extruded)	0.032 (0.81)[b]	0.032 (0.81)[b]

NOTE – These are minimum dimensions based on nominal metal gauge thicknesses, for example, 22 Manufacturer's Sheet Gauge, is 0.030 inch, nominal, 0.026 inch minimum. Because of the tolerance in metal gauge sizes, metal thickness is to be increased so it is never less than the specified minimum.

[a] See 8.1.5.

[b] 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 that the metal is uncoated when measured, however, it shall have an additional metallic or organic coating when the ballast is marked "Type 1 outdoor use."

8.1.5 A sheet-steel enclosure of a weatherproof ballast shall not be less than 0.056 inch (1.42 mm) thick if galvanized steel, and not less than 0.053 inch (1.35 mm) thick if uncoated steel.

8.1.6 A closure for a hole no larger than 1/2 square inch (323.0 mm^2) in area in the base of a metal enclosure complies with this requirement if:

a) The closure is not less than 0.014 inch (0.36 mm) thick;

b) The surrounding metal is reinforced by forming; and

c) The closure is secured in place so that it cannot be removed without the use of a tool.

8.1.7 Fiber or phenolic-composition sheet material used for an end piece of the enclosure of a reactance ballast shall not be less than 1/16 inch (1.6 mm) thick, and shall be:

a) Secured in place so that all seams are closed; and

b) Rigidly supported to prevent displacement or removal.

Exception: An end piece of insulating material of small area that serves principally as a bushing for a lead may be not less than 1/32 inch (0.8 mm) thick if the exposed area of the piece is not more than 1/4 square inch (161.0 mm^2), and if the insulating material is supported in a complete frame or rests on the metal enclosure around the entire perimeter. See 13.4.

8.1.8 Fiber shall not be employed for any part of the enclosure or for lead bushings of a ballast intended for outdoor use, and fibrous material shall not be used for any internal part of an outdoor ballast unless it is covered completely with a material that will prevent the absorption of moisture by the fibrous material.

8.2 Raintightness

8.2.1 A weatherproof or Outdoor Type 2 ballast shall be constructed so that it excludes a beating rain when tested in accordance with the Water-Spray Test, Section 37.

Exception: The Water-Spray Test is not required when a ballast is fully potted.

8.2.2 Means for drainage shall be provided in the enclosure of a weatherproof ballast that has a knockout or unthreaded conduit opening.

9 Means for Mounting

9.1 A ballast intended for permanent installation shall have at least two mounting feet or ears, or shall be otherwise arranged for support at not less than two points to reduce the likelihood of turning.

9.2 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.

9.3 A ballast connected in the power-supply cord, as specified in 46.3.1, shall not have screw holes or other means that may be used to mount the ballast permanently.

10 Protection Against Corrosion

10.1 General

10.1.1 An enclosure constructed of iron or steel shall be protected against corrosion by plating, painting, or the equivalent. Both inside and outside surfaces of an enclosure shall be protected against corrosion.

Exception: A protective coating need not be applied to:

a) The interior of a ballast enclosure that is completely filled with potting compound; or

b) Flat metal surfaces that are tightly clamped together.

10.1.2 Exposed surfaces of the iron from which a core is assembled shall be protected against corrosion.

10.2 Outdoor ballasts

10.2.1 A ferrous-metal enclosure of a ballast marked for Type 1 outdoor use shall be protected against corrosion in accordance with 10.1.1 and 10.1.2.

10.2.2 A ferrous-metal enclosure of a ballast marked for Type 2 outdoor use shall be protected against corrosion as specified in Table 10.1.

Exception No. 1: The interior of a compound filled section of a ballast need not be so protected.

Exception No. 2: A steel enclosure provided with an organic coating complies with this requirement if comparative tests with galvanized-sheet steel (without annealing, wiping or other surface treatment) conforming with ASTM coating Designation G60 indicate the coating provides equivalent protection. Among the factors that are to be taken into consideration when judging the acceptability of such a coating system are exposure to salt spray, and moist carbon dioxide-sulphur dioxide-air mixtures.

Table 10.1
Sheet-steel coatings

Table 10.1 revised June 10, 2010

Type of coating		Coating designation or thickness in inches (mm)
(A)	Hot-dipped mill-galvanized steel	G60 or A60[a]
(B)	Zinc coating other than Type (A)	0.00041 (0.0104)[b]

[a] Conforming with the coating Designation G60 (galvanized) or A60 (alloy) in Table 1 of the ASTM Designation A653/A653M, with no less than 40 percent of the zinc on any side, based on the minimum single-spot-test requirement in the ASTM designation.

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

10.2.3 Cut edges and punched holes of a steel enclosure for a ballast need not be treated to reduce the likelihood of corrosion if the ballast is:

a) Marked for Type 1 outdoor use, and the steel enclosure is prepainted; or

b) Marked for Type 1 or Type 2 outdoor use and provided with a metallic ASTM coating Designation of G60 or G90.

10.2.4 A nonferrous enclosure for a ballast marked either Type 1 or Type 2 outdoor use may be employed without corrosion protection.

10.3 Weatherproof ballasts

10.3.1 A ferrous metal enclosure of a weatherproof ballast shall be protected against corrosion with a coating of zinc that complies with one of the following:

a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in Table 1 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 the ASTM specification. The weight of zinc coating may be determined by any acceptable method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight of Coating on Zinc-Coated Iron or Steel Articles, ASTM 490-81(1991).

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 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, Section 36. An annealed coating shall also comply with the requirement in 10.3.5.

10.3.1 revised June 10, 2010

10.3.2 Ordinary painting or ordinary baked enamel is not considered to provide the necessary degree of protection for a cast-iron enclosure or exposed parts of a ballast core of a weatherproof ballast.

10.3.3 Hinges and other attachments of a weatherproof ballast shall be resistant to corrosion.

10.3.4 Metals shall be used in combinations that are galvanically compatible.

10.3.5 An annealed zinc coating that is bent or similarly formed after annealing shall also be painted in the bent or formed area if the bending or forming process damages the zinc coating. The zinc coating is considered damaged if flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification. Simple sheared or cut edges and punched holes are not considered to be formed but extruded and rolled edges and holes shall comply with this requirement.

11 Compound

11.1 An enclosed Type 1 outdoor, Type 2 outdoor, or weatherproof ballast shall be completely filled with potting compound. See 10.2.2.

Exception No. 1: A ballast enclosure need not be completely filled with potting compound if the interior surfaces are in accordance with the requirements for Protection Against Corrosion in Section 10 and spacings for any uninsulated live parts are in accordance with the requirements in Section 19, Spacing of Electrical Parts.

Exception No. 2: An electronic-ballast enclosure need not be provided with potting or may be partially filled with compound if:

a) The interior surfaces are protected against corrosion in accordance with the requirements in Protection Against Corrosion, Section 10; and *b) Spacings with or without a conformal coating that complies with Section 17, are maintained for adjacent uninsulated live parts and any uninsulated live part and accessible dead metal parts.*

11.2 Compound shall not soften to the extent that it does not perform its intended function at the temperature to which it is likely to be subjected during normal and abnormal operation. See 6.2, 14.4, 27.5, and footnote (b) of Table 25.1.

11.3 For a resistance ballast, a heat-resistant compound shall comply with the requirement in 11.2; but another material may be used if, upon investigation, the material is found to have heat-resistant properties intended for the application.

12 Insulating Materials

12.1 A coil shall be provided with insulation between the windings and the core and the enclosure, and between windings that operate at a different potential or that are not electrically conductively connected to each other. Insulation, unless inherently moisture resistant, shall be treated so as to be resistant to moisture. Film coated wire does not require additional treatment to resist moisture absorption. See also 20.11.

Exception: Bifilar wound coils, such as on an EMI filter, shall not be used with additional sheet insulating materials between the coils, unless the coils are in a metal enclosure and are protected by a supply fuse of 5 amp or less.

12.2 For other than coil forms, a material used as the mounting of uninsulated live parts shall be porcelain, phenolic, or cold-molded composition, or other thermoplastic or thermosetting material that complies with the appropriate requirements for Polymeric Materials, Section 20.

12.3 Insulating materials of a coil device shall be rated for the temperatures involved in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, as determined during both the Normal Temperature Test, Section 25, and the Abnormal Temperature Test, Section 26 of this standard. Also see 20.11.

12.4 A coil device that operates above Class 105 temperature limits as indicated in both the Normal Temperature Test, Section 25, and the Abnormal Temperature Test, Section 26, shall incorporate an insulation system that complies with the Standard for Systems of Insulating Materials – General, UL 1446.

Exception: The insulation system is not required to comply with UL 1446 when the coil device is located in an electronic ballast and:

a) Involves a potential less than 30 V rms (42.4 V peak), and has power less than 50 watts available when determined in accordance with 29.6;

b) Is an electromagnetic interference filter component:

1) Connected on the load side of an overcurrent protective device rated 5 A or less;

2) Incorporating a single winding; or

3) Incorporating rigid, fixed insulation between coils connected to opposite polarity (such as a bobbin or spacer);

c) Is a winding consisting only of film coated magnet wire wound on an insulating bobbin with a magnetic core isolated from ground or accessible dead metal; or

d) Does not provide electrical isolation between primary and output or primary and accessible low voltage circuits.

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12.5 An insulating pad made of silicone rubber and having a minimum thickness of 0.005 inch (0.13 mm), or mica and having a minimum thickness of 0.004 inch (0.10 mm) is acceptable for the insulating of a semiconductor device to accessible dead metal provided the voltage is 120 volts (170 volts, peak) or less between the device's metal part and its mounting. Another insulating material can be considered acceptable provided the material has a Relative Temperature index as determined by the Standard for Polymeric Materials– Long Term Property Evaluations, UL 746B exceeds the temperature found in the Normal Temperature Test, Section 25, and the material acceptably withstands the Dielectric-Voltage Withstand Test, Section 32.

12.6 An insulating material having a minimum thickness of 0.010 inch (0.25 mm) is acceptable for insulation between the soldered side of a printed wiring board and the ballast enclosure provided the material is prevented from bearing against sharp points, although random contact is acceptable. Potting compound surrounding the liner is considered to provide adequate protection of the insulating liner. For other applications, such as insulation between a wound coil and the ballast enclosure, a sheet insulating material other than paper or polyester, shall have puncture resistance equal to or greater than the average puncture force of 0.005 inch (0.13 mm) polyester.

12.7 A Type 1 outdoor ballast that is not provided with an enclosure, such as in an open-core-and-coil type, shall:

a) Be impregnated to reduce the risk of absorption of moisture.

Exception: A bobbin of nylon or other molded plastic meets the intent of the requirement without further impregnation.

b) Have lead wire insulation that complies with 13.2.2.

c) Comply with the Humidity-Conditioning Test, Section 38.

d) Have rated output of 300 volts or less.

12.8 An outdoor rated ballast that is not potted into an enclosure or have conformally coated printed wiring board shall be subjected to the Humidity Conditioning Test, Section 38.

13 Supply and Load Connections

13.1 Terminal and lead wire compartments

13.1.1 A terminal compartment or splice compartment for the connection of the source of supply and lamp lead wires shall provide field wiring space for the incoming wires and splices to the ballast lead wires. Field wire size is expected to be 12 AWG (3.3 mm^2). See 13.1.3.

Exception: A ballast marked for use only in signs, in accordance with 45.5.1, is expected to have 14 AWG (2.1 mm^2) field wires.

13.1.2 The field wiring compartment volume shall be at least the sum of the number of the specific wire volume allowances from Table 13.1, multiplied by the number of specific wire sizes. See Section 42, Volume Method of Measurement, for the procedure to determine the field wiring compartment volume.

Table 13.1
Conductor size for determination of the minimum terminal or splice compartment volume

Size of conductor, AWG (mm^2)		Conductor volume	
		in^3	(cm^3)
18	(0.82)	0.5	(8.2)
16	(1.3)	0.6	(9.8)
14	(2.1)	0.75	(12.3)
12	(3.3)	1.0	(16.4)
10	(5.3)	1.7	(27.9)

Example: An autotransformer ballast has a 120 volt input and operates two F32TB lamps in a rapid start design. All ballast wires (2 supply and 6 lamp) are 18 AWG. There are two incoming 12 AWG supply wires and six incoming 18 AWG wires from the lampholders.

Required Volume = 14 x 0.5 + 2 x 1.0 = 9 in^3 = 147.8 cm^3

13.1.3 The wire count shall include:

a) Branch circuit wires entering a terminal or wire compartment (for the purposes of calculating compartment volume, incoming supply wires are assumed to be 12 AWG (3.3 mm^2) or 14 AWG (2.1 mm^2) per the exception to 13.1.1, and the lamp circuit wires are assumed to be 18 AWG (0.82 mm^2);

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.

13.1.4 There shall be no openings in a terminal or splice compartment other than those provided for drainage, and those required for mounting the ballast.

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

13.1.6 A bushed hole for open wiring shall not be located in the top or back of a weatherproof ballast unless a 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 wires leaving the enclosure. See 45.5.7.

13.1.7 A nipple provided with a weatherproof ballast for field connection to a splice box:

a) Shall provide a smooth, rounded opening for the leads; and

b) Shall be located in the bottom of the enclosure unless the leads are sealed within a nipple.

See 45.5.7.

13.1.8 The words below, lowest, top, back, side, above, downward, and bottom in 13.1.5– 13.1.7 denote relative positions while the ballast is oriented as it is intended to be when mounted.

13.1.9 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 employed, there shall not be less 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.

13.1.10 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 less than five full threads in the metal. An inlet hole for the conductors shall be smooth, rounded, and afford protection to the conductors equivalent to that provided by a standard conduit bushing. The inlet hole shall have an internal diameter approximately equal to that of the corresponding trade size of rigid conduit.

13.1.11 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 13.6. A sheet metal screw shall not be used.

13.2 Lead wires

13.2.1 A ballast lead wire provided for the field supply connection or output connection shall be 18 AWG (0.82 mm^2) or larger and be a solid or stranded, copper conductor with or without tinning. Ballasts with a factory-attached lampholder of a type that involves handling by the user during relamping (lamp connector) shall employ stranded conductors in lead wires to the lampholder.

13.2.1 revised July 19, 2009

13.2.2 The insulation on the lead wires of a ballast marked weatherproof, Type 1 outdoor, or Type 2 outdoor shall be a material resistant to moisture absorption, such as polyvinyl chloride (PVC). An outer braid on a lead shall be treated to resist moisture absorption.

13.2.3 A rubber-insulated lead wire shall employ an outer braid.

13.2.4 Deleted December 11, 2007

13.2.5 The insulation on a lead wire shall be rated for the temperature and voltage involved. The insulation shall be rated for a temperature of at least 90°C (194°F), or shall be rated for a temperature of 75°C (167°F) and have an outer braid. Primary lead wires and other lead wires in the primary circuit shall have insulation rated for the maximum rated input voltage. All other lead wires, other than lead wires connected to a low voltage Class 2 circuit, shall have insulation rated for the rated input voltage or output voltage, whichever is higher. Lead wires for a low voltage Class 2 circuit shall be rated at least for the voltage available in the circuit. Lead wires for a low voltage Class 1 – power limited circuit shall have insulation rated for the rated input voltage or output voltage, whichever is higher.

13.2.6 Primary lead wires are intended for connection to the supply source. Other lead wires in the primary circuit, as described in 13.2.5, include:

a) A lead wire connected to a tap in the primary winding; or

b) A lead wire connected to a winding intended to provide current to heat the cathodes of a rapid-start circuit if such a winding has one end common with either a primary lead wire or a tap in the primary winding.

13.2.7 A primary lead wire that is specified in Table 22.1 and is intended to be grounded:

a) Shall not be provided on a ballast having a rated input voltage in the ranges of 200 – 215 or 460 – 600 volts; or

b) Shall be provided on a ballast having a rated input voltage in the ranges of 100 – 150, 220 – 250, 265 – 280, or 340 – 350 volts, unless the ballast operates correctly with either primary lead wire connected to the grounded supply conductor.

13.2.8 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,″ ″WHT,″ 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.

13.2.9 A ballast having a rated input voltage outside the ranges specified in 13.2.7 may or may not have a primary lead wire that is intended to be grounded, depending upon the intended supply system. See 45.2.2.

13.2.10 The surface of an insulated lead wire intended for 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. For an electronic ballast, a lead wire brought out and intended to be grounded shall be green in color with or without one or more yellow stripes and shall be bonded directly to the accessible metal parts of the enclosure.

13.2.11 An electronic ballast having a lead wire brought out that is intended to be connected to an isolated earth ground or connected to a special equipotential grounding point:

a) Shall be other than green in color with or without one or more yellow stripes;

b) Is not required to be bonded to the enclosure; and

c) Shall have an explanation on the ballast label indicating its purpose and connection.

13.2.12 The insulation on a lead wire not provided with a braid or a nylon jacket shall be at least 1/32 inch (0.8 mm) thick unless investigated and found to have properties intended for the application.

13.2.13 Thermoplastic-insulated wire, used as a lead wire or for internal connections, shall have an insulation having a minimum thickness of:

a) 1/64 inch (0.40 mm) for a starting voltage of 600 volts peak or less;

b) 1/32 inch (0.80 mm) for a starting voltage of 2500 volts peak or less; or

c) 3/64 inch (1.20 mm) for a starting voltage of 5000 volts peak or less.

Exception: If rated for the voltage involved wire with thinner insulation meets the intent of the requirement.

13.2.14 A neoprene-insulated lead wire provided on a ballast intended for outdoor use shall employ an outer braid unless the insulation on the lead is at least 3/64 inch (1.2 mm) thick.

13.2.15 A ballast lead wire shall be at least 6 inches (152 mm) long.

Exception: The length of lamp lead wires for a ballast intended for use with a circline lamp is not specified.

13.2.16 If tubing and a lampholder are provided on ballast lead wires to a circline lamp with the intent of complying with the applicable requirements in the Standard for Luminaires, UL 1598, the tubing shall:

a) Be acceptable for at least 90°C (194°F);

b) Have a wall thickness of at least 0.017 inch (0.42 mm); and

c) Cover the entire length of the lead wire except up to a 1/2 inch (12.7 mm) maximum at each end of the lead if it is permissible.

Exception: When all lamp lead wires do not exit from the same opening of the ballast enclosure, the length of tubing may be reduced by the minimum amount necessary to accommodate the bifurcation of the wires.

13.2.16 revised December 11, 2007

13.2.17 A ballast may be provided with a connector for connection of non-integral lead wire by means of a wiring harness with at least 6 inch (152 mm) leads for connection to the supply circuit, and a mating connector. The connector shall be suitable for the application. The mating connector shall have a detent, and shall be wired or keyed uniquely so as to reduce the risk of electric shock due to improper connection of the mating parts.

13.3 Flexible cords

13.3.1 For a simple reactance ballast of a through cord or a direct plug in type, the conductor of the incoming cord or plug blade that is intended to be grounded, shall be directly connected to the conductor of the outgoing cord that is intended to be grounded. For the through-cord ballast, there shall be no difference in potential between the conductors of the incoming and outgoing cords that are intended to be grounded when the ballast is in operation. For the direct plug in ballast, there shall be no difference in potential between the plug blade and the outgoing cord that is intended to be grounded when the ballast is in operation.

13.3.2 An attachment plug of a through cord or other cord connected ballast shall be provided on the supply end of a cord, see 13.3.4 – 13.3.6. The overall length of the supply and lamp cords, and ballast shall not be less than 6 feet (1.83 m) and the length of the supply cord between the plug and the ballast shall be between 2 – 4 feet (0.6 – 1.22 m).

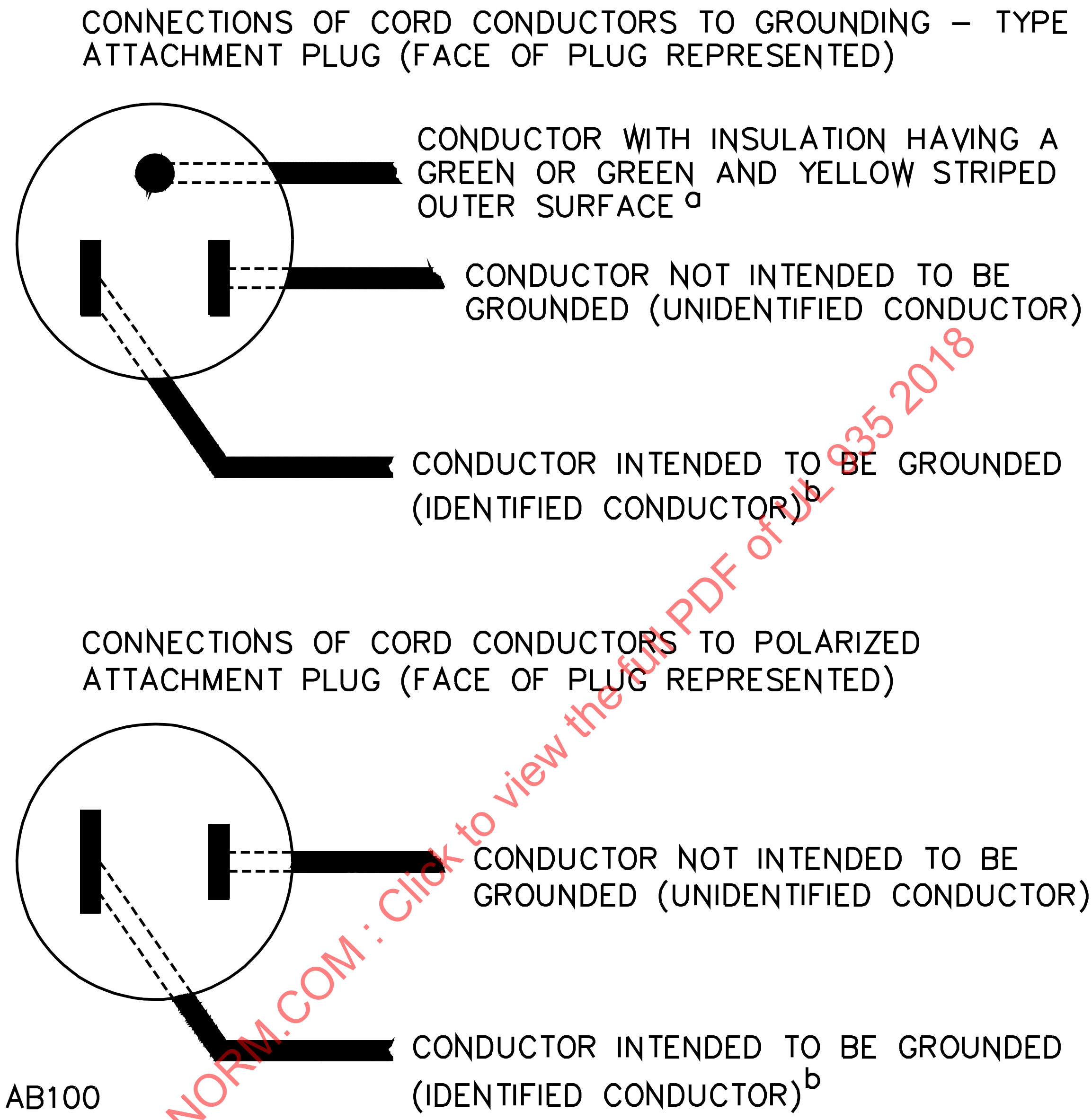
13.3.3 The insulation on a cord shall be rated for the temperature and voltage to which it is subjected during normal operation. See 46.3.1 for cord types to be used.

13.3.3 effective October 27, 2002

13.3.4 A power-supply cord of a through-cord or other cord connected ballast, or the blades of a direct plug-in ballast, shall terminate in a 2-pole, 3-wire, 15-ampere, 125-volt grounding attachment plug or in a 2 pole, 2-wire, 15-ampere, 125-volt polarized plug. A power-supply cord shall comply with the requirements of Cordsets and Power Supply Cords, UL 817. A ballast determined to have an output greater that 150 volts shall be provided with a grounding type plug. Also see 22.8 and 45.5.3.

13.3.5 If a 2-conductor flexible cord is provided for connection to the source of supply, the conductors shall be connected to a parallel-blade attachment plug as illustrated in Figure 13.1. If only two blades are provided with a direct plug in ballast, the blades shall be connected as shown in Figure 13.1. The dimensions of the blades are to be as shown in Figure 13.2. For a simple reactance ballast, the smaller blade shall connect directly to the ballast. The larger blade shall connect to outgoing cord as described in 13.3.1.

Figure 13.1
Connectors to attachment plug



[a] The blade to which the green or green and yellow conductor is connected may have a U-shaped cross section instead of the circular cross section shown.

[b] The conductor intended to be grounded signifies a conductor identified in one of the following ways:

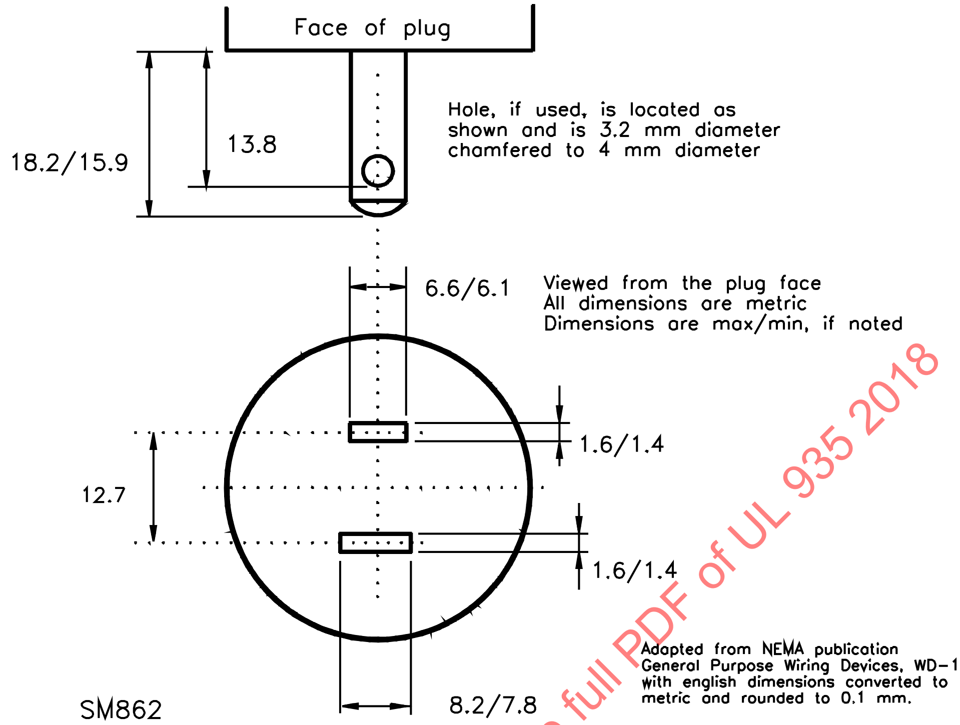
1) A white or gray colored conductor insulation;

2) A light blue colored conductor insulation when the other conductors are colors other than white or gray;

3) Have a rib or ribs running the length of the cord; or

4) Have tinned or white metal on all strands of the conductor.

Figure 13.2
Polarized plug dimensions



13.3.6 When the flexible cord includes an equipment-grounding conductor, that conductor shall be green in color with or without one or more yellow stripes. The conductors of the flexible cord shall be connected to a parallel-blade, 3-wire grounding attachment plug as illustrated in Figure 13.1. The grounding conductor shall be connected to the ballast enclosure, when constructed of metal. The grounding lead is to be crimped, or crimped and soldered, to the ballast enclosure. The dimensions of the blades are to be as shown in Figure 13.2. The grounding conductor shall also connect to a conductor on the outgoing cord and shall be green in color with or without one or more yellow stripes. For a simple reactance ballast, the smaller blade shall connect directly to the ballast. When both blades are the same size, the right blade shall connect directly to the ballast when viewed with the ground pin on top.

13.4 Bushings

13.4.1 A bushing shall be provided where a lead wire or flexible cord enters the enclosure of a ballast, and shall protect the insulation on the lead or flexible cord from damage.

13.4.2 An insulating bushing employed in a ballast intended for outdoor use shall be made of non-absorptive material. Polymeric materials shall have a flammability resistance rating of at least V-2 and a temperature rating exceeding the temperature found in Normal Temperature Test, Section 25.

13.4.3 A smooth metal grommet, a turned-over punched hole in a sheet-metal enclosure, an insulating bushing securely held in place, or a smooth hole in an end piece of insulating material meets the intent of providing a bushing where a lead enters the enclosure.

13.4.4 An insulating bushing, not less than 1/16 inch (1.6 mm) thick, shall be used where a flexible cord or lighter service than Type SV enters an enclosure.

13.5 Strain relief

13.5.1 Strain relief shall be provided on a lead wire or a flexible cord to resist stress on the lead wire or cord from being transmitted to the interior wiring or connections or to the terminals of the attachment plug. See the Strain-Relief Test, Section 39.

13.5.2 A lead wire or flexible cord that is embedded in compound inside the enclosure at the wire entrance is considered to be provided with the necessary strain relief.

13.6 Terminals

13.6.1 Wire binding screws or pressure-type terminals provided for field wiring terminals shall comply with 13.6.2 – 13.6.11.

13.6.2 A terminal intended for the connection of a grounded power-supply conductor as specified in item (a) of Table 22.1 shall be:

a) A pressure-type wire connecting means 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,″ ″WHT,″ or ″COM″; or

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

13.6.3 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;

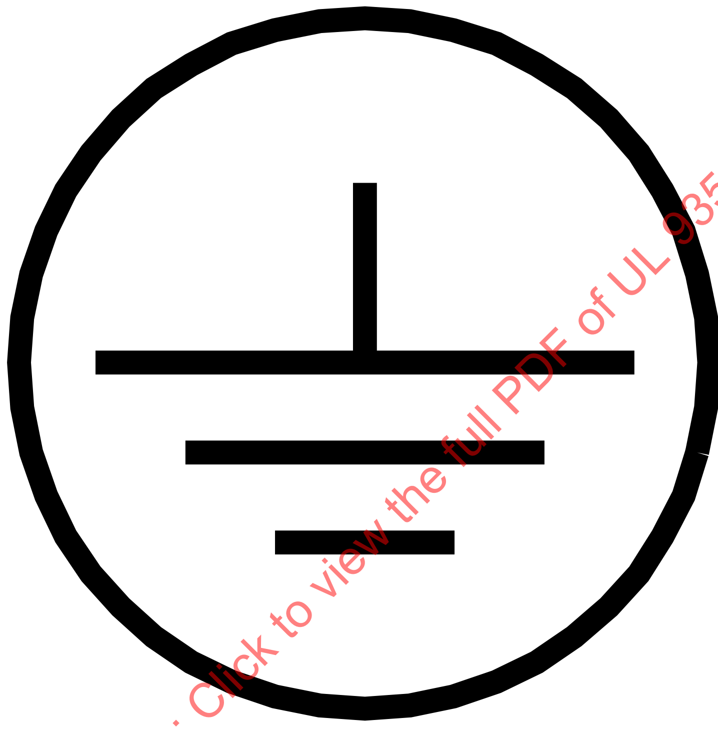
b) A machine thread screw, at least 8-32 thread, with a hexagonal head, green in color;

c) The word ″ground″, the letters ″G,″ ″GND,″ or ″GR″, or the symbol in Figure 13.3;

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; or

e) A pan head screw colored green, when used as a pressure terminal means for grounding in junction boxes and in other wiring compartments.

Figure 13.3
Grounding



13.6.4 A wiring terminal shall be provided with a soldering lug or pressure-wire connector, bolted or held by a screw.

13.6.5 A wiring terminal employing a wire-binding screw shall be provided with upturned lugs or the equivalent to hold a wire under the head of the screw.

13.6.6 A wire-binding-screw terminal or a pressure terminal connector shall be recessed or located so that it will be unlikely that wires will contact live parts after installation of the device.

Exception: Wire binding screws need not be recessed or otherwise located provided the spacing between the field wiring terminals is at least the dimensions given in Table 19.1 between parts of opposite polarity or between live parts and dead metal parts.

13.6.7 A pressure type wire connector intended for the connection of supply leads shall comply with the Standard for Wire Connectors, UL 486A-486B, be rated 600 volts, and be capable of connection to either a 12 AWG (3.3 mm^2) or 14 AWG (2.1 mm^2) supply wire.

13.6.7 revised November 6, 2009

13.6.8 A terminal plate having a tapped hole for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick and shall have not less than two full threads in the metal.

13.6.9 For a binding screw having 32 or more threads per inch, a terminal plate formed from stock 0.030 inch (0.76 mm) thick may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

13.6.10 A wire-binding screw shall thread into metal.

13.6.11 A wire-binding screw shall not be smaller than No. 6, and shall not have more than 36 threads per inch.

13.6.12 A push-in (screwless) field wiring terminal (one in which a stripped copper conductor is inserted and automatically locked in a wire entrance hole) meets the intent of providing a current-carrying connection if it complies with Tests on Push-In Terminals, Section 40, and the requirements specified in 45.7.3. A push-in wiring terminal for connection of supply leads shall only allow for the termination of the branch circuit conductor supplying the ballast, and not provide for additional connections, unless the push-in wiring terminal has been evaluated to handle full branch circuit current.

13.6.13 A push-in type field wiring supply terminal shall be provided with a 3/8 inch (9.5 mm) minimum clearance and creepage distance measured from the recessed contact to accessible dead metal.

13.6.13 revised April 27, 2001

14 Live Parts

14.1 Iron or steel, plain or plated, shall not be used for parts that are depended upon to carry current.

Exception No. 1: This requirement does not apply to current-carrying parts of a component covered by requirements separate from this standard. See 3.1.

Exception No. 2: Steel may be a live part if it is in a parallel path with copper or aluminum conductors, and would not be subject to corrosion – for example, a steel ring that is crimped around two conductors to splice them.

14.2 A soldered connection shall be mechanically secured before being soldered. The connection shall be insulated unless the spacings are in accordance with Spacing of Electrical Parts, Section 19.

Exception: If mechanical security of a soldered joint is impractical or impossible, a joint may be made without mechanical security before soldering, provided both sides of the joint are secured in such a way that stress on the connection, either during or after manufacturing process, will be unlikely.

14.3 An uninsulated live part shall be permanently mounted and secured to resist turning or shifting in position if such motion may result in a reduction of spacing below minimum values.

14.4 Live parts that are mechanically secured and positioned with respect to dead metal parts and that are covered with compound are considered to be insulated.

14.5 Foils on a printed wiring board shall be subjected to the requirements of Section 18, Printed Wiring Boards.

15 Capacitors

15.1 If capacitor is connected so that a voltage is available at any of the external leads or connections after the ballast is deenergized, the capacitor shall be equipped with a positive means for draining the stored charge so that the difference in potential between the capacitor terminals will be 50 volts or less within 1 minute after the capacitor is disconnected from the source of supply.

Exception: This requirement does not apply to a capacitor:

a) Rated not more than 0.06 microfarad and charged to a potential of not more than 500 volts peak; or

b) Charged to less than 7.5 mJ when using:

$$J = 1/2\ CV^2$$

where

C = is the capacitance, in farads

V = is the charged voltage, in volts.

15.2 A capacitor connected so that it does not discharge through the ballast windings shall discharge to a potential 50 V peak or less within one minute through a bleeder resistor. The maximum resistance value of a bleeder resistor shall be determined by this relation:

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

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

No Text on This Page

e is base e

The value of the discharge resistance is able to be determined by the simplified relation:

$$R = \frac{K}{C}$$

in which:

R is the resistance value in megohms,

K is the resistor factor determined from Table 15.1, and

C is the value of the capacitor in microfarads.

Table 15.1
Bleeder resistor factor (k)

Voltage		Factor (k)
Peak	**rms**	
0 – 100	0 – 70	85
101 – 110	71 – 78	76
111 – 120	79 – 85	70
121 – 130	86 – 92	63
131 – 140	93 – 99	55
141 – 150	100 – 106	54
151 – 170	107 – 120	50
171 – 200	121 – 141	44
201 – 240	142 – 169	39
241 – 280	170 – 197	35
281 – 325	198 – 230	32
326 – 375	231 – 265	30
376 – 450	266 – 318	27
451 – 500	319 – 353	26
501 – 700	354 – 495	23
701 – 1000	496 – 707	19
1001 – 1400	708 – 999	18

15.3 The potential specified in 15.1 and 15.2 is the maximum voltage measured between capacitor terminals under any condition of ballast operation – including lamp starting, lamp operation, operation without a lamp, and operation with a deactivated lamp or lamps – while the ballast is in a heated condition from the Normal-Temperature Test, Section 25.

15.4 The voltage rating of a power capacitor shall not be less than the potential developed across its terminals during normal operation with any lamp, or combination of lamps for which the ballast is rated, see Voltage Measurement – Power Capacitors, Section 31. In addition, the potential developed across the capacitor terminals shall not exceed 140 percent of the rated capacitor voltage during the lamp-starting cycle, and for the abnormal-operation tests.

15.5 A power capacitor employing a dielectric medium of wax or of liquid other than askarel 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.

15.6 A pressure-interrupting-type capacitor as described in 15.5 relieves an internal fault condition by movement of the terminal end of a capacitor enclosure to break the circuit internally. The movement is initiated by an internal pressure during a fault condition, causing expansion of the capacitor body. The amount of clearance space in a ballast, not including the potting compound, is dependent on the capacitor construction.

Exception No. 1: A thermally protected capacitor does not need additional clearance space.

Exception No. 2: Clearance space in the potting compound need not be provided, if an investigation shows the protector operation of a capacitor is not adversely affected.

15.7 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, 1000 amperes AFC; or

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

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

2) Abnormal operation without the lamps.

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

Exception: A capacitor need not have an AFC rating provided it is:

a) Intended for EMI filtering rather than power factor correction;

b) Rated 1.0 μF or less; and

c) Located inside a metal ballast enclosure.

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

15.8 effective October 27, 2002

15.9 A dry-metallized-film capacitor operating at a voltage of 330 volts or less need not have a maximum available fault current rating. A capacitor operating at a voltage of more than 330 volts may be subject to a special investigation to determine the need for a fault current rating.

15.10 Across the line capacitors less than 1 μF shall comply with the applicable requirements in the Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

Exception: The capacitor is not required to comply when it is:

a) Encased in potting compound;

b) Encased in a metal enclosure; or

c) On the load side of a fuse or foil trace rated 5 A or less.

15.10 revised August 7, 2014

16 Protective Devices Provided in Class P Protected Ballasts

16.1 Other than as noted in 16.2, a Class P protected ballast shall be provided with a protector that opens the power-supply circuit to the ballast before the ballast temperature exceeds the limits specified in Section 27, Fault-Condition Test – Conventional Magnetic Ballasts – Class P Protection and Section 28, Increased-Ambient Temperature Test – Class P Protection.

16.2 A Class P protected electronic ballast is not required to be provided with a discrete thermal protector nor be subjected to the Increased-Ambient Temperature Test – Class P Protected Ballasts, Section 28 when the ballast complies with the, Section 29, Fault-Condition Test – Electronic Ballasts – Class P Protection without the protector functioning (when provided).

16.3 The protector shall have a voltage rating and a current rating not less than the input-voltage and the input-current ratings of the ballast, respectively. The protector shall be either:

a) Automatically resetting (thermostatic) type acceptable for the control of a fluorescent ballast as specified in the Standard for Temperature-Indicating and Regulating Equipment, UL 873. 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; or

b) Nonrenewable, nonresetting (a thermal fuse or thermal cutout) as specified in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

Exception: A protective mechanism other than as specified in this Section may comply with this requirement if investigated and found to provide equivalent thermal protection.

16.3 revised December 6, 2013

16.4 When a ballast has a supply lead wire or terminal intended to be grounded, the protector shall open the side of the line not intended to be grounded. See 13.2.7, 13.3.5, 13.6.2, and Table 22.1.

16.5 The protector or protectors shall be located within the ballast so that they are:

a) Protected against mechanical damage; and

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

A protector located under the final wrap of insulation provided on an open core-and-coil simple reactance ballast is considered to be an inaccessible location.

16.6 A simple reactance ballast that:

a) Has an integral starter; or

b) Is intended for other than with a straight tubular lamp

shall be provided with a thermal protector that opens the power supply circuit to the ballast before the ballast temperature exceeds the limits specified in Fault-Condition Test – Class P Protected Ballasts, Section 27 and Increased-Ambient Temperature Test– Class P Protected Ballasts, Section 28. The ballast shall be marked in accordance with the requirements specified in 45.6.1. This is also applicable to through-cord and direct plug-in ballasts.

16.7 A Class P ballast marked ″Type HL″ for use in a Class I, Division 2 hazardous (classified) location fixture shall have:

a) A thermal protector fully submerged in potting compound;

b) A hermetically sealed protector;

c) A protector immersed in oil; or

d) No protector.

See 45.7.6.

16.8 A foil trace on a printed wiring board designed so it opens in the event of a short circuit shall be:

a) Potted or conformally coated;

b) In a location determined inaccessible to deter defeat;

c) Subjected to the Limited Short Circuit Test, Section 34, for foil traces;

d) Subjected to the Foil Trace Calibration Test, Section 35; and

e) Subjected to periodic, randomly specified, retesting as described in Appendix B.

17 Protective Devices Provided in Other Than Class P Protected Ballasts

17.1 A fuse or other thermally actuated element that is provided in a ballast other than a Class P ballast that, without such element, would exceed any of the limits specified for the normal- and abnormal-temperature tests described in Normal-Temperature Test, Section 25 and Abnormal-Temperature Test, Section 26 shall be:

a) Non-automatically reclosing;

b) Intended for the application; and

c) Located so that it cannot be replaced or readily serviced.

17.2 The thermally actuated element shall be located in the same manner as described in 16.5.

17.3 The addition of a fuse or other thermally actuated element to a ballast shall not result in temperatures higher than those that would otherwise exist and shall not cause ignition of insulation or compound under any condition of normal or abnormal operation, including capacitor short circuit.

18 Printed Wiring Boards

18.1 A printed wiring board shall be intended for the application. The criteria shall include:

a) The bonding of the foil to the substrate for the minimum conductor width and maximum unpierced area as required by the Standard for Printed Wiring Boards, UL 796;

Exception: Printed wiring boards that are completely encased in potting compound or conformal coating are not required to additionally comply with UL 796.

b) The temperatures measured in the Temperature Test, Section 25, shall be less than the temperature rating of the substrate as required by the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

c) The flammability of the printed wiring board substrate shall be no less than V-1 in accordance with the Standard for tests for Flammability of Plastic Materials for Parts and Appliances, UL 94.

19 Spacing of Electrical Parts

19.1 General

19.1.1 Spacings for clearances (through air) and creepage distances (over surface of insulating material), including the point of field wiring, shall be at least as described in 19.1.2 and 19.1.3 and Table 19.1 for:

a) Uninsulated live parts of opposite polarity; and

b) An uninsulated live part and a dead metal part that is able to be grounded, a metal part exposed to contact by persons, or a metal surface on which the ballast is mounted as intended.

19.1.2 A dead metal part, such as the head of a screw or rivet, is determined not to be exposed to contact when it is recessed to clear the surface by at least 3/16 inch (4.8 mm) in a hole not more than 9/32 inch (7.1 mm) in diameter.

19.1.3 When measuring a spacing, an isolated dead metal part located between uninsulated live parts of opposite polarity, or between an uninsulated live part and a dead metal part, is determined to reduce the spacing by an amount equal to the dimension of the isolated dead metal part in the direction of the measurement.

19.1.4 For an uncoated printed-wiring board, the minimum spacing between adjacent foil traces shall be at least as specified in Table 19.1. For printed wiring boards that are covered with potting compound or a conformal coating, the minimum spacing between the adjacent foil traces prior to coating shall be as specified in the first row of Table 19.1.

Exception No. 1: When the power available between two insulated parts is less than 50 watts when determined in accordance with 29.6, the spacing is not required to comply with this requirement.

Exception No. 2: The minimum spacing is determined by the dielectric voltage withstand test described in 32.10.

19.1.5 Where a conformal coating is used as described in 19.1.4, the conformal coating shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

19.1.6 For components mounted along the edge of a printed wiring board, clearances between parts described in 19.1.1 are to take into consideration the possible movement of the component and the printed wiring board itself. When applying the limits in Table 19.1, the printed wiring board is positioned, when movement is possible, in the direction that yields the smallest clearance between the parts in question.

19.2 Alternate method

19.2.1 The dimensional requirements described in 19.1 are a summary of requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. Additional clearance and creepage distances between conductive parts that are rigidly held in place and reliably spaced in production are determined using UL 840. Parts that are rigidly held in place and reliably spaced in production include conductors on a printed wiring board. The spacing requirements in UL 840 shall not be used for field wiring terminals or spacings to a dead metal enclosure. Creepage distances shall not be less than clearances.

19.2.2 When using the requirements specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, to determine clearances, the ballast is identified as operating on supply circuits having an over voltage category of II.

19.2.3 When using the requirements specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, to determine environmental pollution, it is possible that the ballast be evaluated with different environmental pollution degrees so the construction affects to what extent environmental pollution enters the enclosure. The following conditions apply:

a) A ballast marked for weatherproof or outdoor type 2 use is exposed to environmental pollution degree 3.

b) A ballast marked for indoor or outdoor type 1 use is exposed to environmental pollution degree 2.

c) The portion of a printed wiring board covered with a potting compound or a conformal coating that complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C, is exposed to environmental pollution degree 1.

d) Additional applications are determined as a result of a special investigation.

19.2.4 Printed wiring boards constructed of Types XXXP, XXXPC, G 10, FR 2, FR 3, FR 4, FR 5, CEM 1, CEM 3, GPO 2, or GPO 3 industrial laminates in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, are identified to have a minimum comparative tracking index (CTI) of 100 [PLC=4] without further investigation.

Table 19.1
Spacings for indoor and outdoor locations

	Maximum voltage between parts, Vrms (Vpeak=1.4 Vrms) [clearance/creepage distance]								
Locations / dimensions in millimeters	50	150	300	450	600	750	900	1050	1200
Parts potted or subsequently coated	-/0.18[a]	-/0.3[a]	-/0.7	-/0.8	-/0.8			-/3.2	-/4.2
For Indoor & Outdoor, Type 1: Live parts relaibly positioned AND insulator CTI ≥ 600 (PLC=0); example: lead wires of a transistor or diode to its mounting[c]	0.2/0.6	0.5/0.8	1.5/1.5	-/2.25	3.0/3.0	-/3.75	-/4.5	-/5.8	-/6.0
For Indoor & Outdoor, Type 1: Live parts relaibly positioned AND insulator CTI < 600 (PLC=3 or 4); examples: adjacent foils on printed wiring board or lead wires of a transistor or diode to its mounting[d]	0.2/1.2	0.5/1.6	1.5/3.0	-/4.5	3.0/6.1	-/7.5	-/9.0	-/10.5	-/12.0
For Outdoor, Type 2 & Weatherproof: Live parts relaibly positioned AND insulator CTI ≥ 600 (PLC=0); example: lead wires of a transistor or diode to its mounting[e]	0.2/1.5	0.5/2.0	1.5/3.7	-/5.6	3.0/7.5	-/9.5	-/11.4	-/13.3	-/15.2
For Outdoor, Type 2 & Weatherproof: Live parts reliably positioned AND insulator CTI < 600 (PLC=3 or 4); examples: adajacent foils on printed wiring board or lead wires of a transistor or diode to its mounting[f]	0.2/1.9	0.5/2.7	1.5/4.7	-/7.1	3.0/9.5	-/11.9	-/14.3	-/16.7	-/19.0
Parts on printed wiring boards that are soldered in place but can move in production prior to soldering to fixed parts or parts on printed wiring board to enclosure where enclosure and can deflect.[g]		3.0/-	3.9/-	4.7/-	5.6/-	6.5/-	7.4/-	8.2/-	
Live parts and dead metal parts in a conventional magnetic ballast construction where the coil size can vary due to random wind OR where coil assembly placement can vary in production.	3.2/6.4	3.2/6.4	6.4/9.5	6.4/9.5	9.5/9.5	9.5/9.5	9.5/9.5	9.5/12.7[b]	9.5/ 12.7[b]
Field wiring terminals to each other and fixed live or dead metal parts	Not defined	6.4/6.4	6.4/6.4	6.4/6.4	6.4/6.4	Not defined	Not defined	Not defined	Not defined

[a] Or as determined from the investigation of the Conformal Coating, whichever is greater.

[b] When the insulating material involved is not readily carvonized – for example, porcelain or urea-formaldehyde porcelain – the minimum required creepage distance is 9.5 mm.

[c] Other dimensions of creepage distance calculated by the following for voltage less than or equal to 160 V:

$$D = 0.002V + 0.5$$

and the following formula for voltages greater than 160 V:

$$D = 0.005V + 0.007$$

in which D is distance and V is volts.

Table 19.1 Continued on Next Page

Table 19.1 Continued

	Maximum voltage between parts, Vrms (Vpeak=1.4 Vrms) [clearance/creepage distance]

[d] Other dimensions of creepage distance calculated by the following for voltages less than or equal to 160 V:

$$D = 0.004V + 0.976$$

and the following formula for voltages greater than 160 V:

$$D = 0.01V + 0$$

in which D is distance and V is volts.

[e] Other dimensions of creepage distance calculated by the following formula for voltage less than or equal to 160 V:

$$D = 0.005V + 1.26$$

and the following formula for voltages greater than 160 V:

$$D = 0.126V + 0$$

in which D is distance and V is volts.

[f] Other dimensions of creepage distance calculated by the following formula for voltage less than or equal to 160 V:

$$D = 0.0057V + 1.61$$

and the following formula for voltages greater than 160 V:

$$D = 0.016V + 0$$

in which D is distance and V is volts.

[g] Other dimensions of clearance calculated by the following formula for voltages between 150 and 1050 volts:

$$D = 0.0059V + 2.09$$

in which D is distance and V is volts.

20 Polymeric Materials

20.1 A polymeric material, thermoplastic or thermosetting, used to provide all or part of the enclosure for electrical parts as specified in 8.1.1 or used to provide structural support of live parts as specified in 12.2 shall comply with the requirements of this section. Table 20.1 summarizes the specific requirements regarding use of a material as an enclosure.

Table 20.1
Summarized enclosure requirements

	Ballasts with fixed mounting and potted or no live parts within 0.8 mm of the enclosure	Ballasts with fixed mounting and having live parts within 0.8 mm of the enclosure	Cord connected or direct plug-in type ballasts and potted or no live parts within 0.8 mm of the enclosure	Cord connected or direct plug-in type ballasts and having live parts within 0.8 mm of the enclosure
Relative Temperature Index (RTI)	see 20.3	see 20.3	see 20.3	see 20.3
Impact – 5 ft-lb at room temperature	yes	yes	no	no
Impact – 3 ft drop at room temperature	no	no	yes	yes
Impact – 5 ft-lb conditioning with minus 17.8°C (0°F) for outdoor type 1 and minus 35°C (minus 31°F) for outdoor type 2 and weatherproof	yes, when outdoor rated	yes, when outdoor rated	no	no
Molded stress relief distortion	yes	yes	yes	yes
UV stability	yes	yes	no	no
Flame resistance	5VA	5VA	V1 or better	V1 or better
Comparative Tracking Index (CTI)	Not applicable	PLC = 4 or less (more resistant)	Not applicable	PLC = 4 or less (more resistant)
Hot Wire Ignition (HWI)	Not applicable	PLC = 3 or less (more resistant)	Not applicable	PLC = 3 or less (more resistant)
High Ampere Ignition (HAI)	Not applicable	PLC = 2 or less (more resistant)	Not applicable	PLC = 2 or less (more resistant)
Note – This table is a summary of requirements contained in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and therefore shall not be identified as complete. Additional considerations are specified in UL 746C.				

20.2 In applying the requirements of UL 746C, a ballast is to be considered permanently connected equipment, a ballast with a cord or a direct-plug in ballast is to be evaluated as a portable, non-attended equipment.

20.3 Regarding the Relative Thermal Endurance (RTI) in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, the polymeric material rating depends on the type of ballast and shall:

a) For a ballast intended for fixed mounting;

1) Have a mechanical temperature index, determined with respect to impact and long-term aging, of at least 90°C (194°F); and

2) Have an electrical temperature index, determined with respect to long-term aging, of at least 90°C (194°F) when the part is involved in the direct or indirect support of a live part.

b) For a cord connected or direct plug-in ballast;

1) Have a mechanical temperature index, determined with respect to impact and long-term aging, of at least the measured temperature; and

2) Have an electrical temperature index, determined with respect to long-term aging, of at least the measured temperature when the part is involved in the direct or indirect support of a live part.

Exception: A material without an RTI rating complies with this requirement when it has been accepted for the temperature as a generic material class in accordance with the table for relative thermal indices based upon past field-test performance and chemical structure in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

20.4 The investigation in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall include the ball impact test. Weatherproof and Outdoor Type 2 rated ballasts shall be subjected to the minus 35°C (minus 31°F) conditioning prior to the impact test. Outdoor Type 1 rated ballasts shall be subjected to the minus 17.8°C (0°F) conditioning prior to the impact test. The test method in UL 746 specifies the test sample is to be mounted in the intended manner. For this application, the test sample shall be mounted to a 3/4–inch thick plywood panel, 24 inches square. The plywood is to be placed on a concrete floor. The test sample is able to be removed from the temperature conditioning chamber and then secured to the plywood.

Exception: The drop test shall be conducted when the fluorescent lamp ballast (such as cord connected or direct plug-in type) is not provided with a mounting means.

20.5 The mold stress-relief distortion testing specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall be conducted only by the air-oven method, not by the test cell method.

20.6 The severe conditions and abnormal operation testing in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, are not to be conducted.

20.7 A push-in field wiring terminal at the point of exit from the enclosure shall have a flame resistance rating of at least V-2, even when the terminal closes an opening in the ballast enclosure.

20.8 When a ballast or accessory has a polymeric enclosure and is potted with epoxy, the polymeric enclosure shall have a flame resistance level of V-2 or better. The end-use qualifying flame test shall be conducted, in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and shall be applied to the outside of V-2 material.

20.9 A material used for the direct support of live parts, or within .03 inches (0.8 mm) of a live part, as defined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall comply with the requirements in the table for mechanical/electrical property considerations for maximum temperature limit of polymeric material based upon its functional end use product in UL 746C.

Exception: A material is not required to comply with Table 20.1 when it has been tested in the application in accordance with UL 746C.

20.10 The enclosure material shall comply with ultra violet light (UV) Stability described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Cord connected or direct plug-in ballasts do not require the UV Stability.

20.11 Polyamide thermoplastic coil forms (Type 6, 11, 12, 66, 6/0, or 6/2 nylon), either unfilled or glass filled, are appropriate for use in insulation systems which operate at or below Class 105 (Class A) hotspot temperatures. Polymide thermoplastic coil forms shall have a flame resistance calssification of HB or better. Nylon or similarly classed polyamides are not required to meet direct support criteria described in the Standard for Polymeric Materials – Coil Forms, UL 1692, and the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The volume resistivity is not required to be measured for these materials.

20.12 A ballast with a polymeric enclosure and intended for use in air handling spaces as defined in the National Electrical Code, ANSI/NFPA 70-1996, shall employ a polymeric material having a Flame Spread rating not exceeding 25 and a Smoke Developed rating not exceeding 50 when tested to the Standard for Test for Burning Characteristics of Building Materials, UL 723, or the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and their Accessories Installed in Air-Handling Spaces, UL 2043. See also 45.5.9.

PERFORMANCE

21 General

21.1 To determine whether a ballast complies with the applicable performance requirements for input/output measurements, leakage current, risk of electric shock measurements, normal temperature, abnormal temperature, and dielectric voltage withstand, representative samples of the ballast shall be subjected to the tests described in Sections 22 – 26 and 32 and to other performance tests, as applicable.

Exception No. 1: Separate samples are to be subjected to the Limited Short-Circuit Test, Section 34, when applicable.

Exception No. 2: When agreeable to those concerned, separate samples are able to be used for the tests described in 27.6 and for the Increased-Ambient Temperature Test – Class P Protected Ballasts, Section 28.

21.2 A Class P protected ballast shall be subjected to the conditioning described in 21.3, prior to conducting tests in Fault-Condition Test – Class P Protected Ballasts, Section 27, and Increased-Ambient Temperature Test – Class P Protected Ballasts, Section 28.

21.3 All samples of Class P protected ballasts to be used in the Fault Condition Test – Class P Protected Ballasts, Section 27, and in the Increased Ambient Temperature Test – Class P Protected Ballasts, Section 28, are to be subjected to the following conditioning: Class P protected ballasts are to be conditioned for 12 – 72 hours in an oven in which the temperature is maintained at 3.0°C (5.4°F) less than the rated opening temperature of the protector when a thermostatic protector is used, and at 5.0°C (9.0°F) less than the rated opening temperature when a thermal fuse protector is used. A sample in which the protector opens during this conditioning is not to be used for tests.

Exception: Samples that are to be subjected to the Limited Short Circuit Test, Section 34, are not required to be subjected to the conditioning.

21.4 A reactor ballast for use on direct current is to be tested using a resistor as specified by the manufacturer.

21.5 When testing a resistor-type ballast intended for use in conjunction with a reactance ballast, the circuit is to be established as specified by the manufacturer of the reactance ballast.

21.6 Other than as noted in 21.9, all tests are to be conducted with the ballast connected to a supply circuit of rated frequency. The voltage of the supply circuit is to be:

a) 120 volts for a product rated less than 120 volts;

b) 240 volts for a product rated from 220 volts up to and including 240 volts;

c) 120 volts or 277 volts, as described in 21.7, for an electronic ballast capable of operating from a nominal 120 volts to a nominal 277 volts (also known as universal input); or

d) The maximum rated voltage of the ballast, for a ballast rated other than as mentioned in (a) and (b). See Table 22.1.

Exception: Regarding (b), the voltage of the supply circuit is to be the maximum rated voltage of the ballast when:

a) The ballast is rated in the range of 220 – 240 volts and intended to comply with the requirements in 13.2.7 and 45.2.2;

b) The ballast is rated in the range 220 – 240 volts and 50 hertz; or

c) The ballast is rated for 220 volts, 60 hertz, and marked "for export only."

21.7 For ballasts having the ability to accept a range of input voltages that are either selected manually by wiring the ballast during installation or by automatic, self-adjusting circuitry, the following tests are to be conducted as ammended:

a) The Input/Output Test of Section 22 is to be used to confirm the appropriateness of marked ratings. The current and wattage is to be measured at the low range of the input voltage, and in turn, the high range, with the supply conductor grounded as intended.

b) The Leakage-Current Test of Section 23 is to be used to determine the amount of electrical leakage current from the enclosure. Internal ballast circuitry which includes capacitors from line to ground greatly influences the amount of leakage current. The leakage current is to be measured at the highest range of the input voltage with a single side grounded supply, and in turn, the highest range of input voltage with a balanced to ground supply.

c) The Temperature Tests of Sections 25 and 26 are to be used to determine the maximum temperature of insulating materials and ballast mounting surfaces. Temperatures are to be measured at the low range of the input voltage, and in turn, the high range, with either a single side grounded or balanced to ground supply as is the convention for the voltage involved.

d) The Fault-Condition Tests of Sections 27 and 29 are to be used to determine the consequence of a single component failure (open or shorted). The test is to be conducted with the sample connected to the low range of the input voltage, with either a single side grounded or balanced to ground supply as is customary.

e) The Dielectric Voltage-Withstand Test of Section 32 is to be used to determine the adequacy of the dielectric property of insulating materials. The computed test potential is to be determined by using the high range of input voltage.

21.8 For ballasts with the ability to accept a family of lamps in a range of lamp wattages or shapes, the following tests are to be conducted as amended:

a) The Input/Output Test of Section 22 is to be used to confirm the appropriateness of marked ratings. The ballast input current (or wattage) is be to measured for the high range of lamp wattages. Additional lamp currents (or wattages) are to be measured when the ballast label provides ballast input current (or wattage) for corresponding lamps.

b) The Leakage-Current Test of Section 23 is used to determine the amount of electrical leakage current from the enclosure. Interaction of lamp type and enclosure leakage can be considered minimal. Measure leakage current when the ballast is powering the lamp that resulted in the greatest ballast input current or wattage.

c) Risk of Electric Shock Measurements Tests of Section 24 are to be conducted when affected by the lamp the ballast uses. The lamp with the easiest (lowest) starting voltage is to be used for the through lamp measurement. For the foil around the lamp test, the current to ground will be greatest for the lamp that resulted in a ballast condition of the greatest voltage to ground at one end of the lamp.

d) The Temperature Tests of Section 25 are used to determine the maximum temperature of insulating materials and ballasts mounting surfaces. Temperatures are to be measured using the lamp that resulted in the greatest input current or wattage in the Input Test.

e) The Abnormal-Temperature Test of Section 26 is used to determine the maximum temperature of insulating materials and ballast mounting surfaces during an abnormal of either deactivated lamp or shorted starter. Measure temperatures using the lamp that resulted in input current or wattage as a result of the preheat or deactivated lamp condition.

21.9 A ballast rated 50 – 60 hertz need only be tested at 60 hertz unless testing at 50 hertz represents a more severe condition.

21.10 In general, the voltage in other than the primary supply circuit is to be measured using a voltmeter or voltmeter-multiplier combination having a resistance of not less than 10,000 ohms per volt. Meters having higher input impedances are to be employed whenever it is warranted by the impedance of the circuit under test.

21.11 When determining values of voltage, a true rms indicating meter having a frequency response at least three times the frequencies involved and having an adequate crest factor (ratio of peak to rms) should be used. If applicable, consideration should be given to the d-c component of the waveshape. If a referee rms-voltage measurement is necessary, a meter with an input impedance of 10 megohms shunted by 30 picofarads of capacitance is to be used.

21.12 If it is necessary to determine peak-voltage values, an oscilloscope with a high-impedance (10 megohms minimum) input probe is to be used.

21.13 Prior to making the measurements in Sections 22 – 24, it may be necessary to make a preliminary review using an oscilloscope to determine the nature of the available currents. An a-c/d-c meter is to be employed for the recording of d-c with or without a-c.

21.14 To determine compliance with the marking requirements in 45.3.1 – 45.3.3, the power factor is to be calculated by determining the ratio of the active power to the apparent power. The active power is to be measured with a wattmeter capable of indicating the true rms power in watts. The apparent power is to be the product of the input voltage and the true rms current.

22 Input/Output Measurements

22.1 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, and when the ballast is energized at the input voltage and frequency in accordance with 21.6. For the measurements, the ballast and lamps are to be operated first until thermal equilibrium is reached.

22.2 Any commercial lamp for which the ballast is marked may be employed when conducting the current-input measurement mentioned in 22.1. If the input to the ballast exceeds the marked rating by more than 110 percent when such a lamp is used, the ballast may be retested with a selected lamp of which the measured lamp wattage, at rated lamp-operating voltage, equals rated lamp wattage ±2 percent. If the results of the input test with the selected lamp are acceptable, the results of the first input test are to be disregarded.

22.3 When the current input for a ballast connected as a preheat circuit is measured, the lamp is to be started with a manual-starter switch or equivalent starter that does not continually draw current.

22.4 The output voltage mentioned in 22.1 refers to the maximum voltage measured between any pair of terminals or lead wires of a ballast under any condition of ballast operation – including normal lamp operation, operation without a lamp, and operation with a deactivated lamp or lamps – but does not include measurements between primary terminals, or lead wires, and secondary terminals, or lead wires, of:

a) A two-winding transformer (isolating-type) ballast; or

b) An electronic ballast with an isolating output transformer.

22.5 The voltage to ground mentioned in 22.1 refers to the voltage between any terminal or lead wire of a ballast and a point at ground potential in a conventional branch circuit to which the ballast ordinarily would be connected, under the conditions of operation described in 22.4, but does not include measurements from the primary terminals or lead wires, nor does it include measurements from the secondary terminals or lead wires of a two-winding transformer (isolating-type) ballast. The voltage to ground may or may not exist as a voltage between lead wires.

22.6 Output voltage and voltage to ground are to be measured only to those terminals or lead wires that will normally be provided on a ballast and are not to be measured to those terminals or lead wires provided only for measurements as described in 25.4.

22.7 Table 22.1 specifies the power-supply system to be employed in measuring voltage to ground. See 13.2.7 – 13.2.9, 13.3.5, 13.6.2, and 45.2.2.

Table 22.1
Primary power supply for output-voltage test

Primary voltage rating of ballast, volts	One primary lead intended to be grounded[a]	Power-supply system to which primary leads are to be connected
100 – 150	Yes	b or e
200 – 215	No	c
220 – 250	Yes	b
220 – 250	No	d
265 – 280	Yes	b or e
340 – 350	Yes	e
440 – 500	No	c
500 – 600	No	d or c

[a] When the ballast has a lead or terminal that is intended to be connected to the grounded power-supply conductor, identified as described in 13.6.2 or 13.2.8 or terminal is to be connected to such conductor.

[b] Two-wire, single-phase, with one wire grounded.

[c] Four-wire, 3-phase, Y-connected, with grounded neutral. Ballast leads connected to two ungrounded conductors.

[d] Three-wire, single-phase, with neutral grounded. Ballast leads connected to ungrounded conductors.

[e] Four-wire, 3-phase, Y-connected, with grounded neutral. Ballast leads connected to phase conductor and neutral.

22.8 For an isolating transformer-type ballast intended for use in a portable lamp, the voltage between any output terminal or lead and any input terminal or lead shall not be more than 150 volts, with the output circuit open or under normal operating conditions and the ballast energized at an input voltage and frequency in accordance with 21.6. A nonelectronic ballast need only be tested with the output circuit open. If a high-impedance voltmeter is used for the measurement, the input is to be shunted with a 10,000-ohm resistor. See 45.5.3.

22.9 A reactor ballast with a primary voltage rating of less than 150 volts complies with the requirement in 24.2.6, and need not be tested.

23 Leakage-Current Test

23.1 A ballast shall be tested in accordance with 23.2 – 23.10; the leakage current shall not be more than that specified in Table 23.1.

Exception: The leakage current for a simple reactance ballast is not required to be measured.

Table 23.1
Leakage current

Type of ballast	Maximum measured voltage[a]	Maximum leakage current, Meter Indication Units (MIU)[b]
AC	150 volts or less	0.5 MIU
AC	greater than 150 volts	0.75 MIU[c]

[a] See 22.4 for description of input/output voltage measurement.
[b] See 2.14.
[c] See 45.5.4.

23.2 Leakage current refers to all currents, including capacitively coupled currents, that are conveyed between exposed conductive surfaces of a ballast and ground during any condition of ballast operation, including normal lamp operation, open circuit operation, and operation with a deactivated lamp or lamps. It does not measure the current for all modes of ballast operation when it is determined that one mode, for example no lamps, results in the most severe current.

23.3 During the leakage-current measurement, the core and the metallic case of a power capacitor that could be in random contact with the ballast enclosure are to be conductively connected to the ballast enclosure unless the construction, such as an interposing sheet insulation, specifically precludes such contact.

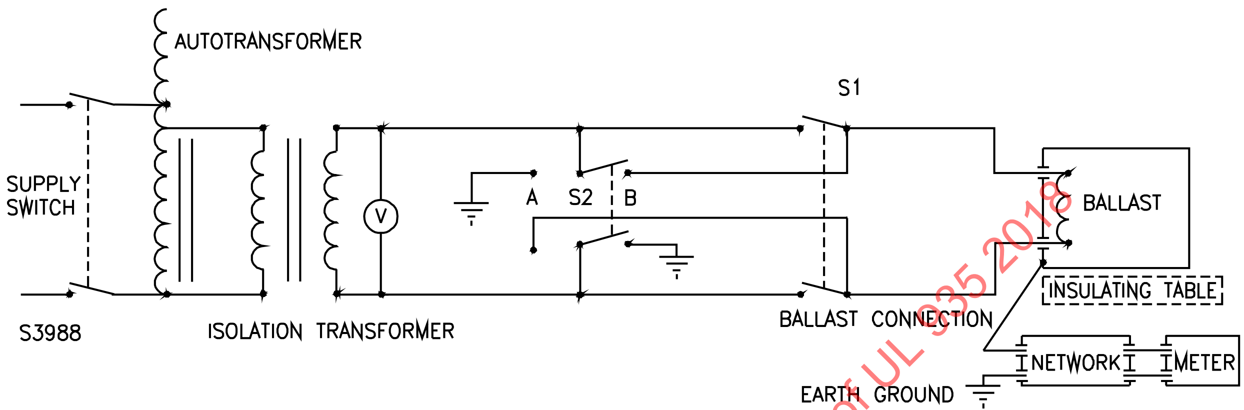
23.4 The leakage current from the enclosure is to be measured to the grounding supply conductor of the measurement circuit test transformer, see Figure 23.1. A ballast having a nonmetallic enclosure is to be tested using a metal foil with an area of 10 by 20 centimeters in contact with the surface of the enclosure as an electrode for the test probe.

23.5 Typical measurement circuits for leakage current with the ground connection open are illustrated in Figure 23.1. The meter input network is defined in Figure 23.2. The meter that is actually used for a measurement is to indicate the same numerical value for a particular measurement as is indicated by the defined instrument; it is not required to have all the attributes of the defined instrument. See also 21.6. Over the frequency range 20 Hz to 1 MHz with sinusoidal currents, the performance of the instrument is to be as follows:

a) The measured ratio V_1/I_1 with sinusoidal voltages is to be as close to the ratio V_1/I_1 calculated with the resistance and capacitance values of the meter input network shown in Figure 23.2 as the instrument is able to measure.

b) The measured ratio V_3/I_1 with sinusoidal voltages is to be as close to the ratio V_3/I_1 calculated with the resistance and capacitance values of the meter input circuit shown in Figure 23.2 as the instrument is able to measure. V_3 is to be measured by the meter M in the defined instrument. The reading of meter M in RMS volts is converted to MIU by dividing the reading by 500 ohms and then multiplying the quotient by 1000. The mathematic equivalent is found by multiplying the RMS voltage reading (in volts) by 2.

Figure 23.1
Circuit for leakage-current test



23.6 The test circuit is to employ an isolating transformer. The grounded test conductor is to be connected to a reliable ground. Switch S2 is to have an intermediate off position.

23.7 A sample of the ballast is to be tested for leakage current in an ambient temperature of 25 ±5°C (77 ±9°F). The supply voltage, V in Figure 23.1 is to be adjusted to the voltage and frequency specified in 21.6. The use of any commercial lamp to measure leakage-current meets the intent of this requirement. However, when the leakage current exceeds the value specified in Table 23.1, the ballast is able to be retested using only lamps of which the measured lamp wattage at the rated voltage of the lamps equals rated lamp wattage ±2 percent. The results of the first leakage-current test are to be disregarded when it is determined that the results of the retest using the specified lamps comply with this requirement. In the following section, the MIU value is to be calculated either from the meter reading when the meter indicates millivolts or read directly from the meter when the meter indicates MIU. The test sequence with reference to Figure 23.1 is to be as follows:

a) With switch S1 in the off position and switch S2 in the intermediate off position, the line switch is to be closed and the input voltage is to be adjusted to the maximum rated voltage of the ballast.

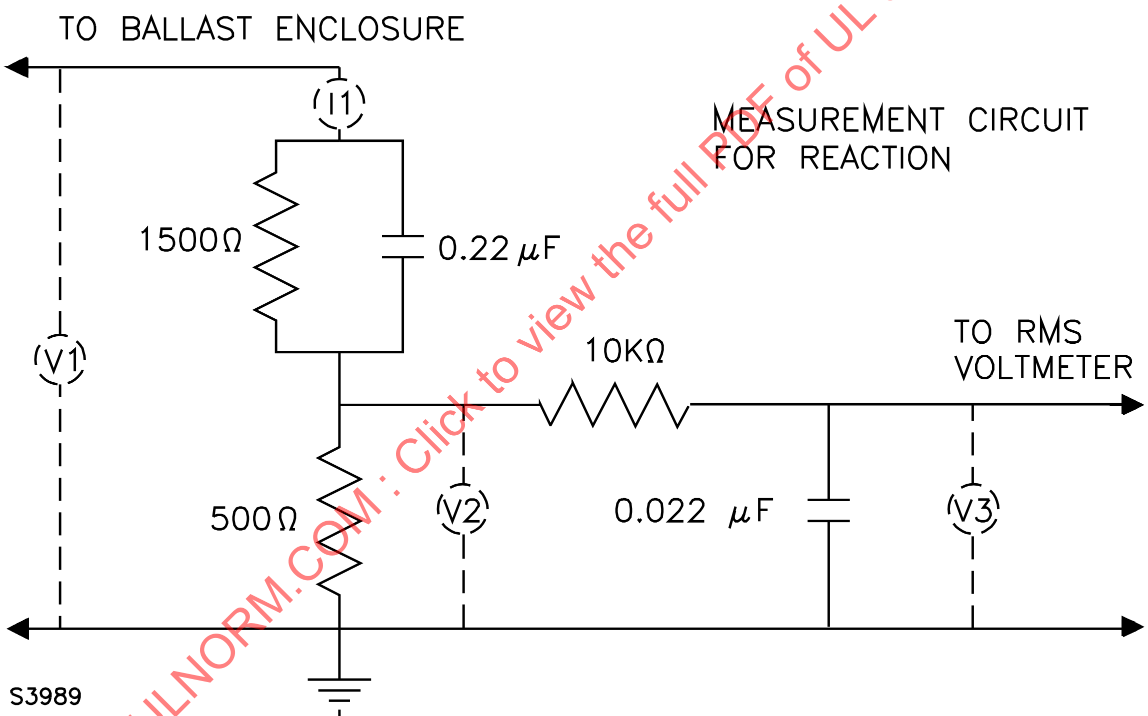
b) With switch S1 in the off position, switch S2 is to be transferred to position A and the leakage current is to be measured. Switch S2 is then to be transferred to position B and the leakage current is to be measured.

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

d) With switch S2 in the intermediate 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 is to be measured. Switch S2 is then to be transferred to position B and the leakage current is to be measured.

e) Switch S2 is to be returned to the intermediate off position and switch S1 is to be turned off. 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 is to be measured.

Figure 23.2
Meter input network



23.8 For the measurements involving an electronic ballast, the lamps and ballast are to be arranged in a test fixture as shown in Figure 24.1 while the ballast supply is connected as shown in Figure 23.1.

23.9 A sample is normally subjected to the entire leakage-current test, as specified in 23.7, without interruption for other tests. When required, the leakage-current test is able to be interrupted to conduct other nondestructive tests.

23.10 Using a commercially available meter having the network shown in Figure 23.2 or built to conform to the Standard for Leakage Current for Appliances, ANSI C101-1992, meets the intent of these requirements.

24 Risk of Electric Shock Measurements

24.1 General

24.1.1 In order to reduce the risk of electric shock, during relamping, a ballast shall comply with the applicable requirements in 24.2 and 24.3.

24.1.2 With reference to the test conditions specified in 24.2.4 and 24.3.2, if agreeable to those concerned, a ballast may be located outside of the fixture wireway as illustrated in Figure 24.1.

24.2 Ballast lead and lamp pin measurements

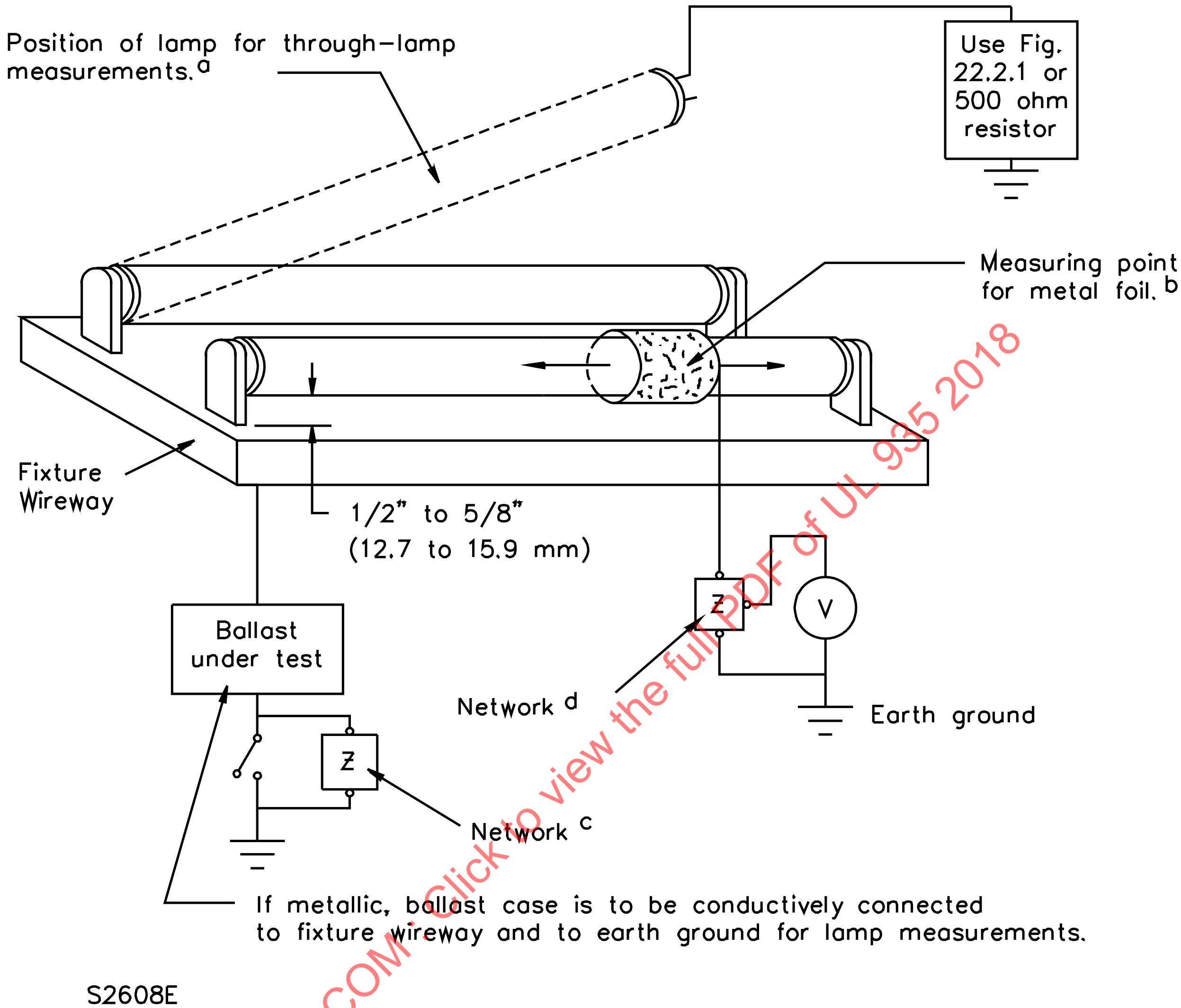
24.2.1 A ballast shall be tested as described in 24.2.3, 24.2.4, or 24.2.6, without exceeding the specified voltage or current limits, as applicable.

Exception: The test is not required to be conducted when the ballast is a simple reactance type and is operated as a preheat circuit, or is marked in accordance with 45.4.4.

24.2.2 For the tests described in 24.2.3, 24.2.4, and 24.2.6, the ballast is to be energized with the input voltage and frequency in accordance with 21.6.

24.2.3 For a two winding (isolated) transformer ballast, the lamp of a single lamp ballast is to be removed from the lampholders. For a multilamp ballast, each lamp, in succession, is to be removed from its lampholders and then replaced. The current from each lead (or lampholder terminal) to ground is to be measured. For the current measurement, a noninductive 500 ohm resistor or the meter input network in Figure 24.2 is to be connected between ground and each lead (or lampholder terminal), in turn, and the current through the resistor is to be measured. The measured values of current shall not exceed the values specified in 24.2.7, Table 24.1, or Table 24.3.

Figure 24.1
Test setup for leakage-current and shock-current measurements



[a] See 24.2.4.

[b] See 24.3.2.

[c] See 23.5.

[d] See Figure 24.3.

Figure 24.2
Alternative circuit – through lamp

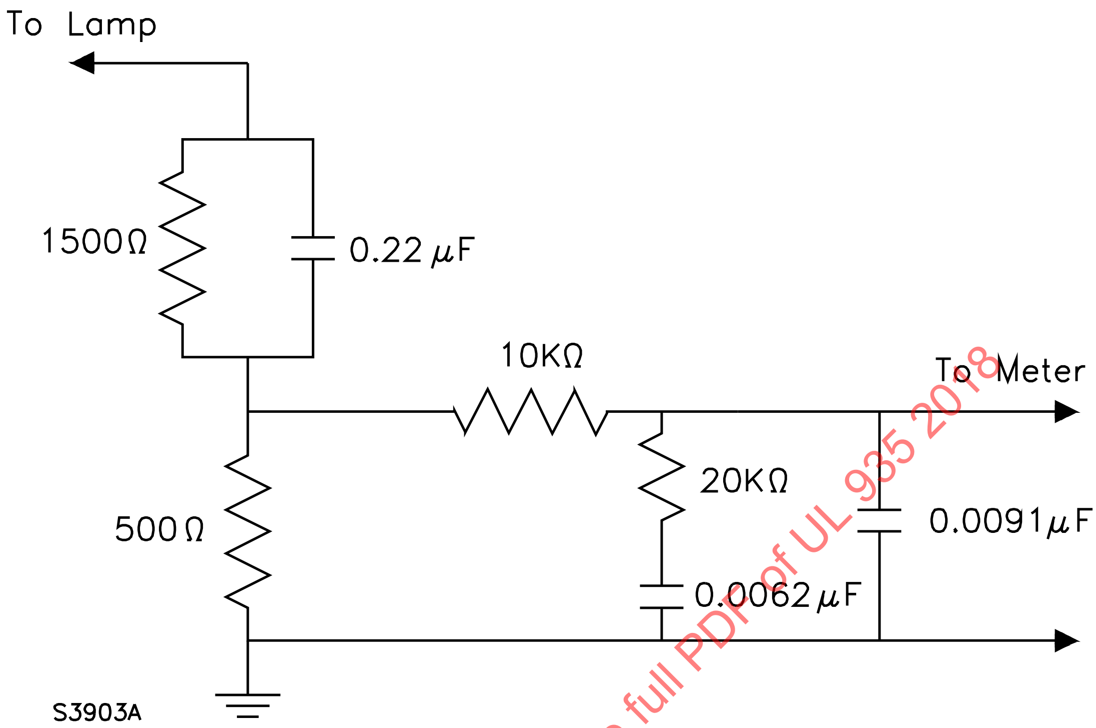
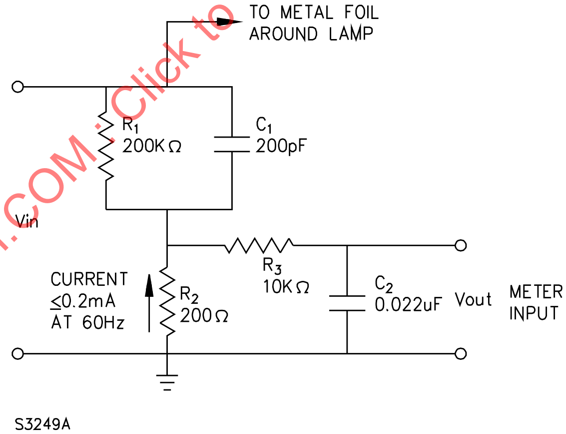


Figure 24.3
Reaction current network



Note 1: The current network consists of two portions. R_1-C_1-R_2 represent a body impedance compensation for a single hand grasping a lamp and contacting a grounded surface with a knuckle. R_3-C_2 represent a frequency sensitive compensation (or weighting) where reaction to current and frequency are related.

Note 2: To determine response of an actual network, a signal generator and a voltmeter can be used. The response at selected frequencies is shown in Table 24.2.

Table 24.1
Shock-current measurements

Frequency (hertz)	Maximum peak M.I.U.[e] when using the network in Figure 24.2	Maximum current when using a 500 ohm resistor as described in 24.2.3 or 24.2.4[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
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.

Table 24.2
Reaction current network attenuation

Frequency (Hz)	Attenuation[a]	
	Ratio (Vin/Vout)	(dBV)
60	1000	60.0
100	1010	60.1
500	1207	61.6
700	1365	62.4
1000	1656	64.4
2000	2629	68.4
5000	4353	72.8
10000	5129	74.2
20000	5403	74.7
50000	5489	74.8
100000	5503	74.8

[a] V_{in} = 1 volt and dBV = 20 $\log_{10}$ (Vout/Vin). See Figure 24.3.

24.2.4 A lamp of a single lamp ballast, and each lamp of a multilamp ballast in turn is to be removed from the lampholder at one end. The meter network shown in Figure 24.1 is to be connected between one of the accessible lamp pins and ground (see Figure 24.1). The measured values of current shall not exceed that specified in 24.2.7, Table 24.1, or Table 24.3 with a noninductive resistor of 500 ohms across the meter input terminals or that specified in Table 24.1 with the meter and network described in Figure 24.2. Unless a certain lamp condition is known to be most severe by being the easiest to start, measurements are to be made under the following possible conditions:

a) Operation within a fixture, or equivalent, see 24.1.2 and Figure 24.1;

b) With the ballast controlling:

 1) A standard lamp or lamps; and

 2) An energy saving lamp or lamps, when the ballast is marked for use with such lamps;

c) With the ballast controlling:

 1) A new lamp or lamps; and

 2) A conditioned lamp or lamps;

d) With a lamp or lamps that are:

 1) At room temperature; and

 2) Heated from normal operation – the measurements are to be made as quickly as possible.

e) With a lamp or lamps that are deactivated, for a multilamp ballast.

24.2.5 If the 500 ohm resistor described in 24.2.4 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.

24.2.6 For a non-electronic ballast intended for use with one or more 40 watt or 4 foot rapid-start lamps rated 34/35 watts, the lamp of a single-lamp ballast is to be removed from the lampholders. For a multilamp ballast, each lamp is to be removed, in turn. In addition, all lamps may be removed. The voltage potential to ground from each lead (or lampholder terminal) is to be measured for each condition. The measured values shall not exceed 175 volts rms and 300 volts peak at any of the ballast leads (or lampholder terminals). For a two or three lamp ballast where the lamps are connected in a series-start lead circuit, the measured values shall not exceed 175 volts rms and 325 volts peak during the condition of one lamp operating.

24.2.7 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 24.3.

Table 24.3
Time and current limits

Pulse time duration, seconds (T)	Current limit (rms), mA when using a 500 ohm resistor as described in 24.2.3 or 24.2.4
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 24.1 whichever gives the greater limit

24.3 Foil measurement (electronic ballasts)

24.3.1 For an electronic ballast, the ballast is to be connected as illustrated in Figure 24.1, and energized at an input voltage and frequency in accordance with 21.6. A piece of metal foil 2 inches (51 mm) wide is to be wrapped around the entire circumference of the lamp, and the foil is to be moved along the longitudinal axis of the lamp as illustrated in Figure 24.1. A lead from the foil is to be attached to the lamp reaction current network shown in Figure 24.3. The measured current shall not exceed 0.2 milliampere through the 200 ohm resistor if the frequency is 60 hertz. When using an rms indicating voltmeter, the voltage at the network output shall not exceed 40 millivolts (minus 28 dBV), regardless of the frequency.

Exception No. 1: For a quad-type compact lamp, the foil need not fit into the crevice between bulb tubes.

Exception No. 2: The test need not be conducted if the ballast is marked for use only with compact lamps rated less than 20 watts.

24.3.2 The measurements using metal foil as described in 24.3.1 are to be made under the following conditions:

a) Operation within a fixture, or equivalent, see 24.1.2 and Figure 24.1;

b) Normal operation;

c) With the ballast controlling:

1) A standard lamp or lamps; and

2) An energy-saving lamp or lamps, if the ballast is marked for use with such lamps; and

d) For a multilamp ballast, the other lamp or lamps are to be:

1) Removed from the circuit, in turn; and

2) Deactivated.

25 Normal-Temperature Test

25.1 A ballast shall be tested within an oven operating at a temperature of 40.0 ±5.0°C (104.0 ±9.0°F) in accordance with 25.4 – 25.20. The maximum temperature shall not exceed those specified in Table 25.1 when corrected to 40°C (104°F), if necessary.

Exception: A through-cord or a direct plug-in ballast is to be tested in an ambient temperature of 25.0 ±2.0°C (77.0 ±3.6°F).

25.2 The temperature on any surface inside a terminal or splice compartment when corrected to 25°C (77°F) shall not be more than 60°C (140°F) unless the ballast is marked in accordance with 45.7.1.

25.3 Regarding coil insulation systems values in Table 25.1, the insulation system temperature is also known as the internal hot spot temperature. The change of resistance measurement method gives the average temperature of the entire coil from internal hot spots to the cooler, outer surface, hence the average limit is lower than the internal hot spot, or system limit. The thermocouple measurement method gives the temperature of the cooler, outer surface, hence the limit is lower than the average limit. Use of the thermocouples measurement method is primarily for convenience. The thermocouple limit may be exceeded provided the average coil temperature by the change of resistance method is not exceeded.

25.4 It may be necessary to test a modified sample, with additional lead wires that are extended, so that the temperature of each coil of a ballast may be measured by the resistance method. The lead wires are to be identified to facilitate making measurements. Thermocouples for determination of temperatures on capacitors may be mounted during assembly of the ballast.

Table 25.1
Maximum acceptable temperatures

Table 25.1 revised November 7, 2011

Materials and components	°C	°F
A. COMPONENTS		
1. Capacitor (other than oil filled)	a	a
2. Capacitor (oil filled)	70	158
3. Fuses	a	a
4. Coil insulation systems		
Class 105 Insulation systems:		
Thermocouple method	90	194
Resistance method (fully potted)	105	221
Resistance method (open core and coil)	95	203
Class 130 insulation systems:		
Thermocouple method	110	230
Resistance method	120	248
5. Potting compound	b	b
6. Printed-wiring boards	a	a
7. Internal wiring	a	a
8. Soldered joint of a resistance ballast	150	302
B. ELECTRICAL INSULATION		
1. Vulcanized fiber employed as electrical insulation for other than coil systems	90[c]	194
C. SURFACES		
1. A surface upon which the ballast is placed or mounted in service	90	194
2. An exposed surface of a resistance ballast	150	302

Table 25.1 Continued on Next Page

Table 25.1 Continued

Materials and components	°C	°F
3. On the case of an enclosed ballast and on the outer surface of an open-core-and-coil ballast	90	194
4. A surface of a direct plug-in or through-cord ballast	75	167
5. Interior surface of field splice compartment	See 25.3	See 25.2

[a] There are no temperatures specified; the rated temperature of the material or component is to be used.

[b] Unless the material is thermo-setting, the maximum potting compound temperature, when corrected to a 40°C (104°F) ambient temperature, shall be:

1) At least 15°C (27°F) less than the softening point of the compound as determined by the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus, ASTM E28;

2) At least 15°C less than the softening point of the compound as determined by the Standard Test Method for Softening Point of Bitumen, ASTM D36/D36M; or

3) At least 25 °C less than the softening point of the compound as determined by the Standard Test Method for Vicat Softening Temperature of Plastics, ASTM D1525.

[c] Vulcanized fiber that has been investigated and found acceptable for use at a higher temperature may be used at that higher temperature.

25.5 During the test the ballast is to be supported as described in 25.9 and as illustrated in Figure 25.1. The floor between the heaters and the ballast under test is to be of a thermal insulating material. The test compartment of the enclosure is to have internal dimensions of 24 by 24 inches (610 by 610 mm). The floor of the test compartment is to be 22 by 22 inches (559 by 559 mm), permitting an air space of 1 inch (25.4 mm) all around the floor for circulation of the heated air. A 3-inch (76.2-mm) deep heater compartment is to be provided below the floor of the test area for the heating elements. One side of the test compartment may be removable, but is to be constructed so that it can be securely fastened to the remainder of the enclosure. One of the sides is to have a 6-inch (152-mm) square opening located centrally at the bottom edge of the test compartment, and the enclosure is to be constructed so that the only possibility of air circulation will be through this opening. The opening is to be covered by an aluminum shield positioned so that it extends 1/2 inch (12.7 mm) beyond the perimeter of the opening. Also see 25.8.

25.6 The heat source used for the test enclosure described in 25.5 is to consist of four 300-watt, 230-volt, strip heaters having heating surface dimensions of approximately 1-1/2 by 12 inches. The elements are to be connected in parallel to a 120-volt supply source. The elements are to be mounted in the 3-inch (76.2 mm) deep heater compartment midway between the test-compartment floor and the base, and are to be arranged so that they form a square with the outside edge of each element 2-1/2 inches (63.5 mm) from the adjacent inside wall of the compartment. The elements are to be controlled by a thermostat.

25.7 In lieu of the oven construction described in 25.5 and 25.6, the oven may be a commercially manufactured oven having still-air convection heating. The heaters are to be located below the floor of the oven compartment, and are to be thermostatically controlled to provide the required oven temperature regardless of the heat gain from the device under test. Glowing coils shall not radiate directly onto the ballast enclosure. The volume of the oven compartment is to be between 5-1/2 ft^3(0.156 m^3) and 8 ft^3(0.226 m^3).

25.8 Prior to the test, the ballast – not energized – is to be placed in the test enclosure until all parts reach the temperature of the heated air therein.

25.9 The ballast is to be in its normal operating position, supported 3 inches (76.2 mm) above the floor of the test enclosure by two 3-inch wooden cleats, and is to be centrally located with respect to the sides of the enclosure. Electrical connections may be brought out of the enclosure through the 6-inch (152-mm) square opening specified in 25.5. During the test, the enclosure is to be located so that the shielded opening is not exposed to drafts or rapid air currents.

25.10 During the test, the ballast is to be energized at an input voltage and frequency in accordance with 21.6.

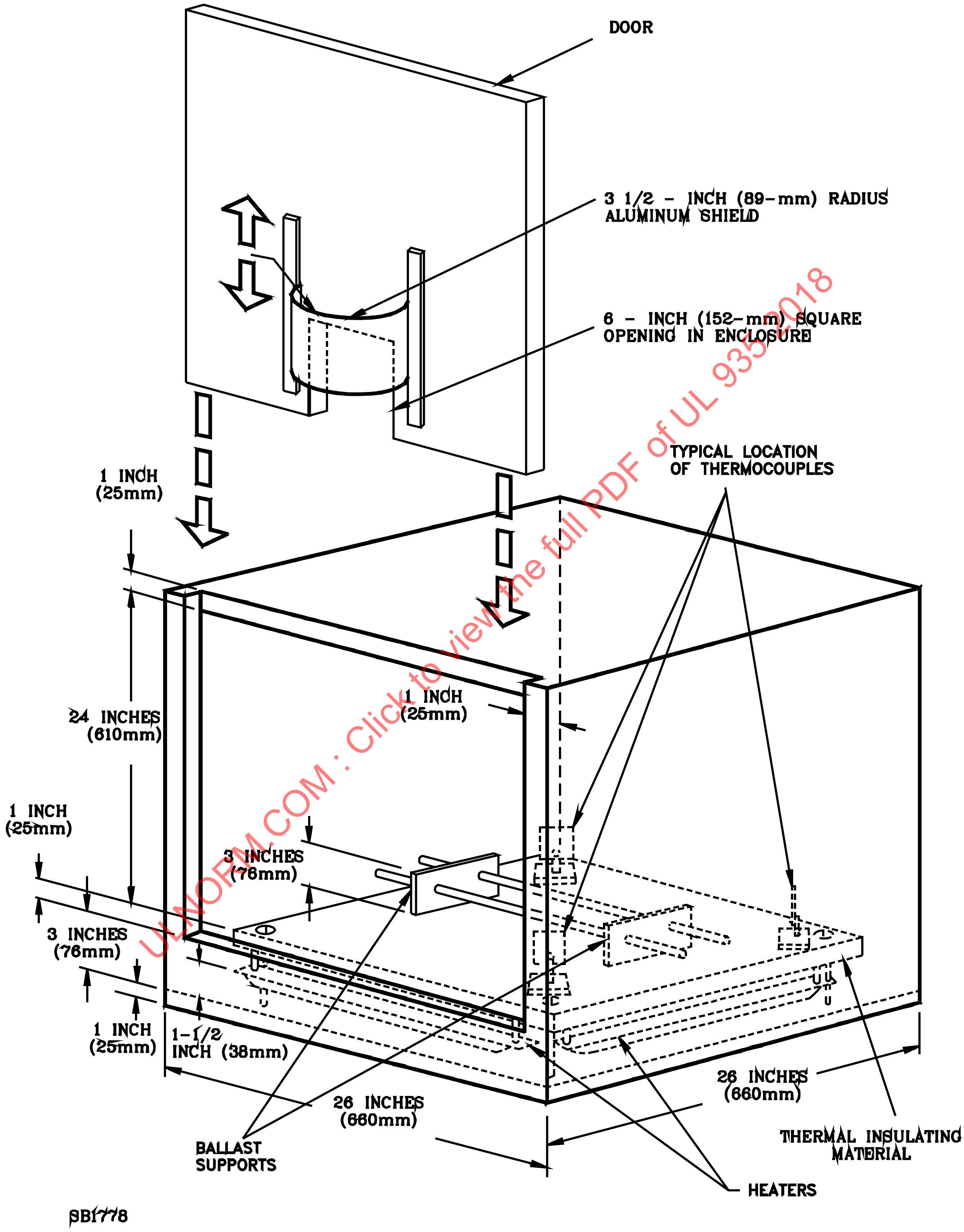
25.11 The ballast is to supply the number and size of lamps for which it is marked. It may be necessary to conduct more than one temperature test in order to determine temperatures using other lamp combinations for which the ballast is marked.

25.12 The current input shall not be less than 90 percent of rated current input.

25.13 If the current input to a ballast being tested is less than 90 percent of its rated value, it may be possible to raise the input current to the required test value by blanketing the lamps.

25.14 The average of two or more thermocouple readings is to be taken for the air temperature within the test enclosure. Thermocouples as described in 25.15– 25.18 are to be located so that the temperature-sensing portions are 3 inches (76.2 mm) from the floor of the test enclosure, and not less than 3 inches from the nearest wall.

Figure 25.1
Test enclosure (see 25.5)



25.15 Temperatures on capacitors and on the case are to be measured by thermocouples. The thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouples and related instruments are to be accurate and calibrated. The thermocouple wire is to comply with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

25.15 revised December 6, 2013

25.16 A thermocouple junction and the adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material of which the temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place; but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

25.17 When thermocouples are used to determine temperatures, it is common to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan (Type J) wires. 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.

25.17 revised June 10, 2010

25.18 The temperature on a coil may be measured by the thermocouple method or determined by the change-of-resistance method (comparing the resistance of the winding at the temperature to be measured with its resistance at a known temperature) using the formula specified in 25.20.

25.19 The test is to continue until constant temperatures are obtained. A temperature is considered constant if:

a) The test has been running for at least 3 hours; and

b) Three successive readings, taken at 15 minute intervals, are within 1 degree C of one another and are still not rising.

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

$$T_H = \frac{R_H}{R_C}(k + T_C) - k + (40 - T_o)$$

in which:

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

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

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

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

T_O is the temperature of the oven in degrees C at the end of the test when R_H is measured; and

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

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

26 Abnormal-Temperature Test

26.1 A ballast shall be tested in accordance with 26.6 – 26.9; the maximum temperature:

a) Of a coil of a reactance ballast shall not be more than 135°C (275°F) when it incorporates a Class 105 insulation system and 160°C (320°F) when it incorporates a Class 130 insulation system, as measured by the resistance method.

b) On a capacitor shall not be more than 10°C (18°F) over the manufacturer's rating, except as noted in 26.4.

c) Of a component of an electronic ballast, other than as noted in (a), shall not exceed the values specified in Table 25.1 nor shall the temperature at any other point be so high as to result in a risk of fire or adversely affect any material used in the ballast.

Exception: The abnormal-temperature test may be waived if it is obvious that temperatures will be lower than they are for normal operation.

26.2 Regarding 26.1(a), a thermocouple measurement is to be made on the outer surface of a ballast coil and shall not be more than 130°C (266°F) when the coil incorporates a Class 105 insulation system, and 150°C (302°F) when it incorporates a Class 130 insulation system.

26.3 A thermal protective device provided with a ballast that complies with Protective Devices Provided in Class P Protected Ballast, Section 16, is to remain functional during the abnormal temperature test.

26.4 The maximum temperature for a capacitor specified in 26.1 and Table 25.1 applies to a power capacitor. Any other capacitor is to be judged on the basis of its performance at the temperatures to which it is subjected during the normal- and abnormal-temperature tests.

26.5 During the test described in 26.6 – 26.9, no compound or other material shall be emitted from the ballast.

26.6 For a resistance ballast operated under the conditions described in 26.7 and 26.9, the temperature on any material used in the ballast shall not exceed the temperature limit for that material.

26.7 For a rapid- or instant-start-circuit ballast, the test is to be conducted with a deactivated lamp for either a single lamp ballast or a multilamp ballast. For a preheat-circuit ballast, the test is to be conducted with either:

a) The starter short-circuited; or

b) A lamp deactivated, so that maximum heating will result.

26.8 For the requirements in this standard, a deactivated lamp is to be simulated by using two lamps with a lampholder connected to one end of each lamp; for an instant start circuit utilizing a circuit interrupting lampholder, the lamp is to be removed and the lampholder contacts are to be shorted together.

26.9 If a semiconductor component can be shorted but the ballast would appear to operate normally, the component shall be separately shorted.

26.10 Other than as noted in 26.11, all other conditions of the test, including the location of the ballast in the test chamber, dimensions of the chamber, and the like, are to be as described in the Normal-Temperature Test, Section 25. If the heat from the ballast causes the air in the test enclosure to exceed the maximum specified ambient value, the test is to be continued at whatever temperature is reached; but the results are to be corrected to the applicable ambient temperature for the ballast under test.

26.11 A ballast is to be tested as specified in 26.10 at an ambient temperature of 40 ±5°C (104 ±9°F).

Exception: A reactor (simple reactance) ballast that is not provided with thermal protection and marked to operate only straight, tubular lamps is to be tested as specified in 26.10 in an ambient temperature of 25°C (77°F).

27 Fault Condition Test – Conventional Magnetic Ballast – Class P Protection

27.1 A ballast provided with an automatic reset thermal protector shall meet the following criteria while the ballast is subjected to any of the conditions of 27.6. When more than one thermal protector is employed, the protectors shall be electrically connected in series.

a) The temperatures on any point on the case of an enclosed ballast (including an electronic ballast without an automatic reset thermal protector) or the outer surface of an open core and coil ballast shall not exceed 150°C (302°F);

b) The locations in (a) that exceed 110°C (230°F) shall comply with the temperature versus time criteria specified in Table 27.1;

c) The locations in (a) that exceed 110°C (230°F) when the protector opens the circuit shall not exceed 85°C (185°F) when the protector cools and recloses the circuit. The locations in (a) that do not exceed 110°C (230°F) when the protector opens the circuit shall not exceed 100°C (212°F) when the protector cools and recloses the circuit;

d) A power capacitor provided as part of such a ballast shall not exceed 90°C (194°F) or the capacitor manufacturer's assigned rating, whichever is higher; and

e) For a simple reactance ballast of a through-cord or a direct plug-in type, the temperature on any point of the enclosure shall not exceed 90°C (194°F).

Table 27.1
Case- or open coil surface-temperature versus time relations

Maximum temperature				Time[a], minutes
More than		Not more than		
°C	(°F)	°C	(°F)	
145	(293)	150	(302)	5.3
140	(284)	145	(293)	7.1
135	(275)	140	(284)	10
130	(266)	135	(275)	14
125	(257)	130	(266)	20
120	(248)	125	(257)	31
115	(239)	120	(248)	53
110	(230)	115	(239)	120

[a] The time is to be measured between the instant the case or outer surface of an open core and coil ballast temperature exceeds 110°C (230°F) and the protector opens or the maximum temperature is reached, whichever is longer.

27.2 The temperatures of a ballast provided with a thermal cutoff type (one shot) thermal protector shall meet the requirements in 27.1(a), 27.1(b), and 27.1(d) while being subjected to any of the conditions of 27.6.

27.3 If the temperature of the enclosure of an enclosed ballast, or outer surface of an open core and coil ballast, exceeds 110°C (230°F) for a specific fault condition in 27.6, the protector shall open the circuit or the current shall be limited for an inherently protected electronic ballast.

Exception: The protector need not open if the fuse described in 27.7 does not open, and if the temperature of the case of an enclosed ballast or the outer surface of an open core and coil ballast does not exceed 110°C (230°F).

27.4 With reference to the requirement in 27.3, if the case of an enclosed ballast or the outer surface of an open core and coil ballast attains a temperature of 110°C (230°F) or less and either remains at that temperature or starts to decrease, the test may be discontinued after 1 hour of operation after the 110°C (230°F) temperature is first reached.

27.5 During the test described in 27.6, there shall be no:

a) Ignition of a compound;

b) Dripping of a compound from the enclosure; or

c) Emission of flames or molten metal from the ballast enclosure.

27.6 To determine whether a Class P protected ballast complies with the requirements in 27.1 or 27.2, whichever applies, the ballast is to be energized at an input voltage and frequency in accordance with 21.6, and is to be operated at thermal equilibrium under normal conditions as described in 22.1– 22.3 and the Normal Temperature Test, Section 25. The following fault conditions are to be introduced, one at a time and not necessarily in the order indicated, and are to be applied throughout each complete test:

a) For a primary winding, two outer layers of a layer wound ballast or 20 percent of the turns of a random wound ballast are short circuited.

b) For a secondary winding, two outer layers of a layer wound ballast or 20 percent of the turns of a random wound ballast are short circuited.

c) Any power capacitor short circuited, when such condition does not short circuit the ballast primary winding.

d) The abnormal conditions described in 26.8, except that this test is not required when the temperature does not exceed 110°C (230°F) during the test.

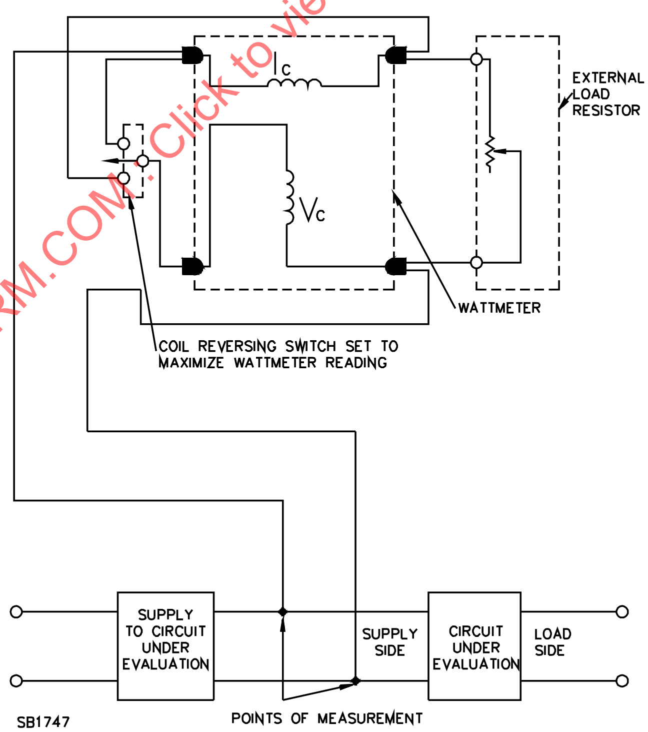
e) For a simple reactance ballast or a single coil device that provides ballast impedance for a lamp – two outer layers of winding or 20 percent of the turns short circuited.

27.7 During the test described in 27.6, the supply circuit is to be connected in series with a 20-ampere fuse (time-delay type), of which the characteristics are such that the fuse will not open in less than 12 seconds when carrying 40 amperes.

27.8 Opening of the 20 ampere supply circuit fuse is determined to be the equivalent of opening of the protector under the test condition described in 27.6(a) and the fuse shall not open under any other test condition.

27.9 If a ballast is marked for use with several different lamps, the lamps causing the highest wattage during the input test are to be used for the tests in this section. If a lamp becomes inoperative during any test, the lamp is to be replaced and the test continued for the specified duration.

Figure 27.1
Connection of wattmeter



27.10 Temperatures of the case of an enclosed ballast or the outer surface of an open core and coil ballast are to be measured during a sufficient number of cycles to determine whether a ballast complies with the requirement in 27.2. Normally for this purpose, measurement of temperatures during 3 to 5 cycles of the thermal protector will be necessary.

27.11 If necessary to cause the protector to reclose the circuit, the temperature of the test enclosure may be reduced below the minimum value specified in 25.1.

27.12 Temperatures are to be measured by thermocouples on the ballast and on the power-capacitor case.

27.13 Temperatures on the case of an enclosed ballast or the coil of an open core and coil ballast are continued to be measured after the protector opens.

Exception: If the protector – reclosing temperature in 27.1(c) is not being determined, the test may be discontinued when temperatures start to decrease following the opening of the protector.

28 Increased-Ambient Temperature Test for Ballasts – Class P Protection

28.1 When tested under the method described in 28.2, the protector of a Class P ballast shall operate, or the circuit of an inherently limited Class P electronic ballast shall open to limit the current, before the temperature of the enclosure of an enclosed ballast, or the outer surface of an open core and coil transformer, exceeds 110°C (230°F) or within 2 hours after the ballast exceeds 110°C (230°F).

Exception: This test is not required to be conducted when 16.2 applies.

28.2 The ballast is to be energized at an input voltage and frequency in accordance with 21.6, and is to be operated until thermal equilibrium is reached under normal conditions as described in the Normal Temperature Test, Section 25, except that the 6-inch (152-mm) square opening in the test enclosure may be closed and the test-enclosure ambient is to be 60.0 ±1.0°C (140.0 ±1.8°F). The temperature in the test enclosure is then to be raised as rapidly as is convenient by a value 2.0°C (3.6°F) more then the difference between 110°C (230°F) and the maximum temperature that the case of an enclosed ballast or the outer surface of an open core and coil ballast reached when the test-enclosure temperature was 60°C (140°F), and is to be maintained at this temperature.

28.3 If the protector has not opened and the temperature of the case of an enclosed ballast or the outer surface of an open core and coil ballast has not reached 110°C (230°F) within 4 hours or if the inherent circuit has not operated so that the temperatures have not stabilized under the conditions described in 28.2, the test-enclosure ambient is to be increased again by a value 2.0°C (3.6°F) more than the difference between 110°C (230°F) and the maximum ballast temperature 4 hours following the first increase in test-enclosure temperature.

28.4 If a ballast is marked for use with several different lamps, the lamps causing the highest wattage during the input test are to be used for the test in this section. If a lamp becomes inoperative during the test, the lamp is to be replaced and the test continued for the specified duration.

29 Fault-Condition Test – Electronic Ballasts – Class P Protection

29.1 An electronic ballast shall meet the following criteria while the ballast is subjected to the tests described in 29.2 – 29.7:

a) The temperatures on any point on the case of an enclosed ballast (including an electronic ballast without an automatic reset thermal protector) or the outer surface of an open core and coil ballast shall not exceed 150°C (302°F).

b) The locations in (a) that exceed 110°C (230°F) shall comply with the temperature versus time criteria specified in Table 27.1.

c) For a through-cord or a direct plug-in type, the temperature on any point of the enclosure shall not exceed 90°C (194°F).

29.2 An increase in a risk of fire exists when any one of the following conditions develops. There shall be no:

a) Ignition of a compound;

b) Dripping of a compound from the enclosure; or

c) Emission of flames or molten metal from the ballast enclosure.

29.3 The sample shall not be used for an additional fault condition unless the sample is operable after a fault condition and possible replacement of a fuse.

29.4 The ballast is to be energized at an input voltage and frequency in accordance with 21.6. The supply circuit is to be connected in series with a 20 ampere fuse (time delay type), of which the characteristics are such that the fuse does not open in less than 12 seconds when carrying 40 amperes. A thermocouple (or thermocouples) such as the type used in the Temperature Test, is to be attached to the ballast enclosure in order to monitor the progress of the test. The ballast is to be tested as described in 29.5. Unless already conducted for Fault Condition Tests, Section 27, the following fault conditions are to be introduced, one at a time and not necessarily in the order indicated, and are to be applied throughout each complete test:

a) For a transformer primary winding, two outer layers of a layer wound ballast or 20 percent of the turns of a random wound ballast are short circuited.

b) For a transformer secondary winding, two outer layers of a layer wound ballast or 20 percent of the turns of a random wound ballast are short circuited.

c) The abnormal conditions described in 26.8, except that this test is not required when the temperature does not exceed 110°C (230°F) during the test.

d) Any electrolytic capacitor or semiconductor junction located in a circuit capable of delivering 50 watts or more of power to an external resistor for 1 minute, as determined in accordance with 29.6, is to be short circuited or open circuited.

29.5 Regarding the ambient temperature of the ballast under test as described in 29.4, the intent of this requirement is met when the test condition operates in an ambient temperature of 25°C ±5°C (77°F ±5°F) until:

a) It is obvious within 30 minutes that a component has opened and the ballast is no longer operable; or

b) For a period of 30 minutes or less and when it is determined that the ballast enclosure or power capacitor temperatures are no longer rising and the ballast operation is stable; or

c) For a period of 30 minutes and when it is determined that the ballast enclosure or power capacitor temperatures are continuing to rise. In this case, the test is to be stopped, the ballast is to be placed in a ambient temperature oven as described in 25.1 – 25.3, and the test restarted. The test is to continue in the elevated ambient temperature until the ultimate result is known, and not exceeding 7 hours.

29.6 When it is not obvious what the power available is at various points in the circuit, a wattmeter and an adjustable external load resistor are to be arranged as illustrated in Figure 27.1 to determine the maximum power transfer. The external load resistor is set for its maximum resistance. After the connection is made, and when there is no protective device in the ballast, the adjustable resistance is to be reduced gradually to the point of maximum wattage as indicated by a peak reading on the wattmeter. When there is a protective device in the ballast, a closed shorting switch is to be connected across the protector, and the resistor is then to be adjusted to result in a power dissipation of exactly 50 watts as indicated by the meter. The switch across the protective device is then to be opened and the time required for the protective device to open is to be recorded. When the protective device opens the circuit in less than 60 seconds, the point is not capable of delivering 50 watts for 1 minute. Similarly, when a circuit component opens in less than 1 minute effectively limiting the available power to less than 50 watts or when the current is inherently limited by the circuit, the point is not capable of delivering 50 watts for 1 minute.

29.7 Opening of the 20 ampere supply circuit fuse as a result of the particular component fault condition signifies compliance.

30 Arcing Test

30.1 An electronic ballast marked “Type CC” shall comply with the requirements in Type CC Ballasts, Supplement SD.

Revised 30.1 effective February 9, 2015

30.2 Deleted effective February 9, 2015

30.3 Deleted effective February 9, 2015

30.4 Deleted effective February 9, 2015

Figure 30.1
Arcing test set-up

Figure 30.1 deleted effective February 9, 2015

31 Voltage Measurement – Power Capacitors

31.1 The voltage across a power capacitor shall not exceed its rating in accordance with 15.2– 15.4.

31.2 The test is to be conducted with the ballast energized at the input voltage and frequency specified in 21.6. It may be necessary to make more than one measurement in order to ascertain the voltage while using various lamps for which the ballast is marked.

31.3 It is not necessary to measure the voltage across a starting capacitor.

32 Dielectric Voltage-Withstand Test

32.1 While in a heated condition from normal operation, a resistance ballast, a reactor ballast, or an autotransformer ballast shall withstand for 1 minute, without breakdown, the application of a test potential between all live parts and all dead metal parts that are exposed or are likely to become grounded. If the ballast is not enclosed in metal, the test potential shall be applied between all live parts and a metal surface on which the ballast is mounted as intended. The value of the test potential shall be:

a) For a resistance ballast and a reactor ballast, 1000 volts plus twice the rated voltage of the ballast; or

b) For an autotransformer (non-isolating type) ballast, 1000 volts plus twice the rated input voltage, 1000 volts plus twice the voltage to ground, or 1000 volts plus twice the output voltage, whichever is highest.

32.2 While in a heated condition from normal operation, a two winding transformer (isolating type ballast) shall withstand for 1 minute, without breakdown, the application of the test potentials described below:

a) 1000 volts plus twice the rated input voltage, applied between live parts of the primary winding and dead metal parts that are exposed or are likely to become grounded;

b) 1000 volts plus twice the output voltage, applied between live parts of the secondary winding and dead metal parts that are exposed or are likely to become grounded; and

c) 1000 volts plus twice the rated input voltage or 1000 volts plus twice the output voltage, whichever is higher, applied between live parts of the primary winding and live parts of the secondary winding.

32.3 A two winding transformer (isolating type) ballast will usually have a resistor for starting purposes between the primary and secondary windings. For the test in 32.2, (a) and (b) can be combined. For the test in 32.2(c) a special sample without the resistor may be needed.

32.4 The output voltage mentioned in 32.2 (b) and (c) is the rated output voltage, if the ballast is so rated in accordance with 32.2. Otherwise, it is the largest of the output-voltage values measured in accordance with 22.4.

32.5 An electronic ballast shall be subjected in turn to a 1-minute application of a 60-hertz essentially sinusoidal potential:

a) Between all live parts and the enclosure;

b) Between all live parts and exposed dead metal parts in the case of an unenclosed ballast; and

c) Between live parts of an output transformer primary and secondary circuits that operate at a different potential or at different frequencies.

The test potential shall be 500 volts for a circuit operating at 50 volts or less, and 1000 volts plus twice the circuit operating voltage for a circuit operating at more than 50 volts. In (c), the test potential shall be the value determined by the higher voltage of the different circuits. The results are acceptable if there is no dielectric breakdown.

32.6 To comply with the requirement in 32.5(c), it may be necessary to disconnect solid-state components interconnecting the two circuits.

32.7 For any of the alternating current values described in 32.1 to 32.5 a direct current and a potential of 1.414 times the specified alternating current value may be used.

32.8 A ballast is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which can be varied. The applied potential is to be increased from zero until the required test value is reached, and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapidly as consistent with its value being correctly indicated by a voltmeter. Some commercially available dielectric testers have an adjustable sensitivity control which will indicate a breakdown when the leakage current exceeds the setting. The control should be adjusted to indicate breakdown (shorted output) and not some arbitrary value of leakage current.

32.9 A capacitor rated 0.020 microfarad or less shall withstand for 1 minute, without breakdown, the application of a 60-hertz essentially sinusoidal potential between the capacitor terminals. If the capacitor is enclosed in metal, it shall also withstand the same test potential between its terminals and its metal enclosure. In either case, the test potential is to be three times the maximum voltage to which the capacitor is subjected during operation of the ballast including lamp starting, lamp operation, and operation without a lamp or lamps, but shall not be less than 900 volts.

Exception: The dielectric voltage-withstand test between the terminals of a capacitor may be omitted if operation of the ballast after internal dielectric breakdown of the capacitor will not result in a risk of fire or electric shock. The dielectric voltage-withstand test between the capacitor terminals and the ballast enclosure may be omitted if an equivalent or more severe test is performed in connection with the dielectric voltage-withstand tests required by 32.1 and 32.2.

32.10 Regarding the spacing for printed wiring board foil patterns described in 19.1.4, Exception No. 2, a bare board shall be subjected for a period of one minute to a dielectric potential of 2V + 1000 V DC where V equals the maximum peak potential, in volts, between the foil traces. The results comply with the requirement when there is no dielectric breakdown.

33 Insulation-Resistance Test

33.1 The insulation resistance of a direct-current ballast, measured between live parts and the metal enclosure and other exposed dead metal parts, shall not be less than 250,000 ohms.

Exception: Electronic ballasts need not comply with this requirement.

33.2 Insulation resistance is to be measured by applying a direct-current potential of 125 volts between live parts and the enclosure and other exposed dead metal parts, using two voltmeters – one voltmeter being connected across the supply line and the other connected in series with one of the leads to the ballast being tested. With the supply voltage adjusted so that V_1-V_2 equals 125 volts, the insulation resistance is to be calculated using the formula:

$$\text{Insulation Resistance} = \frac{(V_1 - V_2)R_2}{V_2}$$

in which:

V_1 is the measured line voltage;

V_2 is the voltage measured by a voltmeter in series with one of the leads of the ballast being tested; and

R_2 is the resistance of the voltmeter measuring V_2.

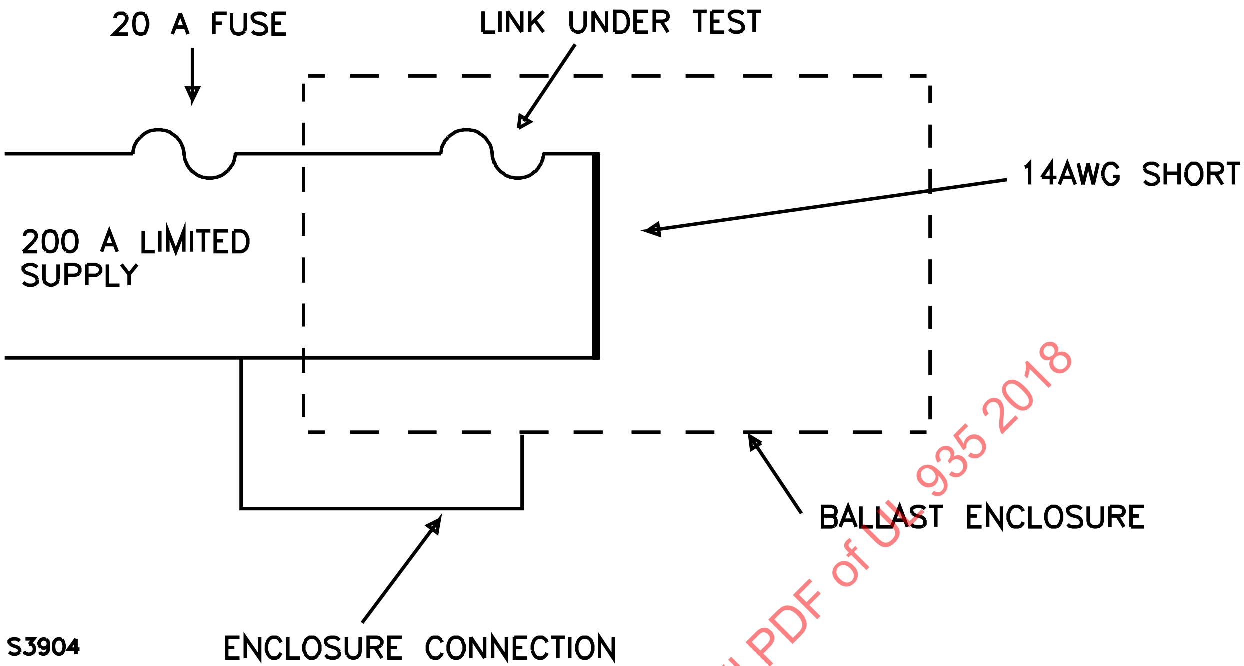
34 Limited Short-Circuit Test

34.1 Three samples of a ballast, employing a protector that interrupts the ballast supply and that has not been separately subjected to a limited short-circuit test, shall not cause a risk of fire when subjected to the test described in 34.2.

34.2 When conducting the limited short circuit test on a link other than a printed wiring board, the primary winding of each ballast is short circuited on the load side of the protector by the shortest feasible length of 14 AWG (2.1 mm^2) copper wire, and the two ballast lead wires are to be cut to a maximum length of 6 inches (152 mm). The ballast is then connected to a supply circuit having a power factor of 0.9 – 1.0, limited to a current of 200 amperes, and at rated ballast voltage ±5 percent. The circuit is connected in series with an 20 ampere nonrenewable fuse (time delay type), the construction characteristics of which are such that the fuse does not open in less than 12 seconds when carrying 40 amperes. The enclosure of the ballast is connected – not through a fuse – to the power supply conductor in which the protector is not connected. Cotton is to be wrapped around the ballast, making sure that the lead holes are covered. The cotton shall not ignite during the test.

34.2 revised June 10, 2010

Figure 34.1
Connection for paragraph 34.2



34.3 One test is to be performed on each of the three samples. For one of the samples, the protector is to be closed on the short circuit if possible.

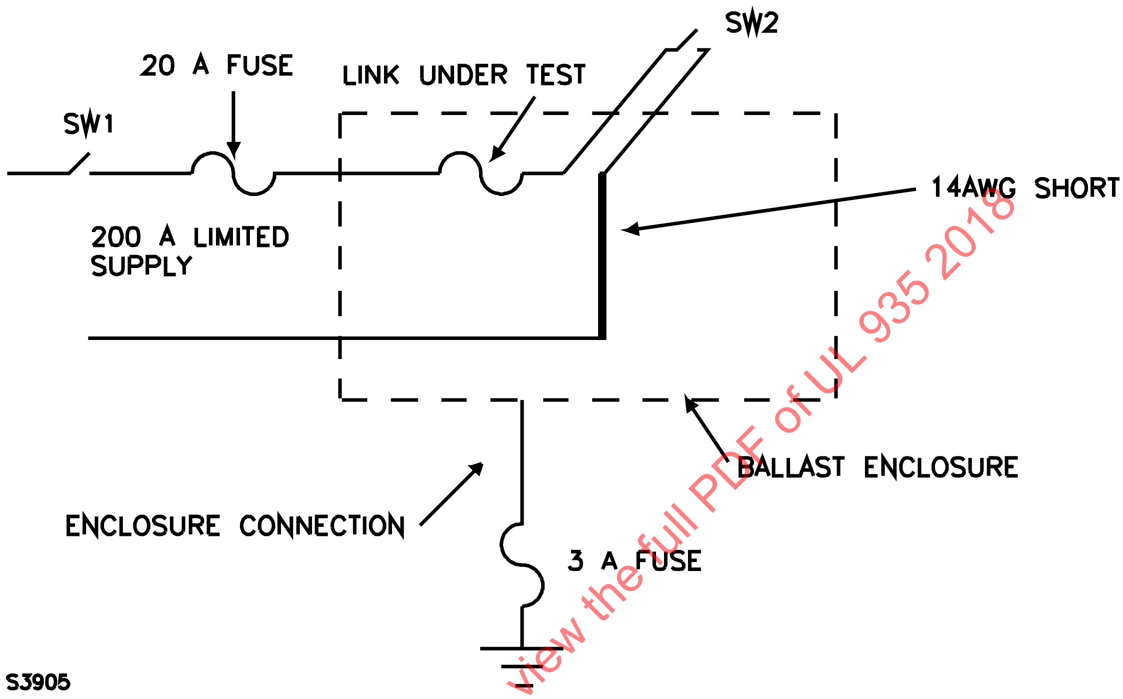
34.4 A foil trace on a printed wiring board designed so it opens in the event of a short circuit shall have seven samples of a ballast incorporating a foil trace as described in 16.8 subjected to the test of 34.5 without introducing a risk of fire or shock.

34.5 Four samples are to be prepared by providing a short circuit on the load side of the foil trace by the shortest feasible length of 14 AWG (2.1 mm) copper wire, and the two ballast lead wires are to be cut to a maximum length of 6 inches (152 mm). The two remaining samples are to be prepared the same way, except that a switch (SW2 of Figure 34.2) is also to be included. Each sample, in turn, is then connected to a supply circuit having a power factor of 0.9 – 1.0, limited to a current of 200 amperes, and at rated ballast supply voltage, ±5 percent. Each sample is connected in series with a 20 ampere nonrenewable fuse (time delay type) to simulate connection to a branch circuit. The fuse characteristics are such that the fuse does not open in less than 12 seconds when carrying 40 amperes. The enclosure of the ballast is to be connected through a 3-ampere non-time delay fuse to earth ground. Cotton is to be wrapped around the ballast, making sure that the lead wire holes are covered. The cotton shall not ignite during the test. Opening of the 20 ampere supply circuit fuse meets the intent of the requirement. Four samples shall have the test circuit connected to the foil trace under test, then two samples have the short connected to the supply and foil trace – See Figure 34.2.

34.5 revised June 10, 2010

34.6 As an option to the sample preparation of 34.5, specially prepared samples incorporating just the fuse trace on the printed wiring board and mounted in the enclosure are to be used for this test.

Figure 34.2
Connection for paragraph 34.5
For five samples SW1 is used, for two samples SW2 is used.



35 Foil Trace Calibration

35.1 As required by 16.8(d), a foil trace on a printed wiring board designed so it opens in the event of a short circuit shall be subjected to an initial calibration that is repeatable periodically – See Appendix B.

35.2 Three samples are prepared by providing a short circuit on the load side of the foil trace by the shortest feasible length of 14 AWG (2.1 mm) copper wire, and the two ballast lead wires are cut to a maximum length of 6 inches (152 mm). Each sample, in turn, is then connected to a supply circuit having a power factor of 0.9 – 1.0, limited to a current of 10 amperes, and at rated ballast supply voltage, ±5 percent. The current is applied to the foil trace and the time to open is recorded. The time to open is then averaged for the three samples. The 10 amp current is only an approximate value of 200% of a typical foil trace. The value of the test current is able to be higher or lower in order to adjust the calibration time to a few seconds. The test current and the average opening time are recorded for comparison with the repeat testing described in Appendix B.

35.2 revised June 10, 2010

36 Metallic-Coating-Thickness Test

36.1 The method of determining the thickness of a zinc coating shall be as described in 36.2– 36.9.

36.2 The solution used for the test is to be made from distilled water and is to contain 200 grams per liter of American Chemical Society (ACS) reagent grade chromic acid (CrO_3) and 50 grams per liter of ACS reagent grade concentrated sulphuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of ACS reagent grade concentrated sulphuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

36.3 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 having an inside bore of 0.025 inch (0.64 mm) and a length of 5.5 inches (139.7 mm). The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.025 milliliters 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 dropping 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 dropping.

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

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

36.6 The sample to be tested is to be supported 0.7 – 1.0 inch (17.8 – 25.4 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 is to be inclined about 45 degrees from horizontal.

36.7 The stopcock is to be opened and the time in seconds until the dropping solution dissolves the protective metal coating exposing the base metal is to be measured. The end point is the first appearance of the base metal recognizable by a change in color at that point.

36.8 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 where the metal coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation are likely to have thin coatings.

36.9 To calculate the thickness of the coating being tested, select from Table 36.1 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 described in 36.7.

Table 32.1
Coating-thickness factors

Temperature,		Thickness factors, 0.00001 inch (0.00025 mm) per second, zinc plating
°F	(°C)	
70	(21.1)	0.980
71	(21.7)	0.990
72	(22.2)	1.000
73	(22.8)	1.010
74	(23.3)	1.015
75	(23.9)	1.025
76	(24.4)	1.033
77	(25.0)	1.042
78	(25.6)	1.050
79	(26.1)	1.060
80	(26.7)	1.070
81	(27.2)	1.080
82	(27.8)	1.085
83	(28.3)	1.095
84	(28.9)	1.100
85	(29.4)	1.110
86	(30.0)	1.120
87	(30.6)	1.130
88	(31.1)	1.141
89	(31.7)	1.150
90	(32.2)	1.160

37 Water-Spray Test

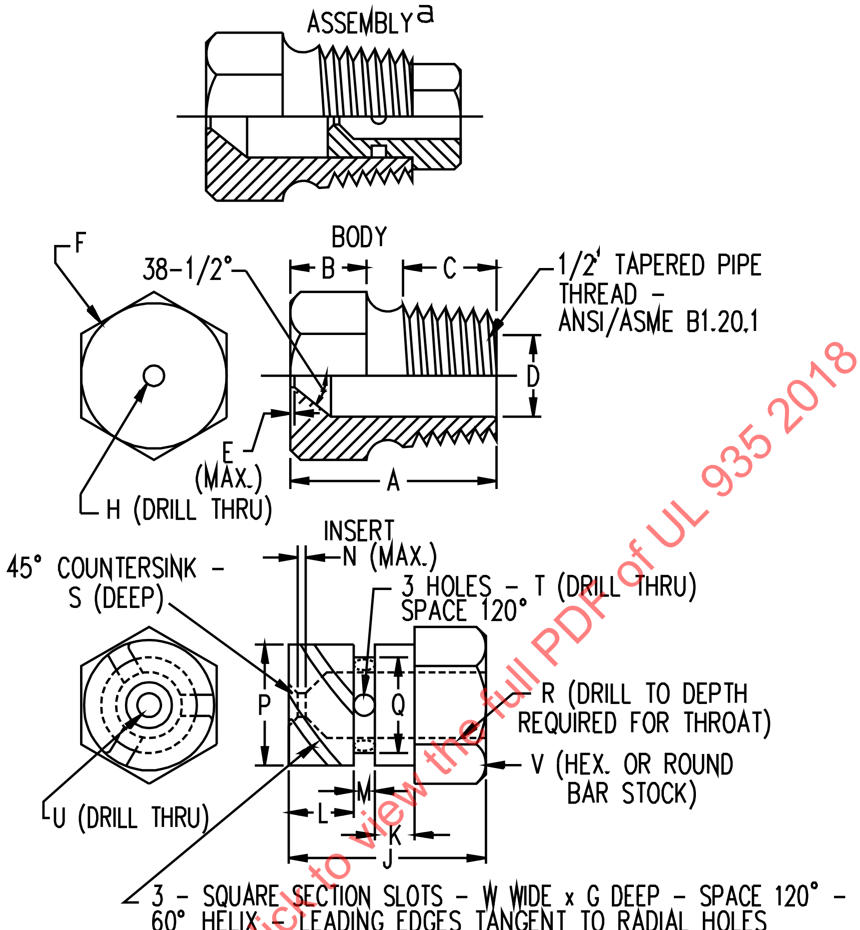
37.1 A weatherproof ballast shall be subjected to the test described in 37.2 and 37.3. Water shall not enter the ballast enclosure. See 8.2.1.

Exception: An enclosure constructed so that it will obviously exclude water need not be tested.

37.2 A ballast is to be tested by mounting the complete enclosure with conduit connections as in actual service, and then applying a water spray as described in 37.3 for 1 hour to the top and sides of the enclosure.

37.3 The rain test apparatus is to consist of three spray heads constructed in accordance with the details specified in Figure 37.1 and mounted in water supply pipe rack as illustrated in Figure 37.2. The water pressure is to be maintained at each spray head at approximately 5 psi. The distance between the center nozzle and the ballast is to be approximately 5 inches (127 mm). The ballast is to be brought into the focal area of the three spray heads in such a position and under such conditions that water will be most likely to enter, except that consideration is to be given to the normal mounting position.

Figure 37.1
Spray head assembly



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

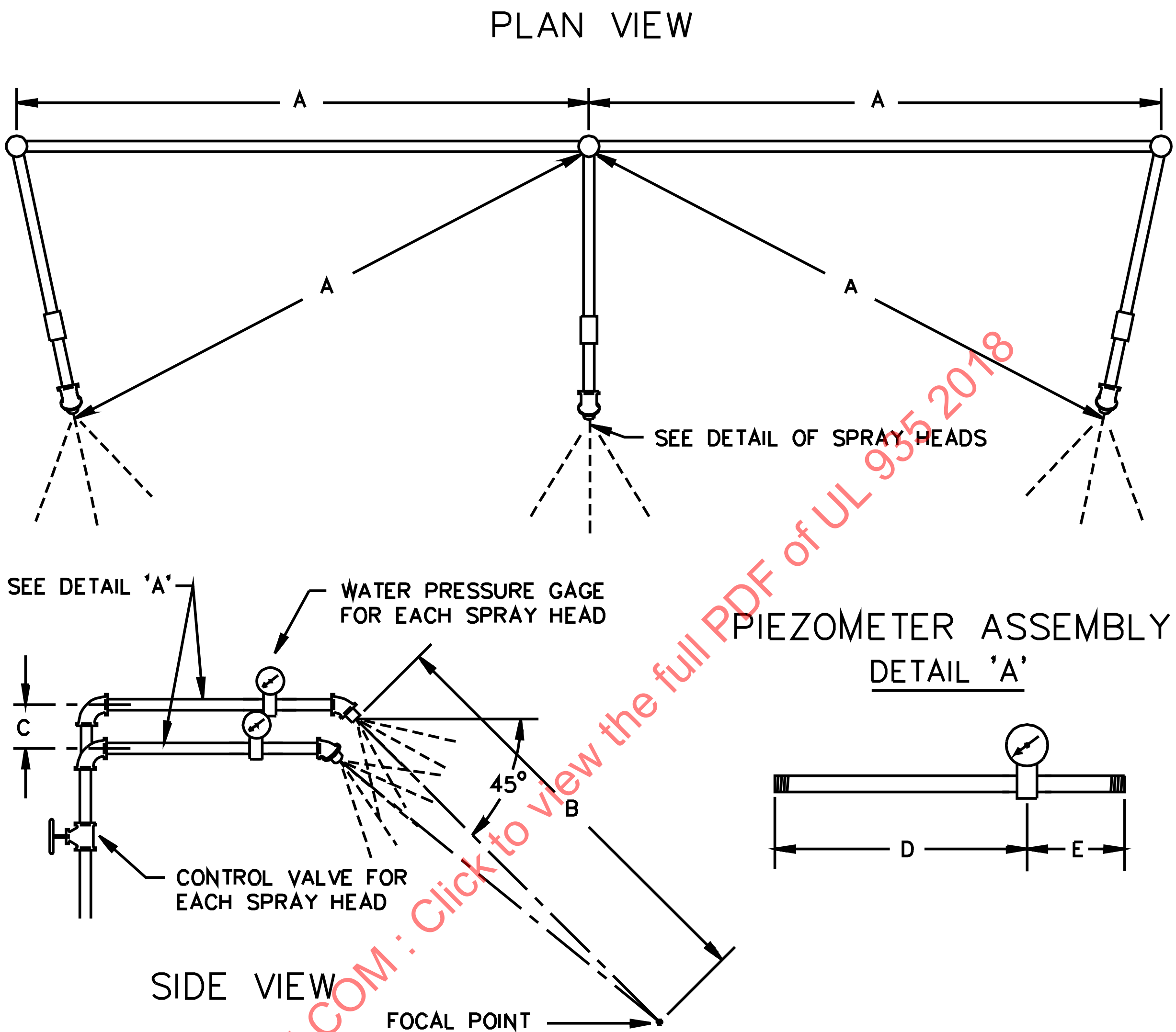
[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

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

RT100F

Figure 37.2
Spray head pipe rack



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

RT101F

38 Humidity-Conditioning Test

38.1 A ballast, described in 12.8, shall be exposed for 168 hours to moist air having a relative humidity of 88 ±5 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). Following the 168-hour period and while still exposed to moist air, the insulation resistance between live and dead metal parts shall be measured and shall not be less than 50,000 ohms. See 12.7 and 12.8.

38.1 revised November 7, 2011

38.2 Following the insulation-resistance measurements required by 38.1, the ballast is to be tested for dielectric voltage-withstand between live parts and accessible metal parts (core) in accordance with the Dielectric Voltage-Withstand Test, Section 32.

38.3 The insulation resistance is to be measured:

a) By a magneto megohm-meter that has an open-circuit output of 500 volts;

b) By a voltmeter having an internal impedance of at least 30,000 ohms and using a 250-volt direct-current circuit; or

c) By equivalent equipment.

39 Strain-Relief Test

39.1 The strain-relief means provided for an individual lead wire or flexible cord of a ballast, as specified in 13.5.1 and 13.5.2, shall be tested as described in 39.2 or 39.3, as applicable. For a cord, at the point of connection of the conductors, there shall be no movement of the cord that indicates stress would have been transmitted to the connections. For a lead wire, there shall be no movement of the lead wire that indicates stress would have been transmitted to the connections.

39.2 To determine the compliance of the means for strain relief on an individual lead wire, a force of 20 pounds (89 N) or four times the weight of the ballast, whichever is less but not less than 5 pounds (22 N), is to be applied for 1 minute.

39.3 To determine the acceptability of the means for strain relief on a flexible cord, a force of 35 pounds (156 N) is to be gradually applied and maintained for 1 minute. The force is to be normal to the plane of the cord-exit hole.

40 Tests on Push-In Terminals

40.1 Pullout

40.1.1 A push-in (screwless) terminal shall withstand for 1 minute the test described in 39.2. The conductor shall not pull out of the gripping means, the conductor or any strand of the conductor shall not break, and the gripping means shall not be damaged or permanently distorted.

40.1.2 Six samples of the intended conductor size or sizes, either solid or stranded or six of each, are to be connected to terminals in accordance with the ballast manufacturer's instructions. A push-in (screwless) terminal marked for use only with solid wire is to be tested using only solid wire.

40.1.3 For tests with stranded conductors, all strands of the conductor shall enter the terminal gripping area as intended without exposure of the stray strands or reduction of required spacings. Tests with stranded conductors are to include separate samples for the maximum and minimum numbers of strands available in the wire sizes intended for use with terminal.

40.2 Temperature

40.2.1 A push-in (screwless) terminal shall be tested as described in 40.2.2 until temperatures are constant – see 25.19 for definition for constancy. The temperature of the terminal shall not exceed 55°C (131°F), based on an ambient temperature of 25°C (77°F).

40.2.2 Six previously unused samples are to be assembled with solid and, if intended, six previously unused samples are to be assembled with stranded copper wire in accordance with the ballast manufacturer's instructions. A current equal to:

a) The maximum value obtained during the tests for Input/Output Measurements, Section 22; or

b) The rating specified by the ballast manufacturer, whichever is greater, is to passed through the assemblies.

Separately prepared samples may be used to pass the current through the assemblies without having the ballast operating. The purpose of the test is to determine the heating due to the resistance at the wire connector. This measurement cannot be done as a part of the Normal Temperature Test, Section 25.

41 Rod Pressure Loading Test

41.1 Enclosures made of metal, having a pattern of ventilation openings, and having an electrical spacing between an uninsulated live part and the metal enclosure, shall have the possible reduction in the spacing determined by test described in 41.2. Electrical spacings are described in Spacing of Electrical Parts – Section 19. Enclosures made of polymeric material shall withstand the test described in 41.2 without introducing a shock hazard – see 51.1.1.

41.2 The sample shall be subjected to a force of 20 pounds (89 N) for 1 minute applied to any point by a metal rod. The force is to be increased from 0 to 20 pounds (0 to 89 N) over a period of 5 seconds. The axis of the metal rod is to be perpendicular to the surface under test. The metal rod is 1/2 inch (12.7 mm) diameter, having a flat contact end with the edge rounded to a radius of 1/32 inch (0.8 mm) to eliminate sharp edges.

42 Volume Method of Measurement

42.1 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 required 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. Any lead wires provided with the ballast are to be removed or a special sample without lead wires is to be used in order to measure the total volume. 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:

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

MANUFACTURING AND PRODUCTION TESTS

43 Dielectric Voltage-Withstand Test

43.1 Each ballast shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 hertz or derived from direct current 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 dead metal parts, or grounding lead wire from an internal connection within an electronic ballast, need not be tested.

43.2 The production-line test shall be in accordance with either condition A or condition B of Table 43.1 using either alternating or direct current. The voltage specified in Table 43.1 shall depend on the ballast type and the following conditions.

a) For a two winding, isolating type or electronic ballast with an isolating output transformer:

1) V is equal to the rated input voltage, and is applied between live parts of the primary winding and dead metal parts that are exposed or are likely to become grounded;

2) V is equal to the rated output voltage (but not less than 120 volts), and is applied between live parts of the secondary winding and dead metal parts that are exposed or are likely to become grounded; and

b) For all other ballast types not covered by (a); V is equal to the rated input voltage or the output voltage whichever is higher, and is applied between all live parts and dead metal parts that are exposed or are likely to become grounded.

Exception: For a ballast type described in (a), if agreeable with the manufacturer, all lead wires may be connected together and V shall be the maximum marked input voltage, the voltage to ground, or the output voltage, whichever is higher.

Table 43.1
Production-line test conditions

Condition	Application time, seconds	Applied potential, AC	Applied potential, DC
A	60	1000 + 2V[a]	1400 + 2.8V
B	1	1200 + 2.4V[a]	1700 + 3.4V

[a] Maximum rated voltage.

43.3 The test shall be conducted when the ballast is complete – fully assembled in a heated or unheated condition. It is not intended that the product be unwired, modified, or disassembled for the test.

Exception: The test may be performed before final assembly if the test represents that for the completed product.

43.4 A ballast employing a solid-state component that is not relied upon to reduce a risk of electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected provided that a random sampling of each day's production is tested at the potential specified in Table 43.1. The circuitry may be rearranged for the purpose of the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

43.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit.

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

43.7 If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential may be indicated:

a) By a voltmeter in the primary circuit or in a tertiary-winding circuit;

b) By a selector switch marked to indicate the test potential; or

c) For equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential.

When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown. Some commercially available dielectric testers have an adjustable sensitivity control which will indicate a breakdown when the leakage current exceeds the setting. The control is to be adjusted to indicate breakdown (shorted output) and not some arbitrary value of leakage amount current.

43.8 Test equipment other than that described by 43.7 – 43.9 may be used if found to accomplish the intended factory control.

43.9 During the tests, all lead wires or terminals of the ballast circuit described in 43.2 are to be connected together and to one terminal of the test equipment. The second test-equipment terminal is to be connected to the accessible dead metal. If agreeable to all concerned, all lead wires or terminals can be connected together for all tests, provided the highest dielectric voltage of all tests is applied between the lead wires or terminals and the accessible dead metal.

RATING

44 General

44.1 The electrical rating of a ballast shall include the input voltage, frequency, and current.

44.2 The output voltage as defined in 22.4, when more than 300 volts, shall be included in the electrical rating in order to identify conditions of use described in the National Electrical Code, ANSI/NFPA 70-1996, and field installation of hook-up wire and lampholders. The maximum voltage to ground or to a single lampholder shall be included in that rating, when it aids in specifying a lampholder. See Table 44.1 for common lampholder ratings.

Table 44.1
Lampholders ratings

Type of lampholder (ANSI designation)	Watts	Volts
Miniature bipin (G5)	75	250 or 600
Medium bipin (G13) and mogul bipin (G20)	660	250, 600, or 1000
Recessed double-contact (R17d)	660	600 or 1000
Single-pin (R7s)	660	250, 600 or 1000
4-pin circline (G10q)	660	250 or 600

44.3 A ballast shall be marked with the type(s) of lamp(s) it is to be used with, and the number of lamps, if more than one.

MARKING

45 Details

45.1 General

45.1.1 A product shall be legibly and permanently marked with:

a) The manufacturer's name, trade name, or trademark or other descriptive marking by which the organization responsible for the product is able to be identified;

b) A distinctive catalog number or the equivalent;

c) The electrical rating; and

d) The date or other dating period of manufacture not exceeding any three consecutive months.

The permanence level of a paper or plastic-film marking label shall be such that the label remains securely adhered to the ballast at least until it is installed into an end-use product or system. No hang tags, tack (peelable) tags, or flag type tags shall be used for a marking label.

Exception No. 1: The manufacturer's identification is able to be in a traceable code when the product is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture is able to be abbreviated; or is able to be in a nationally accepted conventional code or in a code affirmed by the manufacturer, when that code:

a) Does not repeat in less than 20 years; and

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

45.1.2 Other than the date code marking, all marking shall appear on a surface of the ballast other than the mounting surface.

45.1.3 A supplementary marking shall be included to indicate the correct method of connection for the various lead wires.

Exception: This requirement does not apply to a single-lamp, simple reactance ballast having only two lead wires.

45.1.4 If a manufacturer produces or assembles ballasts at more than one factory, each finished ballast shall have a distinctive marking by which it may be identified as the product of a particular factory.

45.2 Ratings

45.2.1 If both the output voltage and the voltage to ground are included in the rating as specified in 44.2; each shall be properly identified in the marking. If both the ratings have the same value, that single value may be designated: ″maximum voltage, output circuit or to ground.″

45.2.2 A ballast having a rated input voltage outside the ranges specified in 13.2.9 shall be marked to indicate the type of supply system with which the ballast is intended to be used.

45.2.3 As an alternative to identifying output voltage and voltage to ground ratings as specified in 44.2, the information shall be specified in a table format on the label as shown in Figure 45.1 and shall be in accordance with the following:

a) The values of X and Y shall be determined by the commercially assigned ratings for the lampholder and wire and the measured values of voltage as determined by Section 20, Input/Output Measurements.

b) When specifying the voltage rating for the lampholder:

1) The voltage to ground measurement shall be used for straight, tubular lamps employing two lampholders; or

2) The voltage across the lamp measurement shall be used for compact, circular, and other lamps employing a single lampholder.

The output voltage value assigned shall be in accordance with the note to Figure 45.1. For values that fall between assigned ratings, the next higher value shall be assigned. For example, the measured voltage for a ballast output voltage is 690 V and the measured voltage of the maximum voltage to ground is 550 V. Therefore, X is to be assigned a 600 V rating and Y is to be assigned a 1000 V rating. The table format shown in Figure 45.1 shall be on the ballast or on instructions packed with the ballast. When the table described in Figure 45.1 is provided only on instructions packed with the ballast, the ballast shall be marked with the output voltage, as required in 44.2.

Figure 45.1
Output voltage ratings for ballasts

For installation	Rating, V
Lampholder	X
Wire	Y
NOTE: The value of X shall be 250, 600, or 1000 volts. The value of Y shall be 300, 600, or 1000 volts.	

45.3 High power factor

45.3.1 If a ballast is marked ″High Power Factor″ or the equivalent, the power factor of the ballast shall be 90 percent or higher under the intended operating conditions.

45.3.2 If the power factor of a ballast under some normal operating conditions is 90 percent or higher but is less than 90 percent under other normal operating conditions, such as may occur with a ballast intended for use with more than one type of lamp, the ballast may be marked with the words ″High Power Factor,″ or the equivalent, provided it is also marked as specified in 45.3.3 to identify the normal operating conditions that result in a power factor of less than 90 percent; or the ballast may be marked as specified in 45.3.3.

45.3.3 If the power factor of a ballast under normal operating conditions is corrected to a value less than 90 percent, the ballast may be marked with the statement, ″Power Factor Corrected,″ provided the marking also includes the value of the power factor – the latter being in letters not smaller than those of the statement.

45.4 Lamps

45.4.1 A ballast shall be marked for the intended lamp or lamps in order to:

a) Maintain normal operation of the ballast including normal temperature and operating components at their rated voltage (see 45.4.2); and

b) Restrict use of unintended lamps that would result in exposed live parts when lamps are being replaced (see 45.4.3 to 45.4.5).

45.4.2 A ballast intended for use with:

a) Bi-pin lamps, such as preheat, instant- or rapid-start, shall be marked with the individual lamp-wattage.

b) Single-pin, ferrule-contact, or recessed-double-contact lamps shall be marked with the proper lamp designation– for example, lamp length, diameter, or other acceptable designation.

c) Single-pin or ferrule-type lamp, or for use with any lamp of which current is more than 430 milliamperes, shall be marked with the normal lamp current – per lamp, in the case of a multilamp ballast.

d) An energy-saving version of a standard lamp shall be so identified.

45.4.3 A ballast supplying filament current and intended for use with one or more rapid-start lamps, other than compact or circular lamps, shall be marked with the words ″Rapid-Start″ or ″R.S.″ A ballast intended for use with one or more instant-start bi-pin lamps shall be marked with the words ″Instant-Start″ or ″I.S.″ This designation may be in the form of a statement pertaining to the ballast itself, or may be combined with the marking for the lamps with which the ballast is intended to be used, for example F40T12/1S or F40T12/RS.

45.4.4 In lieu of the test requirements specified in 24.2.1, a ballast for other than a pre-heat circuit shall be marked:

a) For use with circuit-interrupting (or cutout) lampholders;

b) For use only with a compact, circular lamp, U-bend or a similar lamp that would employ a lampholder arrangement that disconnects all lamp contacts simultaneously; or

c) For use only with lamps having recessed double-contact bases.

45.4.5 With reference to 45.4.4 (b) and (c), this information is normally provided implicitly with the marking for the lamp types.

45.5 Application

45.5.1 A ballast intended for use with one or more lamps designed for signs only shall be marked ″For Use Only In Signs.″

45.5.2 A ballast that is a reactor type but does not have an obvious outward appearance to indicate that it is this type, such as a ballast with additional leads for an integral starter, shall be marked ″Reactor Ballast″ or ″Simple Reactance Ballast.″

45.5.3 A ballast intended for use with a portable lamp shall have an output voltage of less than 150 volts and may be additionally marked, ″For use in portable lamps.″ See 22.8 and 22.9 to determine compliance.

Exception: A ballast as described in 22.8 and 22.9 need not comply with this requirement.

45.5.4 A ballast having a maximum leakage current of more than 0.5 milliampere, when tested in accordance with 23.1, shall be marked ″For use in permanently connected (fixed) equipment only,″ or the equivalent.

Exception: The marking need not be provided for ballasts having an input voltage of 277 volts or higher.

45.5.5 An outdoor ballast shall be marked ″Type 1 Outdoor″ or ″Type 2 Outdoor″ according to its construction.

45.5.6 A weatherproof ballast shall be marked ″Weatherproof″ or with the designation ″WP.″

45.5.7 A weatherproof ballast that must be mounted in a certain position to exclude rain shall be marked to convey such information, unless it is obvious from the construction of the ballast or the means for mounting that such a marking is not necessary.

45.5.8 A direct plug-in ballast having a mounting tab as described in 46.3.4 shall be marked on the ballast, a marking tag, or an instruction sheet packed with the ballast – with the word ″CAUTION″ and the following mounting instructions, or equivalent,

a) ″To reduce the risk of electric shock – disconnect power to receptacle before installing or removing the ballast. When removing receptacle cover screw, cover may fall across plug blades or receptacle may become displaced;″

b) ″Use only with duplex receptacle having center screw;″ and

c) ″Secure ballast in place by receptacle cover screw.″

45.5.9 A ballast with a polymeric enclosure marked, ″Suitable for Air Handling Spaces″ shall comply with 20.12.

45.5.10 A ballast with openings in accordance with 8.1.3 shall be marked, ″Use Only Within An Electrical Enclosure.″

45.5.11 Deleted effective February 9, 2015

45.6 Thermal protection

45.6.1 A Class P protected ballast shall be marked ″Class P.″

45.6.2 When a ballast of other than the Class P protected type includes a fuse, a thermally actuated element, or other protective device, no indication of the presence of the protective device shall be given on the ballast, on the shipping carton or container, or on materials shipped with the ballast.

45.7 Field connection

45.7.1 When the temperature on any surface within a terminal compartment or splice compartment exceeds 60°C (140°F) during the Normal-Temperature Test, Section 25, the ballast shall be marked with the following statement or the equivalent, located so that it is readily visible when connections are made: ″For Connections Use Wire Rated for at Least _____ C,″ in which the temperature is to be either 75°C (167°F) or 90°C (194°F) as determined by the Normal-Temperature Test, Section 25.

45.7.2 With reference to 45.7.1, the information is able to be marked by using a nameplate, die-stamping, or a paper sticker securely and permanently held in place, or by an equivalent means. The permanence level of a paper or plastic-film marking label shall be such that the label remains securely adhered to the ballast at least until it is installed into an end-use product or system. No hang tags, tack (peelable) tags, or flag type tags shall be used for a marking label.

45.7.3 A ballast that employs push-in (screwless) terminals shall be marked with instructions that are readily visible during installation:

a) For releasing the wire from the terminal connection;

b) That specify the intended wire gage;

c) That specify use with ″solid copper wire only″ unless the terminal is intended for both solid and stranded wire;

d) To strip the insulation from conductors a specified length;

e) For connecting acceptably sized wire; and

f) That specify the terminal positions related to lamp connections.

45.7.4 A ballast provided with a connector or connectors that are intended for connection of the supply circuit or lamp leads, or both to the ballast shall be marked on the ballast near the connector or connectors with the following or the equivalent: ″For use only in products having this manufacturer's mating connector.″

45.7.5 If a resistor is required to be used in conjunction with a reactance ballast, the marking on the ballast shall include the value of the resistance to be used and instructions regarding the connections to be made.

Exception: This requirement does not apply to a single-lamp simple reactance ballast having only two leads.

45.7.6 A ballast marked ″Class P″ may also be marked ″Type HL″ on the ballast, the shipping container, or on materials shipped with the ballast, only if the Class P ballast complies with the requirements in 16.7. For any other ballast, the ″Type HL″ designation shall not be used on the ballast, the shipping container, or on materials shipped with the ballast.

PART 2 – DIRECT PLUG-IN, AND THROUGH CORD BALLASTS

CONSTRUCTION

46 Direct Plug-In, and Through Cord Ballasts

46.1 General

46.1.1 These requirements pertain to ballasts that are direct plug-in (no cord), ballasts with a cord (also known as a through-cord ballast), and incandescent to fluorescent light source conversion kits using such a ballast.

46.2 Enclosure integrity

46.2.1 The enclosure of a ballast described in 46.1.1 shall be subjected to the following tests:

a) Impact Resistance Test, described in Section 51.2 or 20.4;

b) Crush Resistance Test, described in Section 51.4; and

c) Mold Stress Relief Test in 20.5.

46.2.2 An adhesive used in the assembly of the enclosure shall be investigated as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Methods utilizing fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding comply with this requirement.

46.3 Weight and moment

46.3.1 The weight of a ballast connected in a power-supply cord – exclusive of the cord and any supplementary housing – shall not be more than 5 pounds (2.26 kg) and shall determine the type of cord used with the ballast. The weight of any supplementary housing shall not be more than 1 pound (0.45 kg). When the ballast weighs not more than 2 pounds (0.91 kg), the cord shall not be of lighter service than Type SP-2; and when the ballast weighs more than 2 pounds (0.91 kg), the cord shall not be of lighter service than Type SJ.

46.3.1 effective October 27, 2002

46.3.2 A direct plug-in ballast shall have the maximum acceptable moment, center of gravity, dimensions, and weight complying with the following requirements (see also 46.3.3 and 46.3.4 and Figure 46.1):

a) The quotient of WY/Z shall not exceed 48 ounces (1361 g);

b) The quotient of WY/S shall not exceed 48 ounces (1361 g);

c) The product of WX shall not exceed 80 ounces-inches (0.56 N·m); and

d) The weight of the ballast shall not exceed 28 ounces (794 g).

46.3.3 Definitions for the symbols used in 46.3.1 are as follows:

a) W is the weight of the ballast in ounces (g);

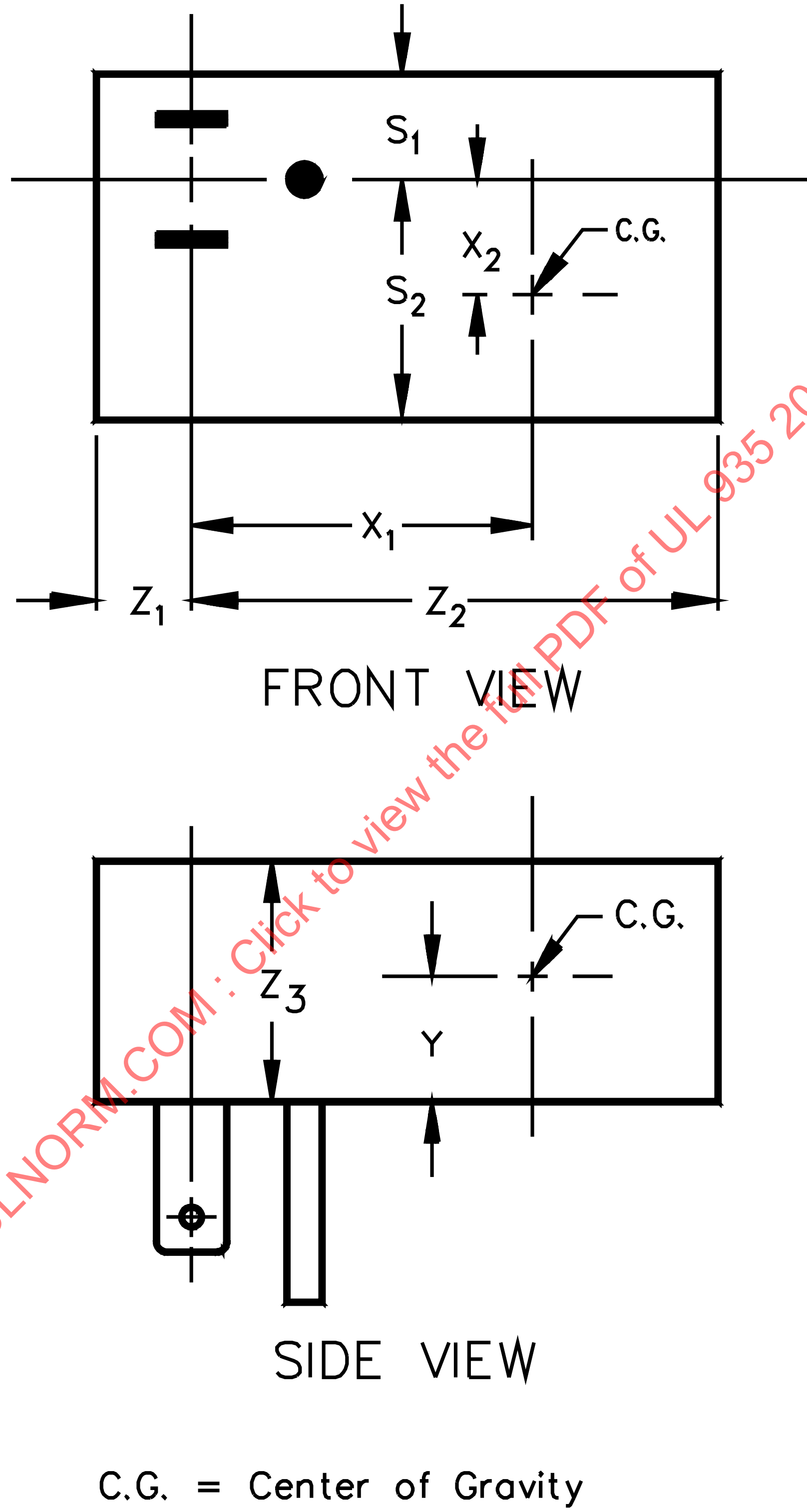
b) Y is the distance illustrated in Figure 46.1 in inches (mm);

c) Z is the lesser of the two distances, Z_1 or Z_2, as illustrated in Figure 46.1 inches (mm);

d) S is the lesser of the two distances, S_1 or S_2, as illustrated in Figure 46.1 inches (mm); and

e) X is the greater of the two distances, X_1 or X_2, as illustrated in Figure 46.1 inches (mm).

Figure 46.1
Dimensions of a direct plug-in ballast



CP100

46.3.4 A mounting tab shall not be provided with a direct plug-in unit unless all of the following conditions are met:

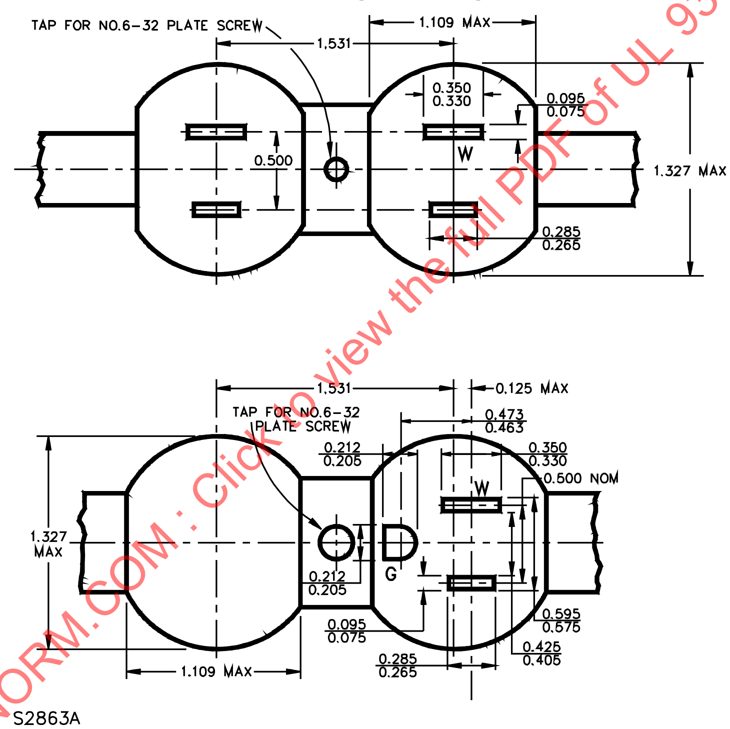
a) The ballast is intended for use on a 15-ampere, 125-volt receptacle;

b) A screw is provided and constructed so as to secure the mounting tab of the device to a duplex receptacle that has a center screw. See Figure 46.2;

c) For a unit without a grounding pin, the mounting tab is constructed so that the device may be mounted to both grounding and nongrounding receptacles; and

d) Marking as specified in 45.5.8 is provided.

Figure 46.2
125V, 15A Duplex receptacle



46.4 Plug face dimensions

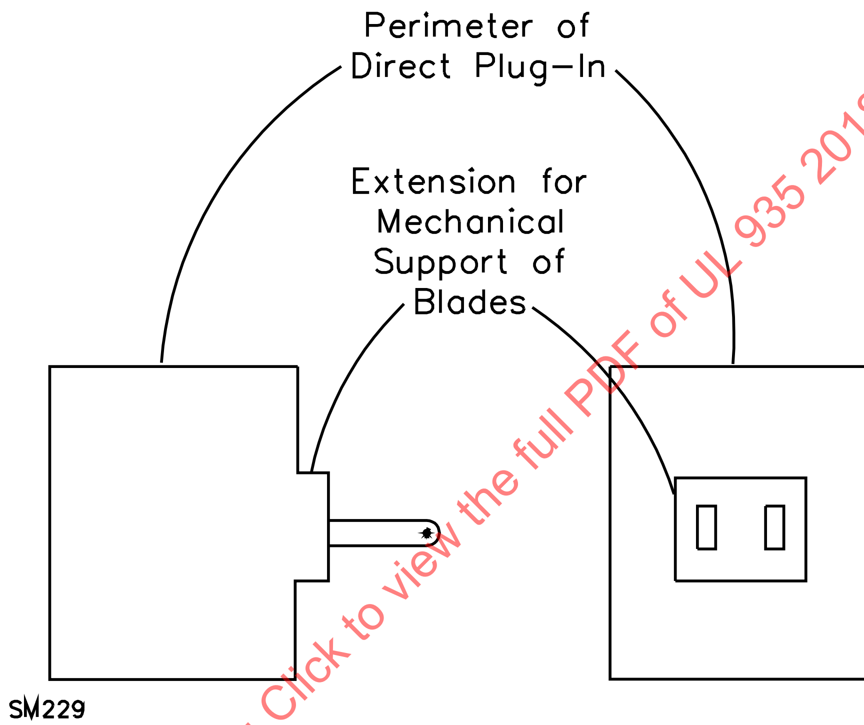
46.4.1 The enclosure of a direct plug-in ballast shall be capable of being gripped for removal from the receptacle to which it is connected, and the perimeter of the face section from which the blades project shall not be less than 5/16 inch (7.9 mm) from any point on either side.

Exception: For devices provided with a mounting tab, the perimeter of the face section may be not less than 1/4 inch (6.4 mm) from any point on either blade.

46.4.2 With reference to 46.4.1, an extension from the face for mechanical support of the blades is not to be considered in the measurement provided the extension measures 0.04 inch (1 mm) or less from the face section of the direct plug-in. See Figure 46.3.

46.4.3 The blades of a direct plug-in ballast shall comply with the construction requirements in the Standard for Attachment Plugs and Receptacles, UL 498. See also Figure 13.2.

Figure 46.3
Extension for mechanical support of blades



46.4.4 When a direct plug-in ballast is inserted in a duplex receptacle, it shall be possible to fully insert an attachment plug into the adjacent receptacle. The attachment plug referred to has the cord exiting behind the plug face, not at a right angle to the plug face. To determine compliance, a duplex receptacle as shown in Figure 46.2 and having 1.531 inches (38.1 mm) dimension between the centerline of the each receptacle is used. A grounding type plug with a diameter of 1.5 inches (38.1 mm) and the ballast under test are inserted into the duplex receptacle. A grounding type plug with a diameter of 1.5 inches (38.1 mm) will overlap any center screw mounting tab of a ballast. This construction complies with the intent of the requirement provided the tab is not thicker than 0.12 inch (3 mm).

Exception: A ballast that renders the adjacent receptacle completely unusable in any one mounting position complies with the intent of the requirement.

46.5 Wiring details

46.5.1 Polarization of the plug blades, cord lengths, and cord strain relief requirements are given in 13.3. For cord strain relief, see also Section 39, Strain-Relief Test.

46.6 Thermal protection

46.6.1 Direct plug-in and through- cord ballasts shall be thermally protected when they operate the lamps described in 16.6. The thermal protection shall comply with the requirements for Class P ballasts described in this standard.

47 Blade Configuration

47.1 The integral blade assembly of a direct plug-in ballast shall comply with the construction requirements in the Standard for Attachment Plugs and Receptacles, UL 498, and the Blade Secureness Test, Section 50. See 46.5 and 46.6.

47.2 A direct plug-in ballast shall be polarized as described in 13.3.

48 Strain Relief

48.1 The input cord of a through-cord ballast and the output cord of a through-cord and direct plug-in ballast shall be tested in accordance with the Strain Relief Test, Section 39.

PERFORMANCE

49 Moment and Weight Test

49.1 The moment and weight specified in 46.3.2 are to be determined as follows:

a) For ballasts with an output cord, the cord is to be cut off at the enclosure, or at the strain-relief means if the strain-relief means is outside the enclosure.

b) For ballasts with directly mounted accessories, the values are to be measured with the accessories in place.

c) The mounting tab described in 46.3.4 is not to be included in measurements of the linear dimensions for the purpose of determining moments unless:

1) The tab and enclosure withstand the impact described in 51.2.1 with one impact on the tab itself, without deformation; and

2) If the enclosure is polymeric, the tab and enclosure do not distort at temperatures to which the material may be subjected under conditions of normal and abnormal use as determined by the mold stress relief distortion test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

50 Blade Secureness Test

50.1 Pull

50.1.1 Each blade and the grounding pin, if provided, shall withstand a direct pull of 20 pounds (89 N) for 2 minutes without loosening. The two blades tested together shall also withstand a direct pull of 20 pounds (89 N) for 2 minutes without loosening.

50.1.2 To determine whether a ballast complies with the requirement in 50.1.1, it is to be supported on a horizontal steel plate with the blades projecting downward through a hole having a diameter sufficient only to permit the blades to pass through it. A 20-pound (9.1-kg) weight is to be supported by each blade and the grounding pin, if provided, in succession and then by the two blades tested together. For a ballast of nonrigid construction – for example, a ballast of soft molded material – the displacement of either blade shall not exceed 3/32 inch (2.4 mm) measured 2 minutes after removal of the weight.

50.2 Push

50.2.1 The plug-in blades and the grounding pin shall not loosen to a degree that would introduce a risk of fire or electric shock as a result of the tests described in 50.2.2 and 50.2.3.

50.2.2 A ballast is to be rigidly supported in the blades-up position. Each blade, in turn, is to be individually subjected to a force of 30 pounds (133 N) applied gradually along the longitudinal axis of the blade in a direction towards the face of the ballast. The 30-pound (133 N) force is to be maintained for 1 minute.

50.2.3 The sample used in 50.2.2 is to be retested by being positioned as described therein and subjecting both blades and the grounding pin, if provided, in combination, to a single applied force of 40 pounds (178 N) for 1 minute.

51 Abuse Tests

51.1 General

51.1.1 The polymeric enclosure of a ballast shall withstand the mechanical abuse tests described in 51.2 – 51.4 without making live parts which pose a risk of electric shock accessible by use of the probe illustrated in Figure 51.1.

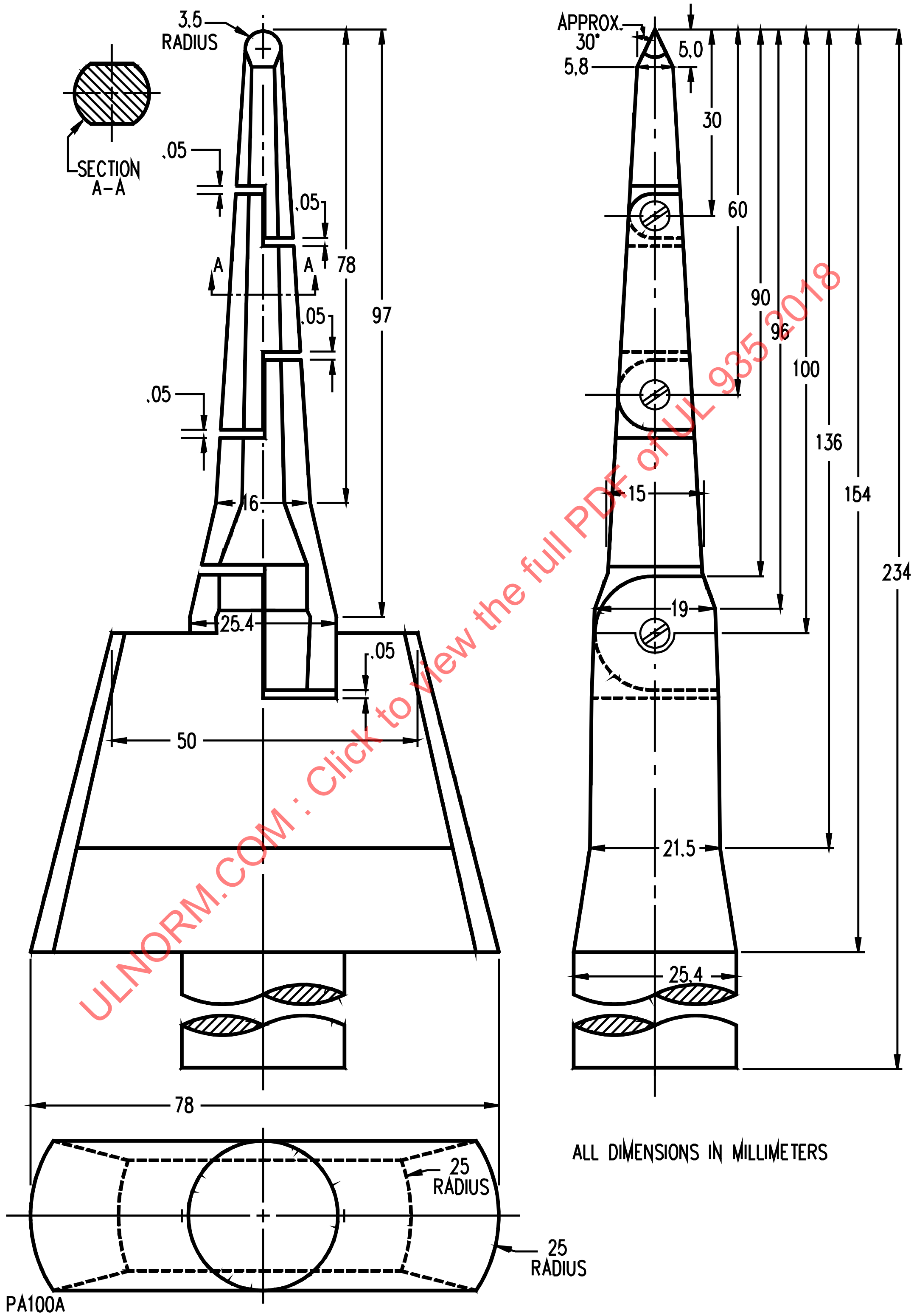
Exception: Enclosures that are completely filled with potting compound need only be subjected to the Impact Test described in 51.2.

51.2 Impact

51.2.1 Three samples are to be subjected to this test. Each ballast is to be dropped (free fall) three times in succession from a height of 3 feet (914 mm) onto a hardwood surface as described in 51.2.2. Each of the drops is to result in the impact occurring at a point on the ballast different from the impact points on the other drops.

51.2.2 The hardwood surface mentioned in 51.2.1 is to consist of a layer of nominal 1-inch (25.4 mm) thick tongue-and-groove oak flooring mounted on two layers of 3/4-inch (19.1-mm) thick plywood. The assembly is to rest on a concrete floor or the equivalent during the test.

Figure 51.1
Articulate probe with web stop
All dimensions are in millimeters



51.3 Rod pressure

51.3.1 The ballast shall be subjected to the Rod Pressure Loading Test, Section 41.

51.4 Resistance to crushing

51.4.1 One sample of the ballast shall withstand for 1 minute a steady crushing force of 75 pounds (334 N) applied at right angles to the mounting surfaces. The enclosure is to be tested between two parallel, flat, maple blocks, each not less than 1/2 inch (12.7 mm) thick. One block is to contain slots into which the blades of the device are to be fully inserted. The crushing force is to be applied gradually in a direction perpendicular to the plane of the mounting surface.

51.5 Accessibility

51.5.1 The probe illustrated in Figure 51.1 applied as specified in 51.5.2 is to be used to determine whether a live part is accessible.

51.5.2 The articulate probe referenced in 51.5.1 is to be applied with a force not exceeding 1 pound (4.4 N) to determine whether the live parts are accessible.

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SUPPLEMENT SA - FLUORESCENT BALLAST ACCESSORIES

SA1 Scope

SA1.1 These requirements cover ballast accessories, such as lamp-power reducers and fluorescent-lamp substitutes, for use with fluorescent lamp/ballast combinations. The effectiveness of these accessories in reducing the input power to the ballast is not investigated as part of these requirements.

SA1.2 These requirements are not to be used solely in judging the acceptability of an accessory. The requirements in Sections 1 – 45 of this standard also apply, except as superseded by a requirement in this supplement.

SA2 General

SA2.1 For the purpose of these requirements, a lamp-power reducer is a reactance that is intended to be installed in series with the fluorescent lamp for the purpose of reducing input power to the ballast. A fluorescent-lamp substitute is a device that is similar in appearance to a standard fluorescent lamp, and that is intended to be installed in place of a fluorescent lamp for the purpose of reducing input power to the ballast. In these requirements, use of the word ″accessory″ means the requirement applies to both a lamp power reducer and a fluorescent-lamp substitute.

SA3 Enclosure

SA3.1 The enclosure of a power reducer shall be made of metal, phenolic, or a polymeric material that has been investigated and found to meet the intent of these requirements. See Polymeric Materials, Section 20, for requirements for polymeric materials used as an enclosure. A polymeric material used as an enclosure shall have a relative temperature index (RTI) with regard to mechanical properties without impact of at least 90°C (194°F) in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: A polymeric material that has a flammability rating of 5VB, V-0, or V-1 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are able to be used when the enclosure is marked in accordance with SA12.10.

Exception No. 2: A polymeric material that has a relative temperature index with regard to mechanical properties without impact of 65°C to 85°C (149°F – 185°F) is able to be used when the enclosure is marked in accordance with SA12.11.

SA3.2 The enclosure of a lamp-power reducer shall completely enclose all live parts of the device.

Exception: This requirement does not apply to an opening intended to accommodate a lamp.

SA3.3 For a fluorescent-lamp substitute, the enclosure for the tubular length shall be made of glass, phenolic or a polymeric material that has been investigated and found to comply with the requirement.