UL 2161

STANDARD FOR SAFETY

Neon Transformers and Power Supplies

UL Standard for Safety for Neon Transformers and Power Supplies, UL 2161

Second Edition, Dated April 6, 2016

Summary of Topics

The second edition of UL 2161 is being issued to address the editorial maintenance of UL Standards for Safety and to remove the reference of the withdrawal date for UL 873. Any changes that were made are considered to be non-substantive and not subject to UL's STP process.

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Standard for Neon Transformers and Power Supplies

First Edition – September, 1996

Second Edition

April 6, 2016

This UL Standard for Safety consists of the Second edition.

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 http://csds.ul.com.

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PART 1 – ALL NEON SUPPLIES

INTRODUCTION

1 Scope

1.1 This standard applies to transformers and power supplies, including those intended to be connected to a Class 2 source of supply, that provide the voltage and ballasting for neon and cold-cathode tubing (electric-discharge tubing) consisting of electrodes and gas such as neon, mercury, helium, argon, and similar gases, enclosed in glass. Neon transformers and power supplies for use in signs and outline lighting are intended to be used in accordance with Article 600 of the National Electrical Code, NFPA 70. Cold-cathode supplies identified for use only in cold-cathode lighting systems are intended to be used in accordance with Article 410 of the National Electrical Code.

1.2 Neon transformers and power supplies covered by this standard are designated by their construction and intended use as specified in Table 1.1.

1.3 The following neon supplies are only covered as components for use in an end product that is determined to comply with the Standard for Electric Signs, UL 48:

a) Type 1 neon supplies;

b) Types 5 and 6 neon supplies when complying with Exception No. 3 to 23.1;

c) Types 6, 7, and 8 neon supplies when complying with the Exception to 14.4.1 or the Exception to 14.4.3;

d) All types of neon supplies having an isolated output when complying with Exception No. 2 to 23.1; and

e) Cold-cathode supplies when complying with Exception No. 5 to 23.1.

1.4 These requirements do not cover transformers or power supplies intended to supply other forms of electric-discharge lighting sources such as fluorescent and high-intensity-discharge lighting. Requirements for fluorescent supply sources are covered in the Standard for Fluorescent-Lamp Ballasts, UL 935, and the requirements for high-intensity-discharge lighting supply sources are covered in the Standard for High-Intensity-Discharge Lamp Ballasts, UL 1029.

1.5 These requirements do not cover transformers or power supplies that are intended for use with oil burners. The requirements for oil ignition transformers are covered in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, and for oil ignition power supplies are covered in the Standard for Power Units Other Than Class 2, UL 1012.

Table 1.1
Construction type designation

Core and/or circuitry		Primary connections			Secondary connections			Type designa-tions
		Wiring terminals or leads			Wiring terminals or leads			
Completely enclosed[a]	Any part exposed[b]	Exposed – not in wiring compartment or through conduit fitting	Unexposed – in wiring compartment or through conduit fitting	Power supply cord	Exposed – not in wiring compartment or through conduit fitting	Unexposed – in wiring compartment or through conduit fitting	Inte-gral recep-tacles	Type designa-tion number – see numbered footnotes for definition
no	yes	yes	no	no	yes	no	no	1
yes	no	yes	no	no	yes	no	no	2
yes	no	no	yes	no	yes	no	no	3
yes	no	no	yes	no	no	yes	no	4
yes	no	no	yes	no	no	no	yes	5
yes	no	no	no	yes	no	no	yes	6
yes	no	no	no	yes	yes	no	no	7
yes	no	no	no	yes	no	yes	no	8

[a] – Enclosed is the containment of electrical parts in a material that complies with 7.1.

[b] – Exposed is any current carrying part other than input and output leads or terminals that is not contained in accordance with 7.1.

Type 1 – Open core-and-coil transformer or open power supply that requires a complete enclosure in the end product.

Type 2 – Neon supply with the input and output terminals, leads, and connections enclosed in the end product.

Type 3 – Neon supply with input leads or terminals enclosed and intended for connection to a permanent wiring system, and with secondary leads or terminals required to be enclosed in the end product.

Type 4 – Neon supply that is fully enclosed including the output and is intended for connection to a permanent wiring system.

Type 5 – Neon supply that is fully enclosed and intended for connection to a permanent wiring system, and is provided with integral output receptacles.

Type 6 – Cord-connected neon supply provided with integral output receptacles.

Type 7 – Cord-connected neon supply with secondary output leads or terminals needing to be enclosed in the end product.

Type 8 – Cord-connected neon supply with enclosed output leads or terminals.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

2.2 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.

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

2.4 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.

3 Reference Publications

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

4 Units of Measurement

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

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

5 Terminology

5.1 As used in these requirements, terms are used to refer to particular parts or features as indicated in Table 5.1.

Table 5.1
Terminology chart

Terms	Refers to:
Input	Primary winding input of a transformer and the input of a power supply
Neon power supply	Electronic power supply
Neon supply	A neon transformer, neon power supply, cold-cathode transformer, and a cold-cathode power supply
Neon transformer	Ferromagnetic transformer supply
Output	Secondary winding output of a neon transformer and the output of a power supply
Secondary ground-fault protection	Ground-fault protection that responds to a ground-fault on the secondary of a neon transformer or on the output of a neon power supply

6 Glossary

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

6.2 ACCESSIBILITY BARRIER – A material provided to limit access to uninsulated live parts and to live parts insulated with materials not intended to be subject to user contact. See Enclosure, 6.12, when an accessibility barrier also serves as an enclosure.

6.3 ADHESIVE – A bonding material (such as epoxy, paste, cement) placed between parts to be fastened together that adheres to each part, and remains the securement medium between the parts.

6.4 BALANCED TYPE – A transformer or power supply construction with two output windings that are isolated from each other with only one end of each winding connected to ground. The construction is such that equal voltage and current is supplied to each secondary output leg and an electrical fault in one output load does not have detrimental effects on the load attached to the other output.

6.5 CLASS 2 CIRCUIT – An electrical circuit derived from a transformer, power supply, or battery source where the open-circuit voltage is less than 30 Vrms (42.4 Vpeak) or 60 Vdc with limited energy as determined by the current and VA limitations for Class 2 circuits in Article 725 of the National Electrical Code, ANSI/NFPA 70.

6.6 COLD-CATHODE SUPPLY – A transformer or power supply for cold-cathode electric discharge tubing in a cold-cathode lighting system used for general illumination in accordance with Article 410 of the National Electrical Code. Cold-cathode supplies provided with secondary ground-fault protection may also be suitable for use in signs and outline lighting systems in accordance with Article 600 of the National Electrical Code.

6.7 CONDUCTIVE CONNECTION – An electrical connection with an impedance or resistance less than a value determined by testing.

6.8 CRITICAL COMPONENT – A component that when shorted or open-circuited, adversely affects the normal operation of a circuit in a way that potentially results in an increased risk of fire or electric shock.

6.9 ELECTRIC DISCHARGE – A method of illumination in which current is passed through a gas medium. This includes neon, cold-cathode, fluorescent, and high-intensity-discharge types of illumination.

6.10 ELECTRODE-HOUSING TRANSFORMER or POWER SUPPLY – A product provided with electrode receptacles within an enclosure with no other secondary output means.

6.11 ELECTRODE RECEPTACLE – An insulating receptacle constructed of porcelain, glass, or similar material, intended to accept electrodes of neon tubing. An individual receptacle is not prohibited from being provided with an integral outer housing of metal or other material.

6.12 ENCLOSURE – A material provided to house electrical parts and components and contain a potential risk of fire. See Accessibility Barrier, 6.2, when an enclosure also serves as an accessibility barrier.

6.13 END-POINT RETURN NEON SUPPLY – A neon supply having one output winding.

6.14 FIELD-WIRING TERMINAL – A terminal connection expected to be made in the field rather than as part of a manufacturing process.

6.15 GROUNDED CONDUCTOR – A supply conductor connected to ground at the building supply source. Also known as common or neutral.

6.16 GROUNDING CONDUCTOR – A conductor provided to bond the dead-metal of a product to earth ground.

6.17 GROUND-REFERENCED NEON SUPPLY – A neon supply having the output circuit conductively connected through the chassis or to the equipment grounding means.

6.18 GTO CABLE – Gas-Tube-Oil ignition cable. A cable rated for 5, 10, or 15 kV for use between the secondary or output of a sign or oil furnace and the neon tubing or oil ignition.

6.19 GTO SLEEVING – An insulation material specifically identified for use over GTO cable. See the definition for Sleeving.

6.20 GUARD – A part provided primarily for the purpose of limiting user access to components (for example, high-temperature or moving parts) having a potential risk of injury to persons.

6.21 HIGH POWER FACTOR – A transformer construction that at rated output draws a ratio of actual (true) power to apparent power of 90% or more.

6.22 INDOOR – Describes a neon supply that is intended for indoor use only where the environmental air is controlled and conditioned within a moderate temperature range.

6.23 INDOOR WINDOW TRANSFORMER or POWER SUPPLY – A cord-connected product with secondary output leads.

6.24 ISOLATED OUTPUT NEON SUPPLY – A neon supply where the secondary or output is not conductively connected through the chassis or to the equipment grounding means.

6.25 ISOLATING BARRIER – A barrier provided to maintain separation between circuits of opposite polarity.

6.26 LUMINOUS TUBE – See definition for Neon Tube.

6.27 MID-POINT NEON SUPPLY – A neon supply having two separate outputs with one lead of each output (3-output leads or terminals) electrically connected to the other.

6.28 MID-POINT RETURN NEON SUPPLY – A mid-point neon supply provided with a return terminal or lead.

6.29 NEON POWER SUPPLY – A step-up supply source in which the high output voltage is produced primarily by electronic circuitry. The output frequency is usually greater than 60 Hz.

6.30 NEON SUPPLY – A transformer or power supply intended to supply current to the electrodes of neon tubes.

6.31 NEON TRANSFORMER – A step-up transformer of the high secondary voltage type intended to supply current to the electrodes of neon tubes.

6.32 NEON TUBE – A glass tube that emits light by passing current through one or more types of rare gas. Also known as a luminous tube.

6.33 OPEN CORE-AND-COIL TRANSFORMER – A neon transformer that has no outer covering over its coil windings that complies with enclosure requirements. This type of transformer is designated as Type 1.

6.34 OPEN HOLE – An aperture in an accessibility barrier or enclosure that is not covered or filled by another part. Typically, open holes are provided for ventilation, mounting means, and supply connections.

6.35 OPENING – An aperture in an enclosure that is covered or filled by a plug or knockout and that has the potential of becoming an open hole. Typically, openings relate to supply connections, commonly referred to as a knockout, and accessibility for inspection of splices.

6.36 OUTDOOR – Describes a neon supply that is intended for use in outdoor applications, and shall be protected from direct contact with the weather by a building structure, sign body, or similar products and constructions. A product so located is subject to moisture by humidity or condensation or similar water vapors.

6.37 OUTPUT – The location on a transformer or power supply from which energy is capable of being drawn by a neon tubing load. On a transformer, this location is commonly referred to as the secondary.

6.38 OVERVOLTAGE CATEGORIES:

CATEGORY I – Signal Level. Low-voltage electronic logic circuits, remote controls, signaling and power limited circuits (Class 2 and similar circuits) connected to the Load Level, Category II.

CATEGORY II – Load Level. Appliances and portable equipment and similar equipment connected to the Distribution Level, Category III.

CATEGORY III – Distribution Level. Fixed wiring and associated equipment (not electrical loads) connected to the Primary Supply Level, Category IV.

CATEGORY IV – Primary Supply Level. Overhead lines and cable systems including the distribution and associated overcurrent protective equipment (equipment installed at the service entrance).

6.39 PERFORMANCE LEVEL CATEGORY (PLC) VALUE – An integer that defines a range of test values for a given electrical/mechanical property test for polymeric (plastic) materials.

6.40 POLLUTION DEGREES:

POLLUTION DEGREE 1 – No pollution or only dry, non-conductive pollution. The pollution has no influence on conductivity.

POLLUTION DEGREE 2 – Normally only non-conductive pollution. However, temporary conductivity is capable of being caused by condensation.

POLLUTION DEGREE 3 – Conductive pollution, or dry, non-conductive pollution that becomes conductive due to condensation.

POLLUTION DEGREE 4 – Pollution that generates persistent conductivity through conductive dust, rain, or snow.

6.41 POTTED TRANSFORMER or POWER SUPPLY – A transformer or power supply in which the windings or circuitry are enclosed in a metal or polymeric container or enclosure and the void is filled with an insulating fluid that becomes solid, or remains plastic, at operating temperatures.

6.42 POWER FACTOR – The ratio of true power to apparent power. See the definition for High Power Factor.

6.43 PRESSURE-WIRE TERMINAL – A wiring terminal that accepts one or more wires for securement and for electrical connection to other conductors. This is accomplished by means of a tightening device that presses and captures a straight segment of the conductor(s) between conductive surfaces.

6.44 SECONDARY – The output voltage and energy from a winding of a neon transformer.

6.45 SECONDARY GROUND-FAULT PROTECTION – An output or secondary sensing circuit that interrupts the input or the output of the supply when a ground fault on the secondary side is sensed.

6.46 SELF-TAPPING SCREWS – Any screw that secures to a material which is not required to be pre-cut with threads to permit entrance of the screw threads. Other common names for screw types are sheet-metal, self-threading, thread-cutting, self-drilling, and thread-forming screws. See 10.4 for requirements for thread-forming screws.

6.47 SLEEVING – A covering, or an insulating or protective sheath, or both, that is intended to cover an electrical part, such as a conductor, a connection, or a splice.

6.48 SOLVENT – A material that acts as a catalyst on parts to be fastened and results in the fusing of the parts to each other, after which the material evaporates and no longer exists as a fastening medium.

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

6.50 STRAIN RELIEF DEVICE – A knot, bushing, or others means determined to be equivalent are provided to reduce the risk of strain being transmitted to a wire or cord at a termination point inside the transformer or sign.

6.51 UNBALANCED TYPE – A transformer or power supply design with one or two output windings that are not magnetically isolated from one another (for example, one shunt for two secondary core legs). The voltage and current in each secondary output is or is not equal and an electrical fault in one output load affects the other output.

6.52 UNGROUNDED CONDUCTOR – A supply conductor that is determined as ″live″ or ″hot.″

6.53 WEATHERPROOF – Describes a neon supply that is intended to be directly exposed to the weather without an additional enclosure.

6.54 WIRE-BINDING SCREW – A screw used as a post around which a wire is to be wrapped.

CONSTRUCTION

7 Enclosures

7.1 General

7.1.1 All insulated and uninsulated current-carrying parts other than supply and output leads or terminals and the center contact of electrode receptacles shall be enclosed in metal or polymeric material in accordance with the requirements in 7.2 and 7.4.

Exception: A neon supply marked Type 1 in accordance with 47.5 is not required to be provided with an integral outer enclosure when intended to be installed in an end product having its own enclosure that complies with the Standard for Electric Signs, UL 48.

7.2 Metallic enclosure

7.2.1 A metallic enclosure shall have a metal thickness that complies with Table 7.1.

7.2.2 The values for minimum metal thickness apply to measurements made before the application of paints, varnishes, or coatings.

Table 7.1
Minimum thickness of enclosure metal

	At small, flat, unreinforced surfaces and at surfaces of a shape or size to provide the required mechanical strength,		At surfaces to which a wiring system is to be connected in the field,		At large unreinforced flat surfaces,	
Metal	in	(mm)	in	(mm)	in	(mm)
Die-cast	0.047	(1.2)	–	–	0.078	(2.0)
Cast malleable iron	0.063	(1.6)	–	–	0.094	(2.4)
Other cast metal	0.094	(2.4)	–	–	0.125	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.026	(0.66)	0.026	(0.66)
Zinc-coated sheet steel	0.029	(0.74)	0.029	(0.74)	0.029	(0.74)
Nonferrous sheet metal	0.030	(0.76)	0.040	(1.02)	0.030	(0.76)

7.3 Corrosion protection

7.3.1 Except at the edge of cut ends and holes, the internal and external surfaces of an enclosure of iron or steel, other than stainless steel, or an internal surface covered with compound shall be corrosion resistant. Examples of corrosion resistance means capable of being used are galvanizing, painting, plating, and enameling or other means determined to be equivalent.

7.3.2 Laminations, and other parts of iron or steel such as washers and screws or a part that does not act as an enclosure, accessibility barrier, water shield, or a current-carrying part, are not required to be provided with corrosion protection.

7.4 Polymeric enclosure

7.4.1 An enclosure of polymeric material (thermoplastic or thermosetting) used to provide all or part of the enclosure for electrical parts as specified in 7.1.1 shall comply with the requirements in 7.4.2 – 7.4.9.

Exception No. 1: A neon supply marked Type 1 in accordance with 47.5 is not required to comply with this requirement.

Exception No. 2: When a neon supply is completely potted and the potting material complies with the enclosure requirements specified in 7.4.4, the polymeric material external to the potting shall have a minimum flammability rating of HB.

7.4.2 A material shall comply with the requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and as amended in this section. For permanently-connected neon supplies, the requirements for fixed equipment in UL 746C are applicable. Cord-connected neon supplies shall comply with the requirements for portable equipment in UL 746C.

7.4.3 A polymeric enclosure material shall be rated with both an electrical and a mechanical (with impact) relative temperature index in accordance with the Standard for Polymeric Materials– Short Term Property Evaluations, UL 746A, of not less than the maximum operating temperature of the enclosure material measured during the temperature test as described in the Temperature Test, Section 30.

7.4.4 For a neon supply intended for permanent connection to a source of supply, the minimum flammability rating for a neon supply enclosure shall not be less than 5 VA, and minimum V-2 for a neon supply with a detachable or non-detachable power supply cord.

7.4.5 A potting material shall have a flammability rating of minimum V-2.

Exception No. 1: A potting material that either encapsulates all insulated and uninsulated live parts or is located within a metal or polymeric enclosure complying with 7.4.4 shall have a minimum flammability rating of HB.

Exception No. 2: A potting material of the thermosetting type, such as epoxy, is not required to be tested for flammability.

7.4.6 For all neon supplies, only the HAI and CTI properties shall be applied, and the CTI and HAI PLC values shall not be greater than 2.

Exception: A thermoset material such as epoxy is not required to comply with this requirement.

7.4.7 The impact evaluation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall include only the ball impact test.

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

Exception: A thermoset material such as epoxy is not required to comply with this requirement.

7.4.9 The polymeric enclosure of a neon supply marked for use in weatherproof locations shall comply with the water exposure, immersion and ultraviolet radiation exposure requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8 Accessibility Barriers

8.1 All uninsulated or insulated current-carrying parts operating at a voltage greater than 30 Vrms (42.4 Vpeak) shall be protected against the risk of contact in accordance with 8.4 by an accessibility barrier in accordance with 8.6 during normal use, maintenance, or servicing.

Exception: A neon supply is not required to have the coil, input, and output connections made inaccessible where identified as "Exposed" in Construction Type Designation, Table 1.1, when it is marked with the intended designation type as identified in Table 1.1.

8.2 Under conditions of normal use, uninsulated current-carrying parts of a cord-connected neon supply operating at a voltage greater than 30 Vrms (42.4 Vpeak) shall be guarded in accordance with 8.3 from contact by the straight metal strip specified in 8.5.

8.3 All uninsulated current-carrying parts of a cord-connected neon supply that result in ignition of combustible materials when shorted together shall be guarded from contact in accordance with 8.1, with the straight metal strip specified in 8.5, so that a short or arc is not capable of resulting in ignition of materials.

8.4 A current-carrying part is determined to be accessible when the articulate probe shown in Figure 8.1 is capable of contacting the part. The probe shall be applied to any depth that an opening permits and with a force not greater than 1 lbf (4.4 N). The probe shall be rotated or angled before, during, and after insertion through an opening to any position that is required to examine the neon supply. The probe shall be applied in any possible configuration and, when required, the configuration is to be changed after insertion through an opening.

8.5 A current-carrying part of a cord-connected neon supply is determined to be accessible when a straight metal strip measuring 2-in (51-mm) long, 1/2-in (12.7-mm) wide, and 1/16-in (1.6-mm) thick, is capable of contacting the current-carrying part, when inserted into an opening with a force not greater than 1 lbf (4.4 N).

8.6 An accessibility barrier shall be constructed of one of the following materials:

a) Metal (ferrous, aluminum, brass, zinc, or copper), minimum 0.016-in (0.41-mm) thick;

b) Glass, porcelain, or ceramic, minimum 1/8-in (3.2-mm) thick;

c) Impregnated glass fiber sleeving minimum 0.01-in (0.25-mm) thick, that is rated for the temperature involved;

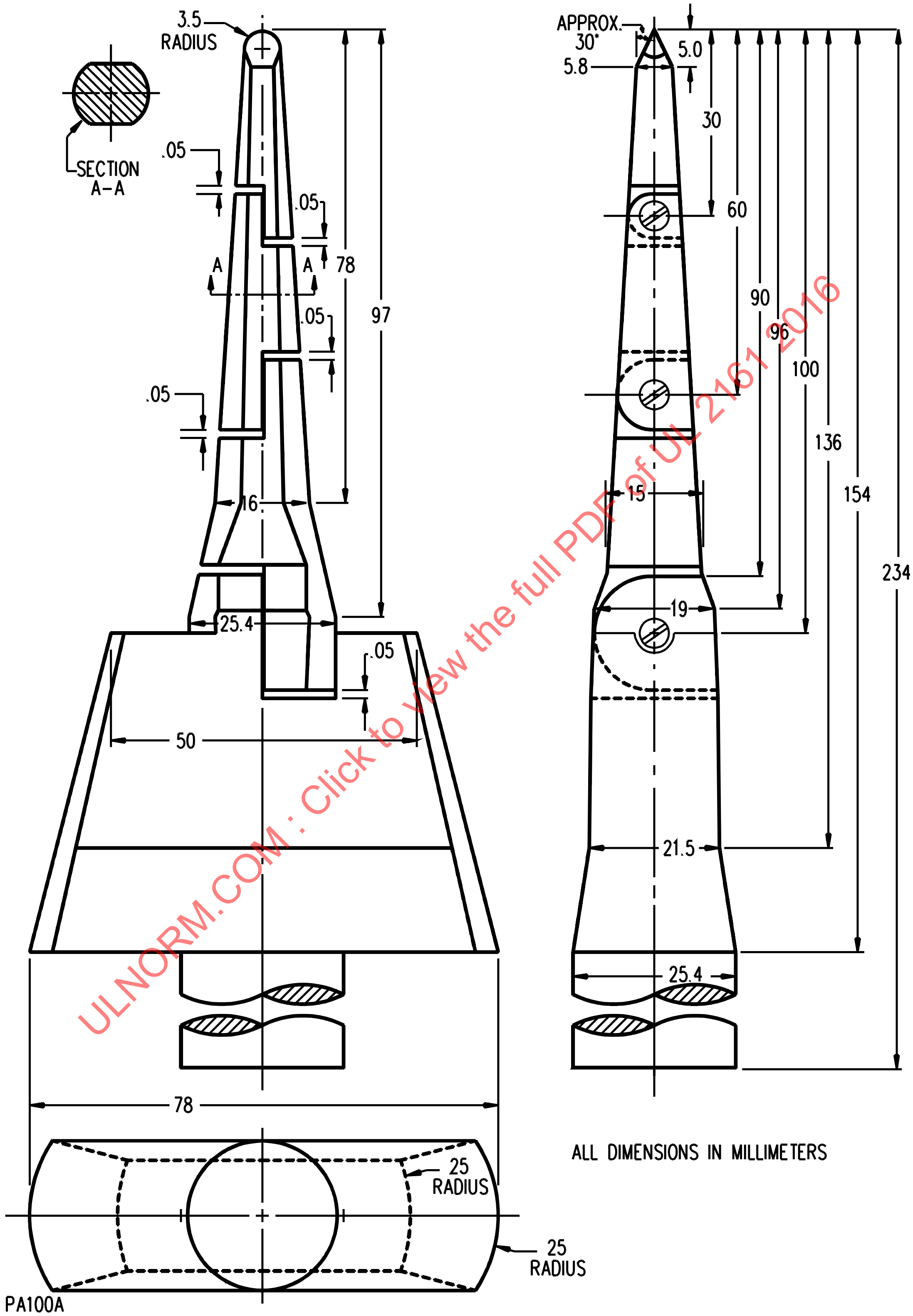
d) Vulcanized fiber, minimum 0.028-in (0.71-mm) thick;

e) A polymeric material that complies with 8.7; or

f) Mica sheet, minimum 0.016-in (0.406-mm) thick where framed by other material.

Exception: An accessibility barrier is not required to be of the minimum thickness specified when during and after the application of a force of 10 lbf (44.5 N) over an area of 1 in^2 (6.45 cm^2) to the barrier, the force applied does not result in permanent or temporary distortion, breaking, or cracking of the barrier where current-carrying parts become accessible to the probe or spacings between metal parts are less than required in Spacings, Section 24.

Figure 8.1
Articulate probe with web stop



8.7 A polymeric material used to form an accessibility barrier shall:

a) Be rated for at least the maximum operating temperature of the barrier as measured by the Temperature Test, Section 30;

b) Be classified at least HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; and

c) Comply with minimum property and test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The minimum properties are 30 s ignition time (maximum assigned PLC 3) for hot-wire ignition (HWI) and 60 arcs (maximum assigned PLC 1) for high-amp arc ignition (HAI). The property test requirement is the Mold Stress-Relief Distortion Test of UL 746C.

8.8 When an accessibility barrier is provided to protect against risk of contact with current-carrying parts exceeding 1000 Vrms (1414 Vpeak) to ground, the combination of the barrier material, spacing between barriers and live parts, and any other material between current-carrying parts and the user or service personnel side of the barrier shall comply with the dielectric voltage-withstand test for barrier and insulating materials as described in 31.3.1 – 31.3.5.

9 Openings and Open Holes

9.1 Open holes in an enclosure or accessibility barrier shall comply with the following:

a) The open holes shall not be larger than the dimensions specified in Table 9.1;

b) The open holes shall not be located on a surface intended to face the material to which the neon supply is to be mounted; and

c) The open holes comply with the accessibility requirements in Accessibility Barriers, Section 8.

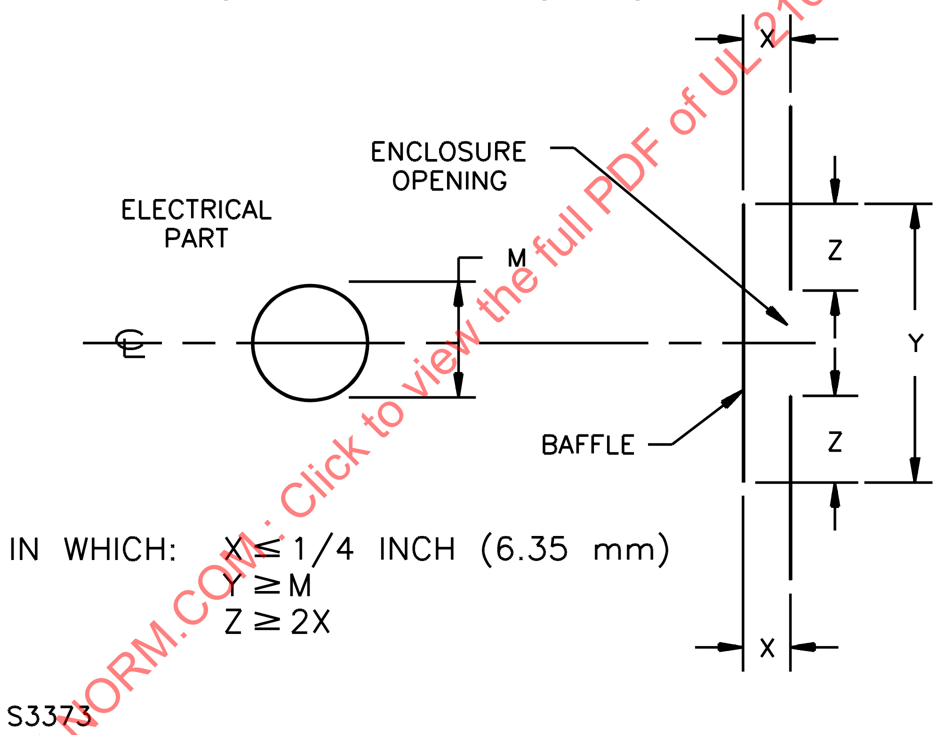
Exception: An open hole that exceeds the dimensions in Table 9.1 is not prohibited when a baffle in accordance with Figure 9.1 is provided.

Table 9.1
Maximum size of miscellaneous open holes

Opening shape	Dimension,			Maximum area,	
	in		(mm)	in^2	(cm^2)
Slot[a]	3/8	(width)	(9.5)	1-1/2	(9.68)
Square	1/2	(side)	(12.7)	–	–
Round	1/2	(diameter)	(12.7)	–	–
Irregular	–		–	1-1/2	(9.68)

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

Figure 9.1
Relationship of baffle and electrical part to prevent emission



9.2 A cover over an open hole in an enclosure shall be provided with means (such as screws, spot welding, or similar securement methods) for firmly securing it in place. Friction alone shall not be used for this purpose.

9.3 A switch or other wiring device shall not be mounted to a cover that is required to be removed for connection of circuit conductors or servicing adjustments.

9.4 When more than one open hole is provided for supply connections or provided for output connections, all open holes shall be covered such that they exist as knockouts only.

9.5 A knockout provided over a supply or output conduit open hole shall completely cover the opening in which it is located. The knockout thickness shall comply with the requirements for enclosures. The open hole dimensions between the opening cover and the enclosure shall not exceed the maximum open hole dimension sizes as specified in Table 9.1.

9.6 A knockout shall be secured and yet removable without undue deformation of the enclosure as determined by compliance with the knockout test as described in 39.2.1 and 39.2.2.

9.7 A knockout provided in a polymeric enclosure shall comply with the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

10 Securement of Parts

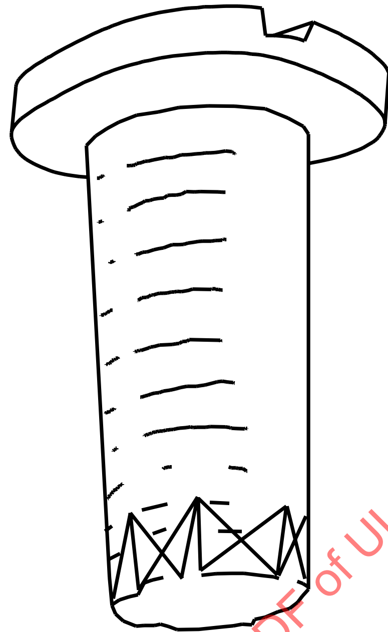
10.1 A neon supply shall be formed and assembled so that it has the strength and rigidity required to resist the abuses to which it is to be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse which results in a reduction of spacings, loosening or displacement of parts, or other serious defects.

10.2 An adhesive (see 10.3 for a solvent) used to secure the enclosure, guard, and accessibility barrier parts together and at any other location for which the reliability of the securement means affects a potential risk of shock, shall be investigated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

10.3 Securement methods that result in two or more materials being joined and fused together, such as solvent, ultrasonic welding, electromagnetic induction, and thermal welding, are not defined as adhesives and are not required to be investigated.

10.4 A thread-forming screw having criss-cross cut threads as shown in Figure 10.1 shall not be used to secure a cover or component or be utilized as a terminal type screw that is removed or replaced during field installation or servicing.

Figure 10.1
Example of thread-forming screw



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11 Sharp Edges

11.1 An edge, projection, or corner of an enclosure, frame, barrier, guard, or similar parts that are accessible to contact during and after installation or as part of user maintenance and servicing shall be smooth and rounded to reduce the risk of a cut-type injury when contacted during installation, intended use, or maintenance.

12 Mounting

12.1 A neon supply shall be provided with a means of securing it to a surface to which it is to be attached. Examples of mounting means are openings in the frame and other parts.

12.2 A mounting means that relies on a polymeric material for support shall comply with the Mechanical Tests, Section 39.

13 User Accessible Controls

13.1 A user accessible control or adjustment of a neon supply shall:

a) Be accessible without removing the enclosure and

b) Be located where uninsulated live parts are guarded by accessibility barriers in accordance with 8.1 – 8.8.

13.2 The operation of a user accessible control or adjustment shall be included in the neon supply installation and operating instructions as specified in Instructions, Section 49.

14 Supply Connections (Does Not Include Equipment Grounding)

14.1 Permanently-connected supplies

14.1.1 A neon supply intended to be permanently connected to a source of building supply and designated as Type 3, 4, 5, or Weatherproof, shall be provided with open holes or knockouts with or without conduit fittings for supply and output connections in accordance with 14.1.2 and 14.1.3.

Exception: A neon supply intended and marked for connection only to a Class 2 circuit in accordance with 47.7 is not required to be provided with supply connection open holes or knockouts.

14.1.2 When more than one opening is provided for either a power supply connection, output connection, or both, no opening for supply or output connections shall exist as an open hole.

14.1.3 Openings for conduit shall have dimensions as indicated in Table 14.1.

Table 14.1
Conduit opening dimensions

Nominal trade size of conduit,		Unthreaded opening diameter[a] size,		Threaded opening – throat diameter				Minimum unobstructed diameter of flat surface,	
				Minimum,		Maximum,			
in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)
1/2	(12.7)	0.875	(22.2)	0.56	(14.2)	0.62	(15.7)	1.15	(29.2)
3/4	(19.1)	1.109	(28.2)	0.74	(18.8)	0.82	(20.8)	1.45	(36.8)
1	(25.4)	1.375	(34.9)	0.94	(23.9)	1.05	(26.7)	1.80	(45.7)
1-1/4	(31.8)	1.734	(44.0)	1.24	(31.5)	1.38	(35.1)	2.31	(58.7)

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

14.1.4 An opening for the conduit shall have the dimensions as indicated in Table 14.1, and shall comply with the following:

a) The opening shall be constructed to properly attach a conduit bushing;

b) The minimum unobstructed diameter of the flat surface surrounding the back of a threaded or unthreaded conduit opening shall be as indicated in Table 14.1; and

Exception: A minimum unobstructed area surrounding the back of a threaded conduit opening is not required when the threads are not formed through the entire length of the hole.

c) At least 3-1/2 to 5 threads shall be provided when the threads are not formed through the entire length of the hole, or at least 5 threads when the threads are formed through the length of the hole.

14.1.5 A field-wiring compartment provided as part of a neon supply shall be located so that the connections are accessible for inspection without disturbing wiring connections after the neon supply is installed as intended.

14.1.6 The attachment means of a field-wiring compartment shall not result in incidental rotation of the compartment.

14.1.7 A neon supply that incorporates one or more of the following supply-circuit components in which polarity is to be maintained shall have one lead or terminal identified for the connection of a grounded (neutral or common) conductor of the supply circuit:

a) Single pole switch,

b) Overcurrent device,

c) Single pole interrupt component,

d) Single pole overtemperature component, or

e) Any other component or construction feature that relies on maintaining polarity.

14.1.8 When a field-wiring compartment is provided on a neon supply, the input and output field-wiring leads and terminals shall not occupy the same compartment.

Exception: When the input field-wiring leads and terminals are located at one end of a neon supply, and the output field-wiring leads and terminals are located at the opposite end, they are not prohibited from being located in the same neon supply enclosure when a conduit connection means is provided at each end of the enclosure.

14.2 Supply terminals

14.2.1 A field-wiring terminal shall be of the pressure-wire connector or wire-binding screw type and shall be capable of being used for connection to solid 10 – 14 AWG (5.3 mm^2 – 2.1 mm^2) conductors.

Exception: A field-wiring terminal that complies with the Standard for Wire Connectors, UL 486A-486B, is not required to be further investigated.

14.2.2 A pressure-type wire terminal shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

14.2.3 A wire-binding screw terminal shall either comply with the Standard for Terminal Blocks, UL 1059, or:

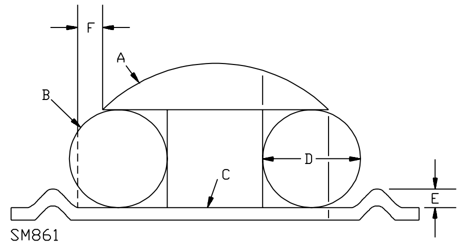
a) Shall be No. 8 (4.2 mm) diameter or larger where the head of the screw and a baseplate shall cover at least three-quarters of the conductor as illustrated in Figure 14.1 and

b) The base plate shall have a tapped hole of metal not less than 0.030-in (0.76-mm) thick and shall not have fewer than two full threads in the metal.

Exception No. 1: A terminal plate metal of less than 0.030-in (0.76-mm) thick is capable of being used, when a tapped hole for a screw having 32 or more threads per inch is provided and the metal extruded at the screw hole provides two full threads.

Exception No. 2: A wire-binding screw terminal is not required to comply with UL 1059 when it complies with 40.1 and 40.2.

Figure 14.1
Terminal and conductor relationship



A – Wire-binding screw

B – Conductor

C – Baseplate

D – Diameter of conductor

E – Minimum height of raised area shall be 0.04 inch (1.0 mm)

F – The horizontal dimension from the edge of the screw head to the inside edge of the raised area shall be maximum 1/64 in (0.4 mm)

14.2.4 A wire-binding screw and an individual stud with nut shall be provided with a means of captivating a conductor such as a cupped washer or screw having a raised ridge on the outer edge of the underside of the screw head.

Exception: A wire-binding screw that is secured in a base material that complies with 14.2.3 and Figure 14.1 is not required to be provided with additional means.

14.2.5 A terminal intended for connection of a grounded supply (neutral) conductor shall be made of or plated with metal substantially white or silver in color and no other terminals shall be white or silver in color.

Exception: A terminal intended for connection of a grounded supply (neutral) conductor is not required to have a distinguishing color when marked on or adjacent to the terminal with the words “NEUTRAL,”“COMMON,” “N,” or when the symbols “–” and “+” are provided on the supply terminals. The lettering and symbols shall be minimum 1/4-in (6.4-mm) high. Ink, paint, die-stamping and other similar marking means are not prohibited from being used as the marking method.

14.3 Supply leads

14.3.1 A field-wiring lead shall not be smaller than 18 AWG (0.82 mm^2).

14.3.2 The free length of a field-wiring lead shall not be less than 6 in (15.2 cm). Free length is measured from the point of entry of the lead into the wiring compartment to the free end of the lead.

14.3.3 The insulation of a lead intended for the connection of a grounded supply conductor (neutral or common) shall be white or gray and readily distinguishable from other supply leads.

14.3.4 The insulation of a lead intended for the connection of an ungrounded supply conductor (hot) shall be any color other than white, gray, green, or green with yellow stripe.

14.3.5 A strain relief shall be provided on field-wiring leads so that stress on a lead is not transmitted to the electrical connection inside a neon supply. The acceptability of the strain-relief means shall be determined by the Strain and Push-Back Relief Test, Section 35.

14.4 Cord- and plug-connected supplies

14.4.1 A neon supply that is not provided with means for permanent connection to a source of supply shall be provided with either a connector and detachable power supply cord or non-detachable power supply cord. The connector and supply cord shall be of the grounding (three-conductor) type.

Exception: A neon supply with no accessible dead-metal parts and evaluated only as a component for use in an end product that is determined to comply with the Standard for Electric Signs, UL 48, is not required to be provided with a supply cord of the grounding type, when marked in accordance with 48.5.

14.4.2 A power supply cord shall be minimum 18 AWG (0.82 mm^2) and be of Type SP-2, Type SPE-2, Type SPT-2, or heavier usage.

14.4.3 A flexible supply cord shall be minimum 6 ft (1.83 m) and maximum 15 ft (4.57 m) in length as measured from the point where the cord emerges from a neon supply, or after any strain-relief means provided, to the point where the cord enters an attachment plug.

Exception: A flexible supply cord shall be permitted to be minimum 1.5 ft (0.46 m) in length, when the neon supply is only for use in wall-mounted signs and covered as a component for use in an end product that has been determined to comply with the Standard for Electric Signs, UL 48.

14.4.4 Strain and push-back relief shall be provided to reduce the risk of mechanical stress on the power supply cord from being transmitted to terminals, splices, or interior wiring. The strain-relief means shall be evaluated by the Strain and Push-Back Relief Test, Section 35.

14.4.5 Where a knot in a flexible power supply cord serves as strain relief, the surface upon which the knot contacts or bears shall not have burrs, fins, sharp edges, and projections that damage the insulation on a cord.

14.4.6 An insulating bushing shall be provided at the point where a flexible supply cord passes through an opening in a metal enclosure or through a non-rounded opening of a polymeric enclosure. The bushing shall be secured in place and have a smooth, rounded surface against which the cord bears.

Exception: The bushing for a flexible cord heavier than Type SVT is not required to be of the insulating type.

14.4.7 The attachment plug of a cord-connected neon supply shall be rated for a 15- or 20-A branch circuit.

Exception: A cord-connected neon supply with a supply voltage of less than 30 Vrms (42.4 Vpeak) is not required to be provided with an attachment plug rated for a 15- or 20-A branch circuit.

14.4.8 When a two-conductor flexible cord is provided for connection to the source of supply and polarity is required in accordance with 14.1.7, the conductors shall be connected to a polarized parallel-blade attachment plug with the identified grounded conductor (neutral) connected to the wider blade. A parallel cord such as Type SPT-2 shall have a stripe, ridge, or groove on the exterior of the cord surface of the grounded (neutral) conductor for identification.

14.4.9 A three-conductor flexible cord with ground shall be provided with conductor identification to identify grounded and grounding conductors. A jacketed cord such as a SJT type shall have the grounding conductor within the jacket colored green or green with a yellow stripe and the grounded conductor shall be colored white or gray.

14.5 Source of supply other than a branch circuit

14.5.1 A neon supply intended to be supplied by a transformer or power supply shall be provided with a means for connection to the output of the transformer or power supply using a permanent wiring method in accordance with the National Electrical Code, ANSI/NFPA 70.

Exception No. 1: A neon supply provided with internal fusing of maximum 5 A and marked "Connect ONLY to a Rated ___ Volts, Class 2 Transformer or Power Supply" in accordance with 47.7 is not required to be provided with a means for connection to a permanent wiring system. The blank shall be filled in with a voltage less than 30 Vrms.

Exception No. 2: A neon supply rated for maximum 30 V input and provided with a receptacle to accommodate the cord connector on the end of either an ac or dc adaptor, is not required to be provided with a means to connect to a permanent wiring system.

Exception No. 3: A neon supply marked for use on vehicles in accordance with 48.4 is not required to be provided with a means for connection to a permanent wiring method.

14.5.2 A Class 2 transformer or power supply shall be provided with each neon supply marked "Connect ONLY to a Class 2 Transformer or Power Supply."

Exception No. 1: A Class 2 transformer or power supply is not required to be provided with each neon supply when the neon supply is internally fused for maximum 5 A and is marked "Connect ONLY to a __ Volts, Class 2 Transformer or Power Supply." The blank is to be filled in with a rated voltage less than 30 Vrms.

Exception No. 2: A Class 2 transformer or power supply is not required to be provided with each neon supply when provided with a receptacle to accommodate the cord connector on the end of either an ac or dc adaptor.

15 Equipment Grounding

15.1 All conductive parts of a neon supply shall be grounded through a direct connection to equipment grounding or shall be bonded to a point on the neon supply that connects to equipment grounding, when the conductive parts of a neon supply are:

a) Not intended to be electrically live;

b) Accessible to the accessibility probe in the Accessibility Barriers, Section 8; and

c) Capable of becoming energized.

Exception No. 1: An adhesive-attached metal foil marking label secured to the outside of an enclosure is identified as material that does not become energized.

Exception No. 2: A dead-metal part is not required to be conductively connected to ground when separated from live current-carrying parts having a voltage potential less than 1000 V, by rigid insulating material, minimum 1/8-in (3.2-mm) thick. The insulating material is permitted to be less than 1/8-in (3.2-mm) thick when, at the highest voltages involved, the material is determined to be in compliance with 31.3.1.

Exception No. 3: The external mounting hardware of a neon supply is identified as parts that do not become energized.

16 Equipment Grounding Means

16.1 General

16.1.1 A neon supply having parts that are required to be connected to equipment grounding or are required to provide a grounding connection when cord-connected shall be provided with the means to connect to that ground. The means shall be by terminal or lead.

16.1.2 The point of connection to the equipment grounding shall be within 6 in (15.2 cm) of the supply connection means, within the supply connection compartment, when provided, and where not required to be removed during normal maintenance and servicing.

16.1.3 A wire-binding screw, stud, or other device, provided for the connection of a grounding or bonding conductor, secured to dead-metal with a non-conductive coating surface shall be provided with a star washer or other device to penetrate the coating.

16.1.4 A grounded conductor (neutral) shall not be connected to any grounding or bonding terminal or lead in or on the surface of a neon supply.

16.2 Grounding terminal

16.2.1 A grounding terminal shall be:

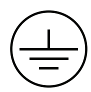
a) A pressure-wire terminal that complies with 16.2.2, and the Standard for Wire Connectors, UL 486A-486B, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E;

b) A wire-binding screw that complies with 16.2.3 – 16.2.8; or

c) A wire-binding stud that complies with 16.2.3 and 16.2.9.

16.2.2 A pressure-wire terminal intended as connection of the equipment-grounding conductor shall be plainly identified as ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or similar identification markings, or marked with the symbol shown in Figure 16.1.

Figure 16.1
Grounding symbol



16.2.3 A grounding terminal shall be rated for connection to solid 10 – 14 AWG (5.3 mm^2 – 2.1 mm^2) conductors.

16.2.4 A wire-binding screw provided for the connection of a field installed equipment-grounding conductor is to be provided with a means to restrain the conductor and retain it under the head of the screw. This is to be done by a cupped washer or a raised projection in accordance with Figure 14.1.

16.2.5 A wire-binding screw for the connection of a field installed equipment-grounding conductor shall have a green colored head that is either hexagonal or round with a slotted or Phillips-keyed head.

16.2.6 The head of a wire-binding screw shall cover at least 3/4 of the conductor as illustrated in Figure 14.1.

16.2.7 A wire-binding screw shall be No. 8 (4.2 mm) diameter or larger.

16.2.8 The baseplate of a wire-binding screw shall be metal, not less than 0.030-in (0.76-mm) thick, and have a threaded hole with no fewer than two full threads.

Exception: The base plate is not prohibited from being less than 0.030-in (0.76-mm) thick, when a threaded hole for 32 or more threads per inch is provided and the metal around the screw hole is extruded to provide two full threads.

16.2.9 A wire-binding stud shall be provided with a:

a) Cupped washer and

b) Hexagonal nut. The nut shall be green in color or the area adjacent to the terminal shall be marked in accordance with 16.2.2.

16.3 Grounding leads

16.3.1 The conductor of a grounding lead shall not be smaller than 18 AWG (0.82 mm^2).

16.3.2 A grounding lead shall have insulation that is green with or without one or more yellow stripes. No other lead visible to an installer shall be so identified.

16.3.3 A grounding lead shall have a free length of at least 6 in (15.2 cm). See 14.3.2 for definition of free length.

16.3.4 A grounding lead shall be provided with strain relief that complies with the Strain and Push-Back Relief Test, Section 35.

16.4 Grounding, cord-connected neon supplies

16.4.1 For a neon supply that is required to be grounded as specified in Equipment Grounding, Section 15, the grounding conductor of a flexible power supply cord shall be connected to the grounding blade of a grounding-type attachment plug and shall be connected to dead-metal parts within the frame or enclosure of a neon supply by means such as welding, soldering, a screw or stud, nut, and lockwasher.

16.4.2 The means to secure the equipment-grounding conductor shall not serve any other function, such as that of an enclosure securement screw. The means shall be located on a part that is not normally removed for servicing.

Exception: The equipment-grounding conductor is not prohibited from being terminated at a screw that serves another purpose when that part of the neon supply is potted such that the equipment-grounding conductor is not removable during servicing.

16.4.3 When a flexible cord for supply connection includes an equipment-grounding conductor, conductors of the flexible cord shall be connected to a parallel-blade, 3-wire grounding attachment plug.

17 Bonding

17.1 All parts required to be grounded shall be conductively connected to the grounding terminal, lead, or pin of an attachment plug such that the resistance between ground and any accessible point is 0.1 Ω or less. Compliance is determined by conducting the grounding continuity test as described in the Grounding Continuity Test, Section 34.

Exception: A neon supply having a power supply cord longer than 10 ft (3 m) shall have a grounding continuity resistance not to exceed 0.15 Ω.

17.2 Bonding shall be accomplished by positive metal-to-metal contact of parts such as screw connections, rivets, bolts, soldering, or welding; or by a separate bonding conductor not smaller than 18 AWG (0.82 mm^2).

17.3 A bonding conductor shall be of copper or copper alloy.

17.4 The continuity of a grounding system shall not rely on the dimensional integrity of a polymeric material. An example of dimensional integrity is when a screw terminal holding a grounding-conductor threads into or through a polymeric material and the continuity of the connection relies on the polymeric material not changing its shape.

17.5 A neon supply bonding lead shall not be terminated at a grounding terminal intended for connection of the equipment-grounding conductor unless it is secured separately from the equipment-grounding lead, and remains in place and securely fastened while the equipment-grounding conductor is being fastened and unfastened to the terminal.

18 Internal Wiring

18.1 General

18.1.1 A conductor provided with insulation shall have insulation rated for the voltage, temperature, and condition of service to which it is subjected to under conditions of intended use.

Exception: The insulation of a conductor is not required to be rated, when surrounded by potting.

18.2 Prevention of wire damage

18.2.1 Conductors shall be securely routed at least 1/4 in (6.35 mm) from, or protected to prevent contact with, any sharp edge, burr, fin, or similar abrading surface that is capable of damaging the conductor insulation. A screw shall be identified as having a sharp edge unless the screw threads and screw ends have been evaluated and determined to be blunt.

Exception: Conductors are not prohibited from being spaced less than 1/4 in (6.35 mm) from, and maintaining no contact with, sharp edges and similar surfaces when located within a potted cavity.

18.2.2 The edge of a sheet metal opening through which insulated conductors pass shall be provided with a bushing or grommet.

Exception No. 1: A smooth, rounded surface is to be provided by rolling the edge of an opening 120° or more.

Exception No. 2: The edges of sheet metal thicker than 0.042 in (1.07 mm) is required to only be treated by reaming or by other methods determined to be equivalent to remove burrs, fins, and sharp edges.

19 Internal Electrical Connections (Other Than Output Circuitry)

19.1 An electrical connection shall be electrically and mechanically secure. A screw, a crimp-type wire connector, a pressure-wire terminal, a quick-connect terminal, a wire-binding screw, or a wire or component lead through a hole in a printed-wiring board that is soldered are examples of methods capable of being used.

Exception: A surface-mounted technology type component on a printed-wiring board is not required to be provided with a wire or a component lead through a hole in the board before soldering.

19.2 A mechanically secured and soldered splice or an uninsulated wire connector shall be covered with insulation material determined as equivalent to that required of the conductors.

Exception: A splice or wire connector surrounded by potting is not required to be covered by such insulation.

19.3 When stranded internal wiring is connected to a wire-binding screw or stud terminal, the construction shall be such that no loose strands result.

20 Output

20.1 Output ratings

20.1.1 A Type 1 neon supply shall have a rated output voltage not greater than 7500 Vrms between terminals or leads and for all other Types, 15,000 Vrms between terminals or leads, or 7500 Vrms between any terminal or lead and ground, as determined under the conditions specified in 29.1.1 – 29.1.5.

20.1.2 The output of a neon supply shall not be rated for more than 300 mA. The output of a cold-cathode supply shall not be rated for more than 150 mA when the open-circuit voltage is more than 7500 V. See also 29.2.1, 29.2.2, and 29.2.4.

20.2 Output terminals

20.2.1 The connection of an output field-wiring terminal shall be by means such as a pressure-wire connector, a wire-binding screw, a wire-binding stud and nut, or similar parts. The connection means shall comply with 16.2.1.

20.2.2 For a wire-binding screw, or wire-binding stud and nut, a cupped washer or other means that readily captures a stranded conductor shall be provided.

20.2.3 The output field-wiring terminal shall be rated for connection to a solid or stranded 18 – 14 AWG (0.82 – 2.1 mm^2) conductor.

20.2.4 An output return terminal shall be separate from the equipment-grounding means specified in Equipment Grounding Means, Section 16.

20.2.5 An output return terminal shall be located in an area adjacent to the output leads or terminals.

20.3 Output cables

20.3.1 An output cable shall:

a) Comply with the Standard for Gas-Tube-Sign Cable, UL 814;

b) Have conductors not less than 18 AWG (0.82 mm^2);

c) Have insulation rated at least as high as the maximum voltage between conductors; and

d) Have insulation rated for at least the temperatures involved, and not less than 105°C (221°F).

20.3.2 An output cable shall be provided with at least 6 in (15.2 cm) of free lead length either within the box or compartment or outside the neon supply enclosure. See 14.3.2 for definition of free lead length.

20.3.3 The maximum length of each output cable shall not be more than 20 ft (6.1 m) as measured from where the lead exits the enclosure to the end of the lead.

20.3.4 At a point where an output cable passes through a metal partition, including an enclosure wall, a non-metallic bushing that spaces the lead at least 1/4 in (6.4 mm) from the edge of the metal partition shall be provided.

Exception: A non-metallic bushing that spaces the lead less than 1/8 in (3.2 mm) from the edge of the metal partition is not prohibited when it complies with the requirements for its intended use.

20.3.5 An output cable shall be provided with a strain relief that complies with the Strain and Push-Back Relief Test, Section 35.

20.3.6 A cord-connected neon supply provided with output leads and designated as Type 7, shall be provided with a collar secured to, or that is a part of, the enclosure around each output lead. Each collar shall be at least 0.375 in (9.53 mm) long and 0.375 in (9.53 mm) in diameter.

Exception: A collar is not required on a neon supply when GTO sleeving is provided over the output leads and either:

a) The sleeving is integral to the output leads or

b) The sleeving is not integral to the output leads. The sleeving extends to within 2 in (50.8 mm) of the free end of the output leads and the sleeving is provided with strain relief within the neon supply enclosure.

20.3.7 An output return cable shall be separate from the equipment-grounding means specified in Equipment Grounding Means, Section 16.

21 Input/Output Isolation

21.1 The output of a neon supply shall be provided with an isolating-type transformer. The level of isolation shall be in accordance with Input to Output Isolation Test, Section 33.

21.2 The output of a neon supply that is not conductively connected within the neon supply to ground shall be isolated from ground in accordance with 23.5, and have an output voltage in accordance with 29.1.1.

21.3 The output of a neon supply that is identified as being end-point or mid-point ground-referenced shall be conductively connected to ground within the neon supply such that the voltage between the ground-referenced output terminal or lead and earth ground complies with 29.1.6.

22 Electrical Components

22.1 General

22.1.1 Electrical components shall have a voltage rating at least equal to the voltage that is applied to the component in intended use, and rated for the type of load they control.

22.1.2 An electrical component shall have an ampere rating at least equal to the amperage it is subjected to in intended use. When the load is inductive and the component is of a type that opens and closes a circuit, such as a switch, the component shall be ″T,″ ″L,″ ″AC″ general-use rated, or shall be rated not less than twice the full-load current rating of the load.

Exception: Components that open and close a circuit are not required to be rated for twice the full-load rating when determined to comply with the switch loading tests specified in Switch Loading Tests, Section 36.

22.1.3 An electrical component shall have a frequency rating equal to the frequency of the circuit in which it is intended to operate. An electrical component operating on a direct current (dc) circuit shall be rated for dc operation.

22.1.4 A component such as a switch, fuseholder, receptacle, or similar devices shall be mounted securely and shall be prevented from turning by means other than friction between surfaces.

Exception: A switch is not required to comply with this requirement when all of the following conditions are met:

a) The switch is a plunger or other type that does not tend to rotate when operated (a toggle switch is deemed to be subject to forces that tend to turn the switch);

b) The means for mounting the switch does not loosen the mounting means during the operation of the switch; and

c) Spacings are not reduced below the minimum required values when the switch rotates.

22.2 Switches

22.2.1 A switch shall disconnect the ungrounded conductor of the incoming line circuit.

Exception: A switch is not prohibited from being located in other than the incoming line circuit while when in the off position, it is determined that the output of the neon supply is always less than the Class 2 limits specified in 6.5, when individual electronic components are opened and shorted.

22.3 Over-current protection

22.3.1 A fuse, when provided, shall be:

a) Mounted in a fuseholder of the proper type and rating,

b) Soldered by pigtail style leads directly to a printed-wiring board, or

c) Mounted using surface mount technology.

22.3.2 The accessible contact of an extractor fuseholder shall be connected towards the load.

22.3.3 An over-current protective device shall not be connected in the grounded (neutral) conductor unless the device simultaneously interrupts the grounded and ungrounded supply conductors.

22.3.4 An over-current protective device such as a supplementary protector or circuit breaker connected in the supply circuit shall open all ungrounded conductors.

22.3.5 A fuse replacement marking shall be provided adjacent to a replaceable over-current protective device as specified in 48.2.

22.4 Capacitors

22.4.1 A capacitor connected across the input supply line for electromagnetic interference suppression shall comply with the Standard for 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, or the Standard for Electromagnetic Interference Filters, UL 1283.

22.4.2 An oil-filled capacitor provided for power factor correction shall comply with the applicable requirements in the Standard for Capacitors, UL 810, and shall be operated within its rated voltage.

22.4.3 The placement and mounting of a pressure-interrupting type oil-filled capacitor in a neon supply shall be such that free air space is provided in front of the capacitor end terminals to enable the capacitor to expand, without obstruction, under a fault condition. This expansion clearance space shall be sized so that the front enclosure and terminals of the capacitor, with associated wire connectors and supply leads attached, are capable of traveling 1/2 in (12.7 mm) in a direction perpendicular to the mounting surface of the terminals.

Exception No. 1: A thermally-protected capacitor does not require expansion clearance space.

Exception No. 2: A potted neon supply is not required to have an expansion clearance space when an investigation demonstrates that the pressure-interrupting feature of the capacitor is not adversely affected.

22.4.4 In addition to the 1/2 in (12.7 mm) expansion clearance space specified in 22.4.3, an electrical air spacing between any exposed live parts of the capacitor, such as exposed terminals and wire connectors, and:

a) Any uninsulated live part of opposite polarity; or

b) Uninsulated, grounded dead-metal parts

shall be at least 1/16 in (1.6 mm) when the voltage involved does not exceed 300 V; or at least 1/8 in (3.2 mm) when the voltage exceeds 300 V.

Exception: Spacings from the capacitor terminals and uninsulated live parts of opposite polarity or uninsulated, grounded dead-metal parts are not required to be provided when the capacitor terminals are potted.

22.5 Transformers

22.5.1 Coil insulation, unless inherently moisture resistant, shall be treated to render it moisture resistant. Film-coated wire is not required to be additionally treated to reduce moisture absorption.

22.6 Thermal protective devices

22.6.1 A temperature regulating control that is required to comply with the performance requirements of this standard shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, including the section on Thermal Protective Devices for Lighting Fixtures where the load is inductive. 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.

22.6.2 A thermal cutoff shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

22.7 Printed-wiring boards

22.7.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, including direct support of live parts, and shall have a flammability rating of V-2 or better, in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A printed-wiring board that has been determined to be connected only to one Class 2 circuit, and circuits on the board operate within Class 2 limits, is to be rated minimum HB.

Exception No. 2: A printed-wiring board that is completely encapsulated in potting compound is not required to comply with a minimum flammability rating.

22.7.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-wiring board to form a printed-wiring assembly shall be electrically and mechanically secured so that it is not capable of being displaced to result in a risk of electric shock or fire by a force exerted on it during assembly, intended operation, or servicing of the neon supply. A component of a printed-wiring assembly that is completely covered by potting compound is determined as having the required mechanical securement.

Exception: A component using surface mount technology is not required to be otherwise mechanically secured.

22.8 Electrode receptacles

22.8.1 A neon receptacle provided within the enclosure or accompanying the neon supply during shipping shall comply with the Standard for Electric Sign Components, UL 879, and the dielectric voltage-withstand test in 31.2.6.

23 Secondary Ground-Fault Protection

23.1 A neon supply shall be provided with secondary ground-fault protection that complies with 23.2 – 23.10, and the test requirements in the Secondary Ground-Fault Parameters Test, Section 41, and the Secondary Ground-Fault Protection Circuit Abnormal Tests, Section 42.

Exception No. 1: A neon supply with an output of maximum 33 (30 + 10%) mA, as measured in accordance with 29.2.2 – 29.2.5 between all output terminals or leads and from any output terminal or lead to ground, is not required to be provided with secondary ground-fault protection when:

a) The output is 100 Hz or less, and has a rated output to ground of less than 3001 V or

b) The output is greater than 100 Hz, and has a rated output to ground of less than 2001 V.

Exception No. 2: A neon supply operating at a frequency of 100 Hz or less, with an isolated output of maximum 7500 V between any combination of leads or terminals, is not required to be provided with secondary ground-fault protection. The maximum voltage is to be measured in accordance with 29.1.3 and isolation is to be determined in accordance with 28.1.

Exception No. 3: Types 5 and 6 neon supplies with the neon tubing in the sign intended to be interconnected only by a freestanding lampholder with no GTO cable, are not required to be provided with secondary ground-fault protection.

Exception No. 4: A neon supply with an output of maximum 15 mA as measured in accordance with 29.2.2 – 29.2.5, between all output terminals or leads and from any output terminal or lead to ground, is not required to be provided with secondary ground-fault protection.

Exception No. 5: A cold-cathode supply marked in accordance with 46.5 is not required to be provided with secondary ground-fault protection.

23.2 The secondary ground-fault protection circuit required in 23.1 shall function in accordance with 23.10 when tested in accordance with 41.1– 41.9, with the equipment-grounding means grounded and ungrounded. This condition is represented in Figures 41.1 – 41.4, and Table 41.1 as SW1.

Exception: A neon supply that incorporates a circuit that limits the output in accordance with 41.2 under the conditions specified in 41.3– 41.5 and complies with 42.1.2, is not required to comply with this requirement with the equipment grounding means ungrounded.

23.3 The secondary ground-fault protection circuit required in 23.1 shall function in accordance with 23.10 when tested in accordance with 41.1 – 41.9, when the return terminal or lead is connected and not connected. This condition is represented in Figures 41.1– 41.4, and Table 41.1 as SW2.

Exception: A mid-point neon supply provided with no return terminal or lead is not required to comply with this requirement.

23.4 The secondary ground-fault protection circuit required in 23.1 shall function in accordance with 23.10 when tested in accordance with 41.1 – 41.9, with the load across any output terminals or leads grounded. This condition is represented in Figures 41.1– 41.4, and Table 41.1 as SW3.

Exception: A secondary ground-fault protection circuit is not required to remain resettable in accordance with 23.10(b) when, with the load grounded and subsequently ungrounded, the output complies with the limits in 23.10(a).

23.5 An isolated output neon supply shall have a current to ground that is 2 mA or less when measured in accordance with the Isolated Output Determination Test, Section 28.

23.6 A magnetically operated switch provided to interrupt primary or input power in response to a secondary ground-fault condition shall comply with 6000-cycle endurance requirements specified in the Standard for Industrial Control Equipment, UL 508.

Exception: A magnetically operated switch that complies with the test requirements in the Switch Loading Tests, Section 36, evaluated for 6000 cycles of endurance, shall be permitted.

23.7 When a neon supply is provided with a feature that bypasses the secondary ground-fault protection circuitry, the bypass feature shall comply with the following:

a) Operation of the bypass feature shall require a manual action by service personnel.

b) Once activated, the bypass feature shall automatically deactivate after no longer than 30 min.

c) Interruption of power to a neon supply shall automatically deactivate any activated bypass feature.

d) Markings shall not be provided on the neon supply indicating that a secondary ground-fault protection bypass feature is provided.

23.8 After tripping, and with the output of a neon supply in accordance with 23.10, the secondary ground-fault protection circuit shall require an action on the part of the user or service personnel to re-set the output of the neon supply. This shall be in the form of a manual reset switch or by disconnecting and reconnecting the input power.

Exception: The circuit shall be capable of resetting itself up to three times when:

a) The reset time is not greater than 10 s;

b) An electromagnetic device such as a relay provided in the secondary ground-fault circuitry complies with the Standard for Industrial Control Equipment, UL 508, including 6,000 cycle endurance;

c) The neon supply is marked with a cautionary marking in accordance with 48.3;

d) After three automatic resets, the circuit must require an action on the part of the user or service personnel to re-energize the output.

e) Except when the circuit resets, after each trip the output voltage shall be no greater than the rated input voltage and the output current shall be no greater than 0.5 mA as measured in accordance with 32.4 and 32.5.

23.9 The secondary ground-fault protection circuit shall be physically integral to the neon supply. The circuit shall be within the neon supply enclosure or wiring compartment or within the outerwrap of a Type 1 neon supply, and electrically connected to the neon supply such that no wiring connections, except normal input and output neon supply connections, are accessible to the installer.

23.10 Under the test conditions described in 41.1 – 41.9, when the fault current to ground reaches 15 mA, the secondary ground-fault protection of a neon supply shall:

a) Reduce the output voltage to no greater than the rated input voltage and the output current to no greater than 0.5 mA within 500 ms and

b) Be resettable such that rated output is obtainable from the supply and the secondary ground-fault protection is capable of functioning and continues to comply with (a).

24 Spacings

24.1 The minimum spacings between uninsulated live parts of opposite polarity, between an uninsulated live part and a grounded dead-metal part, and between an uninsulated live part and an accessible dead-metal part shall be as follows:

a) Input supply terminals, indoor and outdoor use – see Minimum Spacings at Input Wiring Terminals, Table 24.1;

b) Input circuitry, not including input terminals, and output circuitry, including connections and terminals:

1) Spacings – For indoor/outdoor use, without conformal coating, see Table 24.2;

2) Spacings – For indoor use only, without conformal coating, see Table 24.3;

3) Spacings – For indoor/outdoor use, with conformal coating, see Table 24.4.

Exception No. 1: No minimum spacings apply to parts encapsulated in a potting compound.

Exception No. 2: The inherent spacings of discrete components are not required to comply with Tables 24.1 – 24.4.

Exception No. 3: Circuitry operating within Class 2 limits is not required to comply with Tables 24.1 – 24.4.

Exception No. 4: Spacings between traces on a printed-wiring board are not required to comply with Tables 24.2– 24.4 when:

a) The printed-wiring board has a flammability rating of V-0 and complies with the abnormal operation test in 38.1.1 – 38.1.5; and

b) The spacings are not between the printed-wiring board traces and dead-metal parts or between primary and secondary traces.

Exception No. 5: Except for field-wiring terminals and live parts to accessible dead-metal spacings, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as amended in 24.3, are not prohibited from being used in lieu of the spacings in Tables 24.2 – 24.4.

Exception No. 6: For Type 1 neon supplies, the over-surface spacing between uninsulated live parts and dead-metal parts shall not be less than 0.5 in (12.7 mm).

Table 24.1
Minimum spacings at input wiring terminals

Transformer primary rating, V	Minimum through-air and over-surface spacings between live and dead-metal parts, in	(mm)	Minimum spacings between live parts of opposite polarity: Through-air, in	(mm)	Over-surface, in	(mm)
0 – 125	1/4	(6.4)	1/8	(3.2)	1/4	(6.4)
126 – 300	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)
301 – 600	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)

Table 24.2
Spacings – Input circuitry, not including input terminals, and output circuitry, including connections and terminals, indoor/outdoor use, without conformal coating

Voltage range	Through-air, in	(mm)	Over-surface, in	(mm)
0 – 15	0.126	(3.2)	0.252	(6.4)
16 – 30	0.126	(3.2)	0.252	(6.4)
31 – 50	0.126	(3.2)	0.252	(6.4)
51 – 100	0.126	(3.2)	0.252	(6.4)
101 – 150	0.126	(3.2)	0.252	(6.4)
151 – 170	0.252	(6.4)	0.375	(9.5)
171 – 250	0.252	(6.4)	0.375	(9.5)
251 – 300	0.375	(9.5)	0.50	(12.7)
301 – 600	0.375	(9.5)	0.75	(19.1)
601 – 1,000	0.375	(9.5)	0.75	(19.1)
1,001 – 2,500	0.75	(19.1)	1.00	(25.4)
2,501 – 5,000	1.00	(25.4)	1.00	(25.4)
5,001 – 10,000	1.50	(38.1)	1.50	(38.1)
10,001 – 15,000	1.50	(38.1)	2.00	(50.8)

Table 24.3
Spacings – Input circuitry, not including input terminals, and output circuitry, including connections and terminals, indoor use only, without conformal coating

Voltage range	Through-air, in	Through-air, (mm)	Over-surface, in	Over-surface, (mm)
0 – 15	0.05[a]	(1.27)	0.05	(1.27)
16 – 30	0.05[a]	(1.27)	0.05	(1.27)
31 – 50	0.05[a]	(1.27)	0.05	(1.27)
51 – 100	0.063[a]	(1.6)	0.063	(1.6)
101 – 150	0.063[a]	(1.6)	0.094	(2.4)
151 – 170	0.094[a]	(2.4)	0.25	(6.4)
171 – 250	0.094[a]	(2.4)	0.375	(9.5)
251 – 300	0.375[a]	(9.5)	0.50	(12.7)
301 – 600	0.375[a]	(9.5)	0.75	(19.1)
601 – 1,000	0.50[a]	(12.7)	0.75	(19.1)
1,001 – 2,500	1.00	(25.4)	1.00	(25.4)
2,501 – 5,000	1.00	(25.4)	1.00	(25.4)
5,001 – 10,000	1.25	(31.8)	1.50	(38.1)
10,001 – 15,000	1.50	(38.1)	2.00	(50.8)

[a] On printed-wiring boards, their connectors, and board-mounted electrical components wired on the load side of line filters or similar voltage peak reduction networks and components, a minimum spacing of 0.0230 in (0.580 mm) plus 0.0002 in (0.005 mm) per Vpeak shall be maintained over-surface and through-air between uninsulated live parts and other uninsulated, live or dead conductive parts not of the same polarity.

Table 24.4
Spacings – Input circuitry, not including input terminals, and output circuitry, including connections and terminals, indoor/outdoor use, with conformal coating

Voltage range	Over-surface, in	Over-surface, (mm)
0 – 15	0.005	(0.13)
16 – 30	0.010	(0.25)
31 – 50	0.015	(0.38)
51 – 100	0.020	(0.51)
101 – 150	0.025	(0.64)
151 – 170	0.030	(0.76)
171 – 250	0.030	(0.76)
251 – 300	0.030	(0.76)
301 – 600	0.060	(1.52)
601 – 1,000	0.120	(3.05)
1,001 – 2,500	0.300	(7.62)
2,501 – 5,000	0.600	(15.2)
5,001 – 10,000	1.00	(25.4)
10,001 – 15,000	1.20	(30.5)

24.2 The spacings between uninsulated and insulated live parts of opposite polarity, and between insulated parts of the output circuitry, regardless of conformal coating, shall be as specified in Table 24.5. The spacings between insulated live parts of the output circuitry and the plane of the intended mounting surface of the neon supply shall be as specified in Table 24.5. To be considered an insulated live part, the insulation either must be an integral part of a separately investigated component or comply with 25.1.

Table 24.5
Spacings – Output circuitry including connections and terminals, insulated to insulated and insulated to ground in all locations

Potential difference	Uninsulated to insulated,[a]		Insulated[a] to insulated,[a]		Insulated[a] to the plane of the intended mounting surface,	
	in	(mm)	in	(mm)	in	(mm)
0 – 600	Not applicable		Not applicable		Not applicable	
601 – 1,000	0.75	(19.1)	0.252	(6.4)	0.126	(3.2)
1,001 – 2,500	0.75	(19.1)	0.375	(9.5)	0.252	(6.4)
2,501 – 5,000	0.75	(19.1)	0.50	(12.7)	0.252	(6.4)
5,001 – 10,000	1.12	(28.4)	0.75	(19.1)	0.375	(9.5)
10,001 – 15,000	1.50	(38.1)	1.00	(25.4)	0.50	(12.7)

[a] Insulated in accordance with 24.2 and 25.1.

24.3 The spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, shall be amended as follows:

a) For indoor only neon supplies the Pollution Degree shall be 2;

b) For indoor/outdoor neon supplies the Pollution Degree shall be 3;

c) Hermetically sealed or encapsulated enclosures, or conformally-coated printed-wiring boards are identified as Pollution Degree 1;

d) Cord-connected neon supplies shall be rated Overvoltage Category II;

e) Permanently-connected neon supplies shall be rated Overvoltage Category III;

f) To apply Clearance B (controlled overvoltage), a neon supply shall be provided with an integral overvoltage device or system; and

g) All printed-wiring boards have been determined to have a minimum Comparative Tracking Index (CTI) PLC of 1.

24.4 Enameled and similar film-coated wire is identified as an uninsulated live part.

24.5 The spacings between output circuitry and dead-metal for a ground-referenced circuit shall be based on the maximum open-circuit voltage to ground.

25 Insulation

25.1 An insulating material that is not an integral part of a separately investigated component shall comply with the requirements in Table 25.1.

Exception: An insulating material, thinner than specified in Table 25.1 or not included in Table 25.1, shall comply with 31.3.1.

Table 25.1
Minimum thickness of insulating materials

Material	Minimum thickness,				Weatherproof and outdoor non-weatherproof neon supplies	Indoor neon supplies only
	Cap[e],		Barrier,			
	in	(mm)	in	(mm)		
Fiber	1/8	(3.2)	1/32	(0.8)	no	[a]
Phenolic composition	1/8	(3.2)	1/32	(0.8)	no	[b]
Cold-molded composition	1/8	(3.2)	1/32	(0.8)	no	yes[c]
Porcelain:						
Glazed	1/8	(3.2)	1/8	(3.2)	yes	yes
Unglazed	1/8	(3.2)	1/8	(3.2)	Only as tubes on insulated wires	yes[c]
Mica	1/8	(3.2)	1/32	(0.8)	yes	yes
Glass	1/8	(3.2)	1/8	(3.2)	yes[d]	yes[d]

[a] To be used only when the spacings to the barrier or liner from secondary parts (insulated and uninsulated) comply with those specified in Table 24.2 – 24.5 for the spacings between primary and secondary parts and when there is no risk of contact between the barrier or liner and a secondary lead that is installed or to which a connection is made in the field.

[b] To be used only when the spacing (over-surface or through-air) to the barrier or liner from an insulated secondary part is not less than 1/4 in (6.4 mm), and when the spacing (over-surface or through-air) to the barrier or liner from an uninsulated secondary part is not less than 1/4 in (6.4 mm), 3/8 in (9.5 mm), or 1/2 in (12.7 mm) for secondary potentials of 0 – 5,000 V; 5,001 – 10,000 V; 10,001 – 15,000 V, respectively; and when there is no contact between the barrier or liner and a secondary lead that is installed or to which a connection is made in the field.

[c] To be used only when not in contact with secondary parts (insulated or uninsulated) and when inaccessible to contact by a secondary lead that is to be installed or to which a connection is made in the field.

[d] When glass tubing is used, it shall be of double thickness, 0.1-in (2.5-mm) thick, and shall be securely fastened in place.

[e] See 25.2 for cap requirements.

25.2 A cap of insulating material provided over an otherwise uninsulated secondary terminal to reduce the risk of contact between secondary parts shall be tight fitting and capable of being secured to the terminal. The cap shall be of one of the materials indicated in Table 25.1. The cap shall be such that when it is in place, the spacing between the uninsulated live parts of the terminal and the exterior surface of the cap at the crevice where the cap abuts the other insulated parts of the terminal is not less than 1/8 in (3.2 mm) as measured through the crevice.

PERFORMANCE

26 General

26.1 Representative samples of a neon supply shall be subjected to and shall comply with the applicable tests described in Sections 27 – 42.

26.2 Unless otherwise specified, all tests are to be conducted with the neon supply connected to a rated frequency source of supply. The voltage of the source of supply and the branch-circuit rating is to be one of the following:

a) 12 V from the intended supply source for a marked rating within the range of 11 – 12 V.

b) 14 Vdc with a 20-A line fuse when marked for use with moving vehicles only, in accordance with 48.4, and with a marked rating within the range of 11 – 12 V.

c) 26 Vdc with a 20-A line fuse when marked for use in moving vehicles only, in accordance with 48.2, and with a marked rating within the range of 23 – 25 V.

d) 120 V from a 30-A branch circuit for a marked rating within the range of 110 – 130 V.

e) 240 V from a 30-A branch circuit for a marked rating within the range of 220 – 250 V.

f) 277 V from a 30-A branch circuit for a marked rating within the range of 267 – 288 V.

g) The marked voltage rating from either a 30-A branch circuit or from the intended supply source for a marked rating outside of the ranges specified in (a) – (f).

26.3 For all tests that require connection to a neon tubing load, the load for a neon supply, unless otherwise specified, is to be in red neon. Red neon and mercury/argon tubing shall be as specified below:

a) Short-circuit output current of 5 to 45 mA – 0.47 in (12 mm) diameter pumped to 0.43 in of Hg (1.5 kPa);

b) Short-circuit output current of over 45 to 65 mA – 0.59 in (15 mm) diameter pumped to 0.35 in of Hg (1.2 kPa); and

c) Short-circuit output current of over 65 to 300 mA – 0.98 in (25 mm) diameter pumped to 0.24 in of Hg (0.8 kPa).

Exception No. 1: For a neon supply that is not rated for, nor intended for use with red neon tubing, another type, diameter, or the pressure of the neon tubing load rated for the neon supply is capable of being used.

Exception No. 2: For a neon supply with a current and voltage rating other than the values specified in Table 26.1, the length of neon tubing shall be the length that loads the neon supply to 80% of the short-circuit current.

Table 26.1
Neon tubing length chart

Neon supply rating		Number of feet[a] of neon tubing		
Open-circuit output voltage, V	Short-circuit output current, mA	Diameter size of tube, (mm)		
		25 mm	15 mm	12 mm
15,000	120		69	53
15,000	60	102	60	45
15,000	30	102	60	45
15,000	20		50	40
12,000	120		52	40
12,000	60	79	45	35
12,000	30	79	45	35
12,000	20		39	30
9,000	120	77	38	29
9,000	60	67	33	26
9,000	30	67	33	26
9,000	20		28	22
7,500	120	59	28	23
7,500	60	51	24	20
7,500	30	51	24	20
7,500	20		22	18
6,000	120	46	22	18
6,000	60	40	19	16
6,000	30	40	19	16
6,000	20		17	14
5,000	120	38	19	14
5,000	60	33	17	12
5,000	30	33	17	12
5,000	20		14	11
4,000	60	27	13	10
4,000	30	27	13	10
4,000	20		11	9
3,000	60	17	10	8
3,000	30	17	10	8
3,000	20		8	6
2,000	30		7	6
2,000	20		6	5

NOTE – Deduct 12 in (30.5 cm) from above figures for each pair of electrodes. See 26.3 for gas pressure.

[a] Multiply footage length by 25.4 to obtain tube length sizes in metric measurements.

26.4 The electrodes for the test load shall be of the same diameter glass as the neon tubing having an electrode-shell rating and dimensions as specified in Table 26.2.

Exception: For 15-mm diameter tubing and a 20 mA short-circuit output current, the test load is to use a 12-mm diameter electrode.

Table 26.2
Electrode ratings/dimensions for testing

Neon tubing diameter,		Current rating,	Shell diameter,		Shell length,		Ceramic collar
in	(mm)	mA	in	(mm)	in	(mm)	
0.47	(12)	30	5/16	(7.9)	1-1/16	(27.0)	No
0.59	(15)	60	3/8	(9.5)	1-1/4	(31.8)	No
0.98	(25)	120	1/2	(12.7)	1-3/8	(34.9)	Yes
0.98	(25)	250	7/16	(11.1)	2-1/4	(57.2)	Yes

26.5 Unless otherwise specified, all tests are to be conducted using the amount of neon tubing footage specified in the footage chart in Table 26.1. The amount of footage on the footage chart is to be reduced by 1 ft (30.5 cm) for every two neon-tubing electrodes (each separate length of tubing). The neon tubing footage for a neon transformer is to be based on the rated open-circuit voltage and the short-circuit secondary current. The neon tubing footage for a neon power supply is to be the amount specified in Table 26.1, that is determined as equivalent to a neon transformer for a given voltage and current. For example, a 15 kV, 30 mA neon transformer and a 9 kV, 30 mA neon power supply is capable of having the same neon footage as a test load.

27 Input Measurement Test

27.1 The measured input current of a neon supply shall not exceed the rated input current by more than 5%. The measured maximum input current is the input current measured when a neon supply is connected to a rated voltage and frequency supply with the output connected to the neon tubing load specified by the footage chart in Table 26.1.

27.2 A neon supply marked with a power factor rating shall operate under normal operating conditions with a measured power factor of not less than the marked value.

27.3 A neon supply marked to indicate that the product has a high power factor, or is power factor corrected, shall operate under normal operating conditions with a measured power factor of not less than 0.90.

27.4 With regard to the requirement in 27.2, the power factor is to be determined from the ratio of the measured input in watts and in volt-amperes under the conditions described in 27.1.

28 Isolated Output Determination Test

28.1 To determine compliance with 23.5, a neon supply is to have any protective circuitry that prevents the supply from operating without an output load connected to it disabled. The neon supply is to be connected to a source of supply adjusted to rated input with no load connected to the output. While energized, the current from each output lead or terminal to ground is to be measured. The maximum current shall not exceed 2 mArms.

29 Output Measurement Tests

29.1 Maximum output voltage

29.1.1 The maximum output voltage of a neon supply, when tested under the conditions specified in 29.1.3– 29.1.5, shall not exceed:

a) The rated output voltage by more than 10%;

b) The maximum output voltages in Tables 29.1 or 29.2; and

c) 8250 Vac (11,700 Vpeak), without capacitance, from a terminal or lead to ground.

Table 29.1
Maximum open-circuit output voltage for a mid-point neon supply

Neon supply output rating, V	Maximum output peak voltage, open-circuit without capacitance, V	Maximum output peak voltage with capacitive load only, V
5,000 or less	7,800	9,000
5,001 – 10,000	15,600	18,400
10,001 – 15,000	23,300	29,000

Table 29.2
Maximum open-circuit output voltage for an end-point return neon supply

Neon supply output rating, V	Maximum output peak voltage, open-circuit without capacitance, V	Maximum output peak voltage with capacitive load only, V
2,500 or less	3,900	4,300
2,501 – 5,000	7,800	9,000
5,001 – 7,500	11,700	14,000

29.1.2 When the output winding of a neon supply has a tap, the open-circuit rms output voltage of a section of the winding shall not be more than 115% of the rated value for that section, when the open-circuit output voltage of the entire output winding is not more than 110% of the rated voltage for the entire winding.

29.1.3 To determine compliance with 29.1.1 and 29.1.2, a neon supply is to be connected to the rated input. The branch-circuit ground is to be connected to the grounding means on the neon supply when required to be provided. The output is not to be connected to a load (open-circuit). The output from lead to lead, and from each lead to ground is to be measured. A neon supply that does not provide the full output voltage under open-circuit conditions, shall be tested as follows:

a) The circuitry responsible for limiting or interrupting the output voltage under open circuit operating conditions is to be defeated unless it limits the output voltage within 500 ms, and complies with 42.1.2.

b) The maximum output voltage for a neon supply with circuitry responsible for limiting or interrupting the output voltage under open-circuit operating conditions, that does limit the output voltage within 500 ms, and complies with the circuit reliability requirements specified in the Secondary Ground-Fault Protection Circuit Abnormal Tests, Section 42, shall be measured with the neon tubing load that produces the highest output voltage without causing the circuitry to limit or interrupt the output.

29.1.4 The output voltage for a neon supply is to be measured with a capacitance connected to the output. For a ground-referenced neon supply, the capacitance is to be applied from one output lead or terminal to ground, and then the other output lead or terminal to ground without defeating any voltage-limiting circuitry provided in the neon supply. For an isolated output neon supply, the capacitance is to be connected across the open-circuit output leads or terminals. The range of the capacitance is to be 5 – 300 pF. The maximum output voltage is to be measured as the capacitance is varied from 5 – 300 pF. The maximum output voltage shall not exceed the voltage limits specified in 29.1.1.

29.1.5 During this test any adjustable control provided on the neon supply shall be adjusted through its operating range to obtain the maximum output voltage.

29.1.6 A neon supply, when operated with the neon footage in accordance with Table 26.1, shall not have a voltage exceeding 30 Vrms between the return terminal or lead and earth ground during normal operation.

29.2 Maximum output current measurement

29.2.1 Maximum output current available from a neon supply shall not exceed 110% of the marked output current rating when operated under the conditions specified in 29.2.2 – 29.2.3.

29.2.2 To determine compliance of a neon supply with the requirement in 29.2.1, the neon supply is to be connected to the rated input voltage and frequency, and the maximum output current is to be measured for conditions (a) – (c) as specified below, at the point in each circuit as specified in 29.2.3 while connected to the following loads:

a) Short-circuit;

b) Neon tubing as specified in 26.3 and 26.4 in lengths that result in the neon supply operating at 25, 50, 75, and 100% of maximum rated load as specified in the Neon Tubing Length Chart, Table 26.1; and

c) Neon tubing as specified in 26.3 and 26.4 in the same lengths as in (b), except with capacitance connected first in parallel and then separately from each output to ground. The range of the capacitance is to be 5 – 300 pF. The maximum output current is to be measured as the capacitance is varied from 5 – 300 pF.

Exception: The output current of a neon supply with an output frequency of 100 Hz or less is not required to have its output current measured with the capacitance.

29.2.3 To comply with 29.2.2, the maximum output current shall be measured at the point in each circuit for conditions 29.2.2 (a) – (c), as specified below:

a) Short-circuit test condition – The current passing through the shorting conductor.

b) Neon tubing load condition – The current reaching the first electrode of the neon tubing load just before the electrode.

c) Neon tubing with capacitance load condition – The current reaching the first electrode of the neon tubing load just before the electrode and after any capacitance added to the circuit.

29.2.4 When provided, a user adjustable control shall be varied throughout its operating range while obtaining maximum current measurements.

29.2.5 To comply with Exception Nos. 1 and 4 to 23.1, the maximum output current to ground shall be measured while any terminal or lead is connected to ground as specified below:

a) Short-circuit to ground test condition– The current passing through a shorting conductor connected between any output terminal or lead to ground and

b) Maximum current to ground test condition – The current passing through a conductor connected to a variable resistance adjusted to produce the maximum current to ground.

30 Temperature Test

30.1 A neon supply is to be connected to operate under each of the following conditions:

a) Normal operating load using the neon tubing specified in 26.3 – 26.5with or without capacitance as specified in 30.2;

Exception: A neon supply having an output frequency of 100 Hz or less is not required to have the temperature test conducted with capacitance.

b) No load or open-circuit operation; and

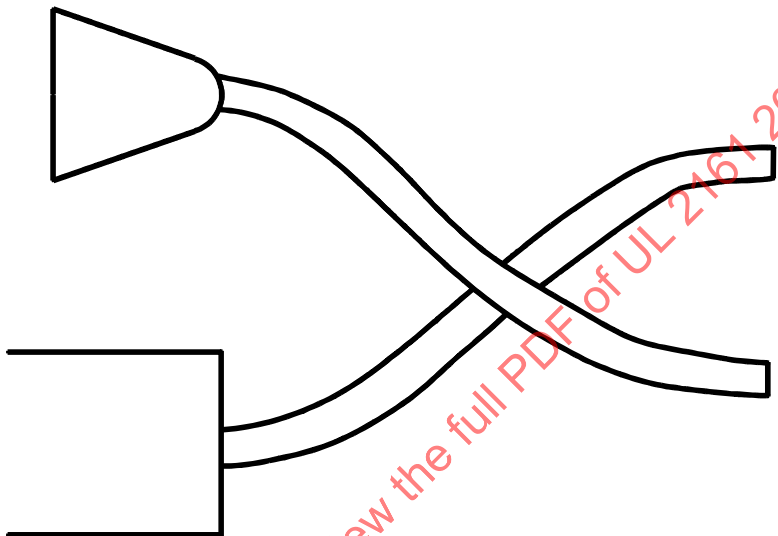
c) Any condition of dimming, flashing, or scripting, or a similar condition provided as an integral feature of the neon supply.

30.2 The load for 30.1(a) is to be the highest measured output current with or without a capacitance load added. The capacitance is to be connected first in parallel and then separately from each output to ground. The range of the capacitance is to be 5 – 300 pF. The maximum steady state output current is to be measured at the output before the capacitive load as the capacitance is varied from 5 – 300 pF.

30.3 For all load conditions where leads are required, GTO cables intended for the voltages involved shall be used in lengths that are short and still functional.

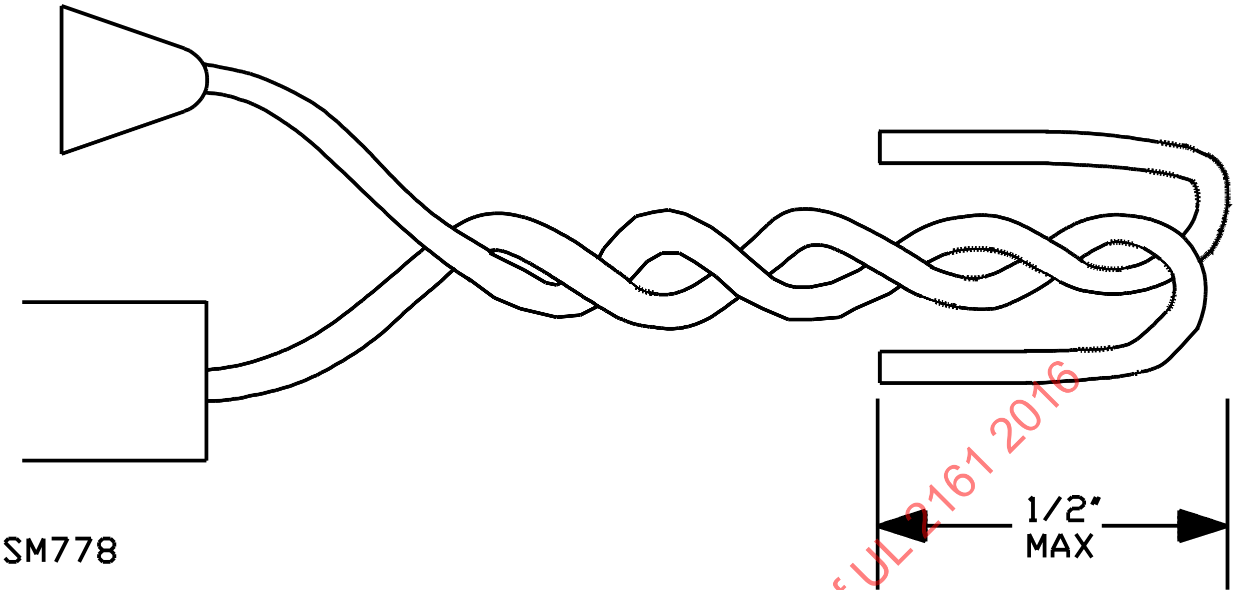
30.4 All GTO splice connections shall be by twisting in accordance with Figure 30.1 and enclosed in a two-piece double back boot of the appropriate size.

Figure 30.1
Twisted leads
Option 1
Step 1



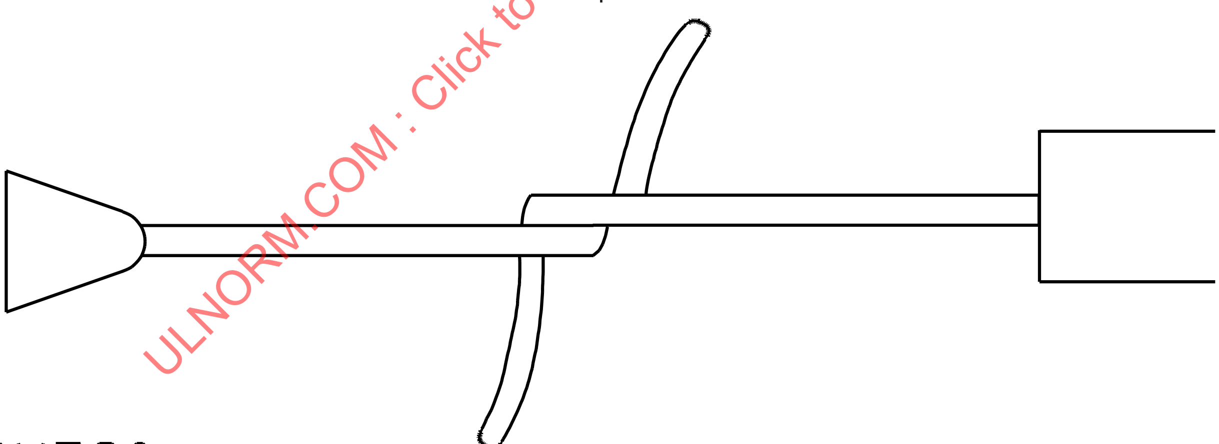
SM801

Step 2



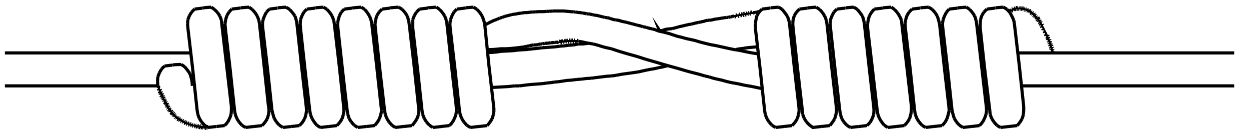
SM778

Figure 30.1 (Cont'd)
Option 2
Step 1



SM780

Step 2

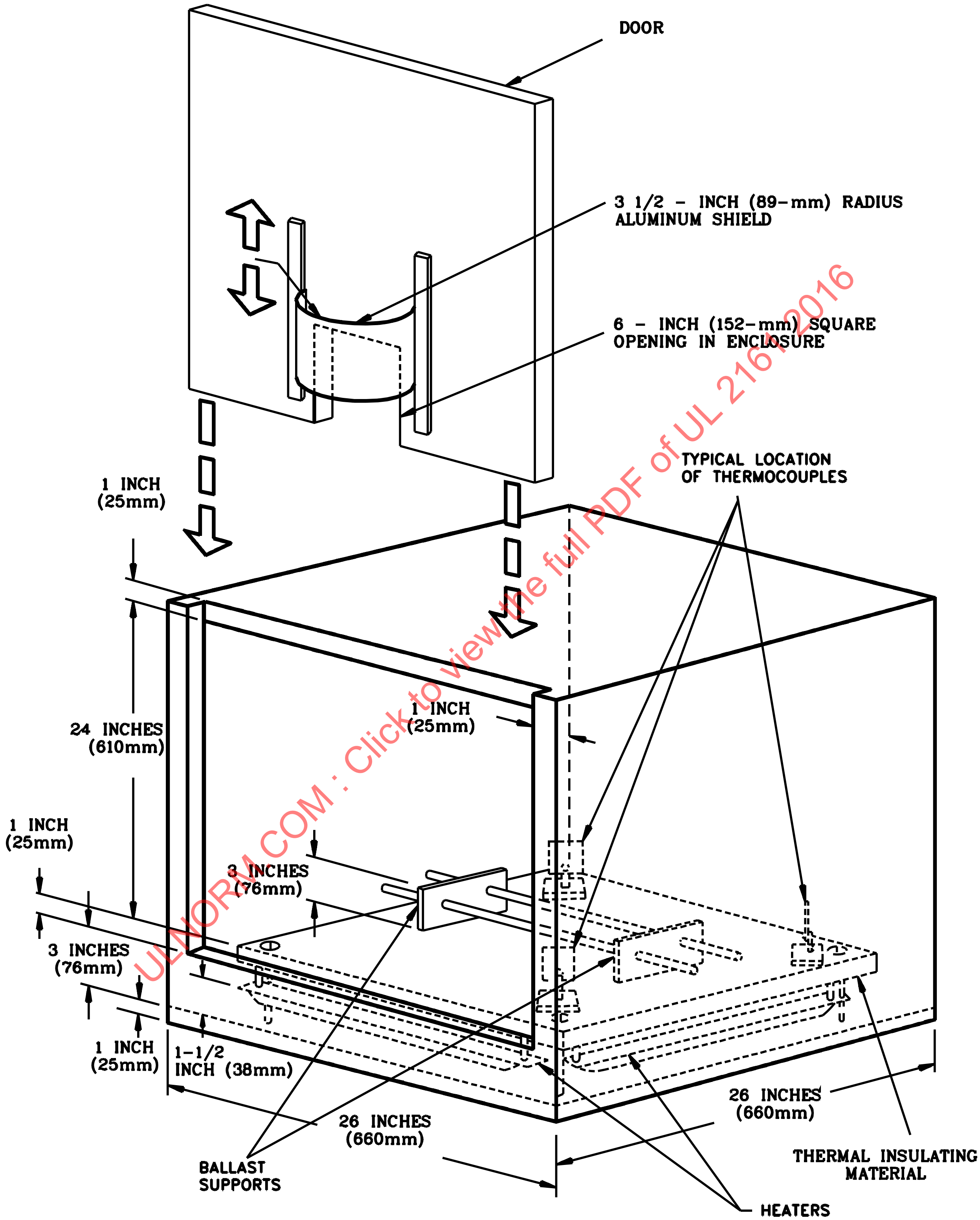


SM800

30.5 The neon supply is to be operated in an ambient environment of 40 ±5°C (104 ±9°F) in the test oven specified in 30.5 – 30.7.

30.6 During the test, the neon supply is to be supported as described in 30.9 and as illustrated in Figure 30.2. The floor between the heaters and the neon supply 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 in (610 by 610 mm). The floor of the test compartment is to be 22 by 22 in (559 by 559 mm), with an air space of 1 in (25.4 mm) all around the floor for circulation of the heated air. A 3-in (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 is not prohibited from being removable, and is to be constructed so that it is capable of being securely fastened to the remainder of the enclosure. One of the sides is to have a 6-in (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 is through this opening. The opening is to be covered by an aluminum shield positioned so that it extends 1/2 in (12.7 mm) beyond the perimeter of the opening.

Figure 30.2
Test enclosure



SB1778

30.7 The heat source used for the test enclosure described in 30.5 is to consist of four 300-W, 230-V, strip heaters having heating surface dimensions of 1-1/2 by 12 in (38 by 305 mm). The elements are to be connected in parallel to a 120-V supply source. The elements are to be mounted in the 3-in (76.2-mm) deep heater compartment located 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 in (63.5 mm) from the adjacent inside wall of the compartment. The elements are to be controlled by a thermostat.

30.8 In lieu of the oven construction described in 30.5 and 30.6, the oven is to 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. 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).

30.9 Prior to the test, the neon supply not energized is to be placed in the test enclosure until all parts reach the temperature of the heated air.

30.10 The neon supply is to be in its normal operating position, supported 3 in (76.2 mm) above the floor of the test enclosure by two 3-in wooden cleats, and is to be centrally located with respect to the sides of the enclosure. Electrical connections are not prohibited from being brought out of the enclosure through the 6-in (152-mm) square opening specified in 30.5. During the test, the enclosure is to be located so that the shielded opening is not exposed to drafts or rapid air currents.

30.11 During the temperature test, with the neon supply operating under the load conditions specified in Table 26.1, and no load conditions, the operating temperatures shall not exceed the temperatures in Tables 30.1 and 30.2.

Table 30.1
Maximum temperature rises

Materials and components		°C	(°F)
1.	On any point of the enclosure of a neon supply	50	(90)
2.	Field-wiring conductors or any surface that is contacted by field-wiring	20[a]	(36[a])
3.	Field-wiring terminals	35	(63)
4.	Class 105 (A) coil insulation systems of a relay, a solenoid, or similar part:		
	Thermocouple method	55[b]	(99[b])
	Resistance method	65[c]	(117[c])
5.	Class 130 (B) coil insulation systems of a relay, a solenoid, or similar part:		
	Thermocouple method	70[b]	(126[b])
	Resistance method	80[c]	(144[c])
6.	Class 105 (A) transformer insulation systems:		
	Thermocouple method	55[b]	(99[b])
	Resistance method	65[c]	(117[c])
7.	Class 130 (B) transformer insulation systems:		
	Thermocouple method	70[b]	(126[b])
	Resistance method	80[c]	(144[c])
8.	Class 155 (F) transformer insulation systems:		
	Thermocouple method	95[b]	(171[b])
	Resistance method	100[c]	(180[c])
9.	Class 180 (H) transformer insulation systems:		
	Thermocouple method	110[b]	(198[b])
	Resistance method	120[c]	(216[c])
10.	Electrode splice enclosure (boot)	65[c,d]	(117[c,d])

Table 30.1 Continued on Next Page

Table 30.1 Continued

	Materials and components	°C	(°F)
11.	GTO cable insulation	65[c,d]	(117[c,d])
12.	Varnished-cloth insulation	45	(81)
13	Fiber used as electrical insulation	50	(90)
14.	Thermoset electrical insulation (phenolic, urea, and similar materials)	110[d]	(198[d])
15.	Wood or other combustible material	50	(90)
16.	Wire insulation or insulating tubing/sleeving	20[e]	(36[e])
17.	Fuses:		
	Class G, J, L, T, or CC	85	(153)
	Tube, ferrule, or blade	70	(126)
	Other	50[f]	(90[f])
18.	Capacitors:		
	Electrolytic	25[g]	(45[g])
	Other than electrolytic	50[g]	(90[g])
19.	Sealing or potting compound	h	(h)
20.	Power switching semiconductor devices	i	(i)

[a] The maximum temperature rise for wire rated 75°C (167°F) is 35°C (63°F), and for wire rated 90°C (194°F) the temperature rise is 50°C (90°F).

[b] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple is not prohibited from being 5°C (9°F) higher than that specified, when the temperature rise of the coil as measured by the resistance method is not more than that specified.

[c] See 30.12 for test guidelines.

[d] These limitations do not apply to a material that has been investigated and rated for a higher temperature.

[e] The maximum temperature rise is the temperature rating of the material minus 40°C (104°F) (ambient temperature).

[f] A fuse investigated and determined to be capable of being used at a higher temperature is not prohibited from being used at that temperature.

[g] The limitation does not apply to a capacitor that is marked for a higher temperature rating.

[h] Unless a thermosetting compound, the maximum sealing compound temperature, when corrected to a 40°C (104°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined in accordance with the Test of Softening Point by the Ball-and-Ring Apparatus, ASTM E28.

[i] The maximum temperature rise on the case is the maximum case temperature for the applied power dissipation specified by the manufacturer minus an assumed ambient of 40°C (104°F).

Table 30.2
Case temperature code

Maximum case temperature,[a] °C	(°F)	Marking code
50	(122)	2161HX
60	(140)	2161KX
75	(167)	2161MH
90	(194)	2161WX

[a] The maximum case temperature on any point of the enclosure of a neon supply, as measured during the Temperature Test in 30.1– 30.7. All temperature limit values are based on an assumed ambient temperature of 40°C (104°F).

30.12 Coil and winding temperatures of a neon supply are to be measured by thermocouples located on exposed surfaces, except that the resistance method specified in 30.13 is to be used for a coil that is inaccessible for attaching thermocouples, such as a coil immersed in sealing compound, wrapped with thermal insulation, or wrapped with more than two layers of insulating material totaling more than 1/32-in (0.8-mm) thick.

30.13 The temperature rise of a winding is determined by the resistance method according to the following formula:

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

in which:

Δt is the temperature rise of the winding in °C;

R is the resistance of the coil at the end of the test in Ω;

r is the resistance of the coil at the beginning of the test in Ω;

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined;

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

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

30.14 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). When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of 30 AWG iron and constantan or copper and constantan wire, and a potentiometer type instrument. Such equipment is to be used whenever reference temperature measurements by thermocouples are required. The thermocouples and related instruments are to be accurate and calibrated. The thermocouple wire is to comply with 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.

30.15 A temperature measured by the thermocouple method is determined to be constant when three successive readings taken at intervals of 10% of the previously elapsed duration of the test, and not less than 15 min, indicate no further temperature increase.

30.16 Just prior to measuring the thermocouples, the power to the neon supply is to be disconnected from the neon supply.

31 Dielectric Voltage-Withstand Tests

31.1 General

31.1.1 A neon supply shall not provide evidence of dielectric breakdown when subjected to the dielectric voltage-withstand tests specified in 31.1.2 – 31.2.6.

31.1.2 Dielectric voltage-withstand tests are to be conducted using a 500 VA or larger capacity testing transformer. The output voltage of the testing transformer is to be sinusoidal and capable of being varied. The applied potential as specified in 31.2.1, 31.2.2 and 31.2.4, is to be increased from zero until the required test level is reached and is to be held at that level for 1 min. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter. The tests are to be conducted at the rated supply input frequency of the neon supply unless otherwise noted.

31.1.3 A neon supply rated for an ac input shall be subjected to an ac potential, and a neon supply that is rated for a dc input shall be subjected to a dc potential.

31.1.4 When a dielectric test is being conducted between current-carrying parts and an insulating type material (polymeric enclosure, accessibility barrier, and similar parts), the outer surface of the insulating material shall be covered with metal foil and the test shall be conducted between the current-carrying parts and the metal foil.

31.1.5 The sensitivity of the test equipment is to be such that when a 120,000-Ω resistor is connected across the output, the test equipment does not indicate a dielectric breakdown for any voltage less than the specified test voltage, and does indicate dielectric breakdown for any output voltage equal to or greater than the specified test voltage. The calibrating resistor shall be adjusted to have a resistance as close to 120,000 Ω as instrumentation will permit, and not more than 120,000 Ω.

31.2 Primary and secondary circuits

31.2.1 While still warm from the temperature test as specified in the Temperature Test, Section 30, an isolated output neon transformer shall withstand for one minute without breakdown the application of a 60-Hz sinusoidal potential of:

a) 1000 V plus twice the maximum rated primary voltage (line-to-ground) applied between the primary-circuit and dead-metal parts (enclosure, core, and similar parts);

b) 1.25 times the maximum measured secondary potential or rated secondary voltage, whichever is greater, applied between the primary and secondary circuit; and

c) With the grounded end of the primary winding solidly connected to the enclosure, 1.50 times the rated primary voltage (line-to-line) applied across the ends of the primary winding. The test is to be conducted first with one end of the secondary and then the other, in turn connected to the enclosure.

31.2.2 While still warm from the temperature test as specified in the Temperature Test, Section 30, and the outputs open-circuited, a neon transformer with a ground-referenced secondary shall withstand for one minute without breakdown the application of a 60-Hz sinusoidal potential of:

a) 1000 V plus twice the maximum rated primary voltage (line-to-ground) applied between the primary-circuit and dead-metal parts (enclosure, core, and similar parts);

b) 1.50 times the secondary voltage induced by applying 1.5 times the maximum rated primary voltage (line-to-line) across the ends of any primary winding, with the grounded end of the primary solidly connected to the enclosure; and

c) When the neon supply is constructed so that the primary winding and each half of the secondary winding are wound on separate legs of the core, with the magnetic paths in parallel and with secondary ground-fault protection defeated, the test described in (b) is to be repeated with first one secondary terminal and then the other, in turn, connected to the enclosure.

31.2.3 The tests described in 31.2.1(c) and 31.2.2 (b) and (c) are to be conducted at a higher frequency when the exciting current at rated frequency is such as to result in excessive heating of the primary winding.

31.2.4 While still in a heated condition, a neon power supply shall withstand for one minute without breakdown the application of a 60-Hz sinusoidal potential of:

a) 1000 V plus twice the maximum rated input voltage (line-to-ground) applied between the input circuit and dead-metal parts;

b) 1.25 times the maximum measured output voltage (line-to-line) applied between the input and output circuits; and

Exception: The potential is to be applied between the primary and secondary of an output transformer when the power supply complies with 33.2(b).

c) 1.25 times the maximum measured voltage between an output circuit operating at more than 1000 Vrms and dead-metal parts.

Exception: Chassis-connected components are to be disconnected at the chassis. Components connecting the secondary mid-point or end-point to the chassis are permitted to be disconnected at the output mid-point or end-point when the voltage across those components to ground is a maximum 30 Vrms under all conditions including ground faults.

31.2.5 When the current through a capacitor of capacitor-type filter connected across the line, or from line-to-earth ground, is large enough to make it difficult to maintain the required alternating-current test potential, the neon supply is to be tested with a dc test potential of 1.414 times the rms value of the test voltage specified in 31.2.1(a), 31.2.2(a), or 31.2.4(a), between primary-circuits and dead-metal parts.

31.2.6 A neon supply with integral electrode receptacles shall be constructed to withstand without breakdown, for a period of 1 min, the application of a dielectric voltage potential as specified in Table 31.1, between current-carrying parts of the electrode receptacles and the neon supply enclosure with the electrodes of gas-filled tubes in place.

Table 31.1
Electrode receptacle dielectric test potential

Rated output voltage of neon supply, V	Applied test potential, Vrms
1000 – 2500	6,500
2501 – 5000	12,000
5001 – 6000	14,000
6001 – 7500	17,000
7501 – 10,000	22,000
10,001 – 12,000	26,000
12,001 – 15,000	33,000

31.3 Barrier and insulating materials

31.3.1 An insulating material used in accordance with the Exception to 25.1 or Exception No. 2 to 15.1 shall be subjected to a dielectric voltage-withstand potential as specified in 31.3.3 or 31.3.4 in accordance with 31.3.2.

31.3.2 The dielectric voltage-withstand potential for an insulating material shall comply with 31.3.3, when insulating between live parts having a potential difference of 1000 V or less and 31.3.4, when insulating between live parts having a potential difference greater than 1000 V.

31.3.3 An insulating material shall withstand a dielectric voltage-withstand potential of 1000 V plus two times the maximum potential voltage difference between the live parts insulated from each other. The dielectric voltage shall be raised gradually, within 10 s, to the test voltage and the test voltage maintained for one minute. During the test, there is to be no indication of dielectric breakdown.

31.3.4 An insulating material shall withstand a dielectric voltage-withstand potential of 1750 V plus 1.25 times the maximum potential voltage difference between the live parts being insulated from each other. The dielectric voltage is to be raised gradually, within 10 s, to the test voltage and the test voltage maintained for one minute. During the test, there is to be no indication of dielectric breakdown.

31.3.5 A material or a combination of materials and air space when functioning as an accessibility barrier in accordance with 8.8, shall withstand a dielectric voltage-withstand potential of 1750 V plus 1.25 times the maximum potential voltage difference between ground and the live part being insulated from user or service personnel contact. The dielectric voltage is to be raised gradually, within 10 s, to the test voltage and the test voltage maintained for one minute. During the test, there is to be no indication of dielectric breakdown.

32 Leakage Current Test

32.1 A cord-connected neon supply shall not result in a leakage current in excess of 0.50 mA when tested in accordance with 32.2 – 32.6.

Exception: A neon supply that is required to have primary-circuit filtering to comply with the EMC (Electromagnetic Compatibility) regulations of the country or area in which it is intended to be used is to have a leakage current at accessible parts of not more than 5.0 mA when the neon supply complies with the grounding requirements in 16.4.1 – 16.4.3.

32.2 Leakage current refers to all currents, including capacitive-coupled currents, that are conveyed between exposed conductive surfaces and ground.

32.3 All exposed surfaces are to be tested for leakage currents. The leakage currents from the exposed surfaces are to be measured to the grounded supply conductor. When the exposed surfaces are constructed of insulating material, the insulating material shall be covered with a maximum 4 by 8 in (10 by 20 cm) foil wrap, and the leakage current shall be measured from the grounded supply conductor to the foil covered surface.

32.4 The circuit for the leakage current measurement is to be as illustrated in Figure 32.1. The measurement instrument is defined in (a) – (c). The meter that is used for a measurement is only required to indicate the same numerical value for a particular measurement as in the defined instrument. The meter used is not required to have all the attributes of the defined instrument.

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

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

c) Over a frequency range of 0 – 100 kHz, the measurement circuit is to have a frequency response ratio of indicated to actual value of current that is equal to the ratio of the impedance of a 1500-Ω resistor shunted by a 0.15-µF capacitor to 1500 Ω. At an indication of 0.5 or 0.75 mA, the measurement is not to have an error of more than 5% at 60 Hz.

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

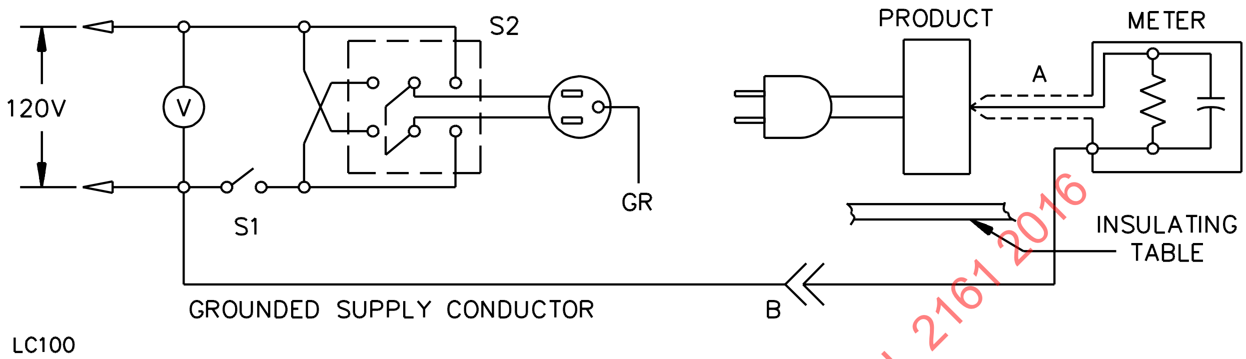
32.6 A sample of the neon supply is to be tested for leakage current starting with the as-received condition. The as-received condition is a sample of the neon supply without prior energization except as part of the production-line testing, with the grounding conductor, when provided, open at the attachment plug. The supply voltage is to be adjusted to the test neon supply maximum rated voltage. The test sequence, with reference to the measuring circuit, Figure 32.1, is to be as follows:

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

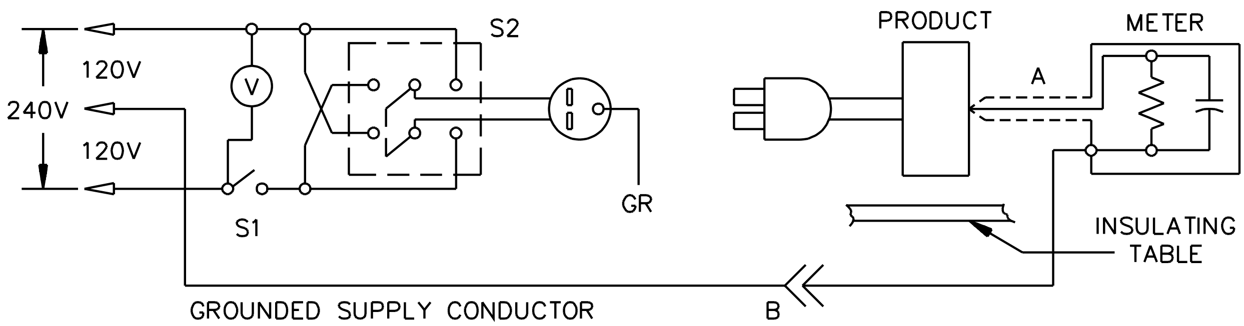
b) Switch S1 is then to be closed, energizing the neon supply, and within 5 s the leakage current is to be measured using both positions of switch S2, and with the neon supply switching devices in all their operating positions.

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

Figure 32.1
Leakage current measurement circuit



Appliance intended for connection to a 120-V power supply.



LC200

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

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of neon supply to another.

33 Input to Output Isolation Test

33.1 The level of output isolation provided at the output transformer of a neon supply shall comply with the dielectric voltage-withstand test in 31.2.2 when the unit is a ground-referenced neon transformer; 31.2.1 when the unit is an isolated output neon transformer; or 31.2.4 when the unit is a neon power supply. The dielectric withstand test potential shall be applied between the input and output of the neon supply. When a neon supply with feedback circuits is determined not to comply with the dielectric withstand test potential applied between the input and output, compliance shall be determined in accordance with 33.2 – 33.4.

33.2 A neon supply with feedback circuits shall:

a) Comply with the dielectric withstand test requirements when the test potential is applied between the primary and secondary of the output transformer while mounted in the neon supply with all circuitry to the transformer disconnected;

b) Not result in a risk of fire or shock while being operated under the test conditions specified in 33.3; and

c) Not be provided with a secondary to primary feedback that is capable of providing more than 0.5 mA leakage current, at a frequency of 60 Hz, to the output under the test conditions specified in 33.4.

33.3 A neon supply is to be connected to a source of supply in accordance with 26.2 under the abnormal test conditions in 37.1.2 with the output open-circuited. The neon supply is to be operated with each capacitor, diode, and other semiconductors electrically located between the input and output (feedback circuits) individually short-circuited.

33.4 A neon supply is to be connected to a source of supply in accordance with 26.2 with the secondary to primary feedback circuitry disconnected where it connects to the output. The leakage current is to be measured from the feedback side of the point where the feedback circuit was previously connected to the output and ground in accordance with the leakage current test procedures specified in Section 32.

34 Grounding Continuity Test

34.1 The impedance within a grounding or bonding circuit shall not exceed the limits specified in 17.1, when tested in accordance with 34.2 and 34.3.

34.2 An alternating or direct current of 30 A from a power supply of not more than 12 V, shall be passed from the point of connection of the equipment-grounding means to a point in the grounding circuit required to be bonded, and the voltage drop between the two points shall be measured.

34.3 The resistance in ohms shall be calculated by dividing the drop in potential (in volts) by the current (in amps).

35 Strain and Push-Back Relief Test

35.1 The power supply cord and each input and output lead, when provided on a neon supply shall withstand for 1 min, without transmitting stress to internal wiring connections, a force applied to the cord and each lead. The amount and direction of force applied shall be in accordance with, 35.3 for each input and output lead provided, and 35.4 and 35.6 for a power supply cord. When polymeric material is provided as part of the strain relief means for a power supply cord and leads, the leads and power supply cord shall additionally comply with 35.2.

35.2 A neon supply that relies on polymeric material for strain relief shall be subjected to Mold Stress-Relief Distortion Conditioning as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, before being subjected to the strain relief tests in 35.3 and 35.4.

35.3 Each field wiring input and output lead or cable provided on a neon supply shall withstand a direct pull of 20 lbs (89 N) or four times the weight of the product, whichever is less, and not less than 4 lbs (17.8 N), following the test method specified in 35.5.

35.4 A power supply cord provided on a neon supply shall withstand a direct pull of 35 lbs (156 N), following the test method specified in 35.5.

35.5 The direct pull specified in 35.3 and 35.4 shall be applied by securing the neon supply in a position that is adjustable and provides for suspending a weight from the power supply cord or lead to be tested. The neon supply shall be positioned in a direction that results in the stress of the suspended weight being applied from any angle the construction of the neon supply permits.

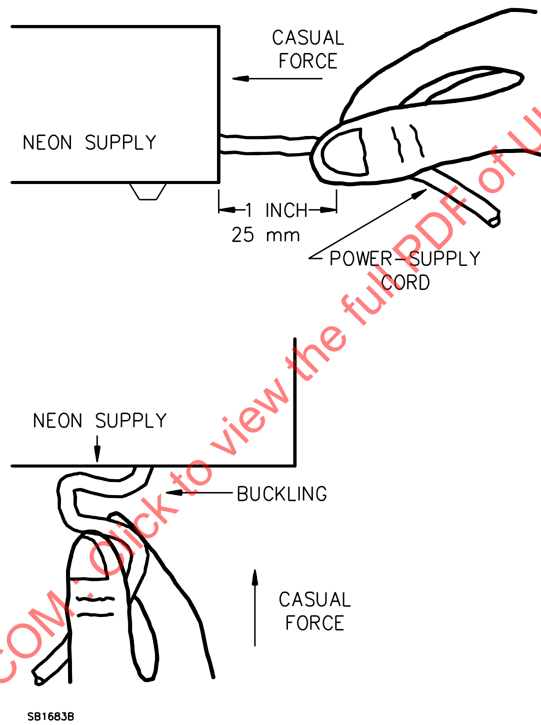
35.6 The power supply cord provided on a neon supply shall be held 1 in (25.4 mm) from the point where the cord emerges from the neon supply. The cord shall then be pushed back, as shown in Figure 35.1, toward where the cord emerges with a force of up to 6 lbf (26.7 N) until the cord buckles. Strain shall not be placed on wiring connections, and the cord shall not:

a) Be subjected to temperatures or voltages above the specified rating;

b) Come in contact with sharp edges or moving parts that can damage the cord insulation; and

c) Displace parts resulting in a reduction of spacings.

Figure 35.1
Supply cord push-back evaluation



36 Switch Loading Tests

36.1 General

36.1.1 A switching type component that opens and closes a circuit with an inductive load shall comply with the Overload and Endurance Tests so as to be in compliance with the requirements in the Exception to 22.1.2.

36.2 Overload

36.2.1 Three samples of each switch, while installed in the neon supply, shall be subjected to an overload consisting of 50 cycles of operation at 10-s intervals opening and closing the input circuit of the neon supply. During the overload, the input is to be connected to a supply circuit of maximum rated input voltage and rated frequency, and the output terminals are to be short-circuited. The enclosure is to be grounded through a 3-A non-time delay fuse.

36.2.2 The results of this test are considered in compliance with this standard when the switches, after the overload test, continue to operate normally; the switch contacts upon visual examination, show no signs of burning, pitting, or other form of damage to the contacts or switching mechanism; and the 3-A fuse does not open during the test.

36.3 Endurance

36.3.1 After the overload test, the same three samples of each switch are to be subjected to an endurance test consisting of 1000 cycles of operation at 1-s intervals, with the input of the neon supply connected to a supply circuit of maximum rated input voltage at rated frequency. The output of the neon supply is to be connected to a neon tubing load adjusted to cause the input to operate at rated current; or the output is to be short-circuited. At the conclusion of 1000 cycles, a dielectric voltage-withstand potential of 1000 V shall be applied for one minute across all live parts and dead-metal parts.

36.3.2 The results of this test are considered to be in compliance when the switches, after the endurance test, continue to operate normally; the switch contacts upon visual examination, show no signs of burning, pitting, or other form of damage to contacts or switching mechanism; and there is no dielectric breakdown between live parts and dead-metal parts.

37 Abnormal Operation Tests

37.1 General

37.1.1 Abnormal operation tests as specified in 37.1.2 – 37.5.1 shall be conducted as described in 37.1.2– 37.1.8, followed by a dielectric voltage-withstand test as described in 31.1– 31.3.5.

37.1.2 During each abnormal test, a neon supply is to be tested on a bench in a 20 – 30°C (68 – 86°F) ambient, unless otherwise stated. The grounding means of the neon supply is to be connected directly to ground through a 3-A fast blow type fuse. The neon supply is to be placed on a softwood surface covered with white tissue paper, and a single layer of cheesecloth is to be draped loosely over the entire enclosure. The cheesecloth used is to be untreated cotton cloth, measuring 14 – 15 yd^2/lb (26 – 28 m^2/kg), and provided with a count of 32 threads in one direction and 28 threads in the other direction for each square inch.

37.1.3 The supply circuit shall be as specified in 26.2.

Exception: When marked for use only with moving vehicles in accordance with 48.4, the neon supply is to be connected to:

a) A 15.5-Vdc supply circuit with a 30-A line fuse, when the neon supply is rated 12 Vdc; or

b) A 31-Vdc supply circuit with a 30-A line fuse, when the neon supply is rated 24 Vdc.

37.1.4 A fuse provided as part of a neon supply that is user accessible is to be shorted out of the circuit.

37.1.5 A user-operated control is to be adjusted to the position representing the most adverse operating condition.

37.1.6 Abnormal operation tests are to be conducted until ultimate results are obtained, or for 7 continuous hours. Examples of ultimate results include the following:

a) Ignition of the neon supply;

b) Electrical breakdown of neon supply;

c) Neon supply becomes permanently inoperable by:

1) Opening of one or more capacitors, diodes, resistors, semiconductor devices, printed-wiring board traces, or similar part or component, when there is no indication of further change;

2) Opening of the intended branch-circuit overcurrent protective device; or

3) Opening of a non-user accessible, non-resettable protective device.

d) The operating temperatures of the neon supply stabilizes, and it is apparent that continued operation for the full 7 h will not effect the test results. Thermal equilibrium is determined to exist only when three successive readings indicate no change when taken at the conclusion of each of three consecutive equal intervals of time, the duration of each interval being whichever of the following is longer:

1) 5 min; or

2) 10% of the total test time elapsed previous to the start of the first interval.

e) Reset protector functions in accordance with 37.1.7; and

f) Any other condition that indicates continued operation will not effect the results of the test.

37.1.7 When an automatically reset protector functions during tests, the test is to be continued for 7 h. When a manual reset protector functions during a test, it is to be operated for 10 cycles using the minimum resetting time, at a rate not faster than 10 cycles of operation per minute. The protector shall be operative upon completion of the test.

Exception: When the manual reset protector is a circuit breaker that complies with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, it is to be operated for 3 cycles using the minimum resetting time at a rate not faster than 10 cycles of operation per minute.

37.1.8 A risk of fire or electric shock is determined to exist when any of the following occurs:

a) Flame or molten metal is emitted from the enclosure of the equipment as evidenced by ignition, glowing, or charring of the cheesecloth or tissue paper;

b) A breakdown results from the dielectric voltage-withstand test;

c) Live parts are made accessible;

d) The 3-A non-time-delay ground fuse opens; or

e) The secondary ground-fault protection circuitry becomes disabled and the neon supply is capable of delivering an output greater than the rated input voltage and an output current of greater than 0.5 mA.

37.2 Output open-circuit

37.2.1 There shall not be damage of insulation of a neon supply following continuous operation in an output open-circuit condition at maximum rated primary voltage and rated frequency until ultimate results are obtained or 7 h.

37.3 Abnormal component short- and open-circuit

37.3.1 The failure of any component in the input and output circuits, excluding secondary ground-fault protection circuits, that results in risk of fire or electric shock, shall be subjected to a short-circuit test between any two terminals, or to an open-circuit test at any single connection, during any condition of operation. Only one short-circuit or open-circuit test is to be conducted at a time.

37.3.2 The component specified in 37.3.1 includes an electrolytic capacitor, a diode, a solid-state device, or any other component not previously investigated and determined to be rated for the application.

Exception: An electromagnetic and radio-frequency-interference capacitor, a resistor, a transformer, an inductor, or an optical isolator, is not required to be subjected to this test.

37.3.3 One test of each open- or short-circuit component condition, using untested components for each test, shall be conducted.

37.3.4 The test for each component shall be conducted until ultimate results are obtained, or until the test has run for 7 h, as described in 37.1.8.

37.4 Output short-circuit abnormal temperature test

37.4.1 A neon supply shall operate at not more than 15°C (27°F) above the temperature limits specified in Table 30.1 when operated in a 40 ±5°C (104 ±9°F) ambient with the output leads or terminals shorted together. When the neon supply does not operate with the output leads or terminals shorted together, the maximum load under the load condition described in 29.2.2(b) (minimum length of tubing the neon supply operates) is to be placed across the output for this test.

37.5 Output shorted-to-ground abnormal test

37.5.1 A neon supply shall comply with 37.1.8 when operated as specified in 37.1.2 – 37.1.5 and in a 40 ±5°C (104 ±9°F) ambient with each output lead or terminal individually shorted to ground. The test shall be conducted until ultimate results are obtained as specified in 37.1.6.

Exception: This test is not required on neon supplies provided with secondary ground-fault protection in accordance with the Secondary Ground-Fault Parameters Test, Section 41.

38 Printed-Wiring Board Tests

38.1 Abnormal trace-to-trace short-circuit

38.1.1 To comply with Exception No. 4 to 24.1, a printed-wiring board shall be tested as described in 38.1.2 – 38.1.5.

38.1.2 Operation of an overcurrent protective device other than the branch-circuit overcurrent protective device is not prohibited from occurring during this test.

38.1.3 A sample of the neon supply employing a printed-wiring board is to be connected to its nominal rated supply circuit. A foil trace is to be short-circuited to each adjacent trace not spaced from the foil trace as specified in Table 24.1 or 24.2 or 24.3, one at a time.

38.1.4 During this test, when a printed-wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results are obtained. This procedure applies to each occurrence. When the circuit is interrupted by the opening of a component other than as described in 37.3.2, the test is to be repeated two more times using untested components as required.

38.1.5 The test is to be continued for 1 hour or until one of the conditions described in 37.1.6 or 37.1.7 occurs. However, when at the end of 1 hour no condition described in 37.1.7 occurs, and indications are that such a condition is to eventually occur, the test is to be continued until ultimate results are obtained or until the test has been run for 7 h.

38.2 Conformal coating

38.2.1 For a conformal coating specified in Table 24.4, the coating shall be at least 1/64-in (0.4-mm) thick and shall comply with:

a) The requirements in 38.2.2 and 38.2.3; and

b) The requirements for use as an insulating material.

Exception: A conformal-coating material that complies with the conformal-coating requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is not required to comply with Spacings, Section 24, 38.2.2, and 38.2.3.

38.2.2 Three samples of a printed-wiring board without electrical components installed, and coated with a conformal coating, shall be subjected to 2500-Vac dielectric voltage-withstand potential applied between the conductors, followed in turn by:

a) 168 h of a heating-cooling cycle, with each cycle to consist of 4 h in an air-circulating oven at a temperature of 105°C (221°F), followed by 4 h at 25°C (77°F);

b) 168 h of oven conditioning at 100°C (212°F);

c) 168 h of humidity conditioning at 85 ±5% relative humidity and 65 ±2°C (149 ±4°F); and

d) A repeated dielectric voltage-withstand test at 2500 Vac.

Samples used for this test are to be equipped with leads already attached so that the test voltage is capable of being applied without disturbing the conformal coating. There shall not be dielectric breakdown between conductors and there shall not be peeling of the coating material due to the conditioning.

38.2.3 In addition, three samples of a printed-wiring board without electrical components installed, and coated with a conformal coating, shall be subjected for 48 h to an atmosphere having a relative humidity of 88 ±2% and maintained at a temperature of 32 ±2°C (90 ±4°F). The humidity conditioning shall be followed by the application of a 2500-V dielectric voltage-withstand potential between conductors while the sample remains in the humidity-conditioning atmosphere. There shall be no indication of a dielectric breakdown and there shall not be peeling of the coating material due to the conditioning.

39 Mechanical Tests

39.1 Polymeric mounting means load

39.1.1 Where the mounting means for a wall-mounted neon supply that is intended for permanent connection to a source of supply and the mounting means for all cord-connected neon supplies rely on thermoplastic for support, the means and thermoplastic shall withstand the static load test referenced in 39.1.2 without permanent deformation, breakage, or cracking, when mounted as specified in the manufacturer's installation instructions.

39.1.2 The mounting means of a unit shall support a static load, while in a 70°C (158°F) air-circulating oven, of four times the load intended to be supported by the mounting means and not less than 20 lbs (9.1 kg) for 12 h:

a) Applied through the center of gravity of the unit in the downward direction or

b) Applied evenly over the horizontal plane of the unit.

39.2 Knockout

39.2.1 In accordance with 9.6, a knockout shall be subjected to the test described in 39.2.2.

39.2.2 A force of 10 lbs (4.5 kg) is to be applied to a knockout for 1 min by means of a 1/4-in (6.4-mm) diameter mandrel with a flat end. The force is to be applied in a direction perpendicular to the plane of the knockout and at the point that results in movement. The knockout shall remain in place and the clearance between the knockout and the opening shall not be more than the maximum open hole size specified in 9.5 and Table 9.1, when measured 1 h after removal of the force.

40 Wire-Binding Screw Terminal Tests

40.1 Solid-wire tightening

40.1.1 Application of the normal clamping action of a wire-binding screw and stud-and-nut type terminal as specified in Exception No. 2 to 14.2.3 and 16.2.4 – 16.2.8, shall not impair the integrity of the joint.

40.1.2 To determine that normal clamping action as intended does not impair the integrity of a connection, the binding member is to be tightened on a solid wire to the torque of 16 in·lbf (1.8 N·m), without causing:

a) The wire to be forced from the connector or

b) Damage to any part of the terminal block.

The wire is to be of the maximum and minimum sizes intended to be connected to the terminal block and is to be formed into a three-quarter loop of a size that is capable of being accommodated by the assembly.

40.2 Performance verification of terminal assemblies on a terminal block

40.2.1 Following the test described in 40.2.2, the conductor ends shall not be cut off or damaged in any way that prevents their further use, and no damage shall have occurred to the terminal assemblies, the terminal block, or the mounting means.

40.2.2 For this test, a terminal assembly is to be supplied for both the maximum rated and the minimum cross section conductors. The terminal block is to be mounted using its normal mounting means. A conductor of the maximum rated cross section is to be inserted in the terminal assembly and a conductor of the minimum cross section of the connector capacity (when specified) in another terminal assembly, and the clamping screws tightened to 18-in·lbf (2-N·m) torque. The clamping screws are then to be unscrewed and new conductors inserted, and the screws tightened as previously specified. The test is to be repeated five times using the same clamping units and five new conductors for each terminal.

41 Secondary Ground-Fault Parameters Test

41.1 A neon supply, required to be provided with secondary ground-fault protection in accordance with 23.1, shall be subjected to the test specified as follows:

a) For a ground-referenced mid-point neon supply, the test procedure in 41.6 is required;

b) For a ground-referenced end-point return neon supply, the test procedure in 41.7 is required;

c) For an isolated output mid-point neon supply, the test procedure in 41.8 is required; and

d) For an isolated output end-point return neon supply, the test procedure in 41.9 is required.

41.2 A neon supply intended to comply with the Exception to 23.2, relating to a circuit that will permit a limited output when the equipment grounding means is not connected, shall have a measured output voltage of no greater than the supply voltage and an output current no greater than 0.5 mA when subjected to the test conditions specified in 41.3 – 41.5.

41.3 A neon supply is to be connected to a supply source adjusted to the rated input voltage and then connected to each of the following loads when tested in accordance with 41.4 and 41.5:

a) Rated output neon tubing load and

b) With no output load.

41.4 With the neon supply operating under the conditions specified in 41.3 (a) and (b), and with the equipment grounding conductor not connected to the neon supply, the output current and voltage are to be measured.

41.5 With the neon supply operating under the conditions specified in 41.3 (a) and (b), and with the equipment grounding conductor connected to the neon supply, the equipment grounding conductor is to be disconnected and the output current and voltage are to be measured.

41.6 A ground-referenced, mid-point neon supply is to be connected to a test circuit as shown in Figure 41.1. At the start of the test, the variable non-inductive type resistors, V_{R1} and V_{R2}, are to be set at infinite resistance and the switches SW1, SW2, and SW3 are to be set in accordance with Test Condition B of Table 41.1. The test is to be conducted as follows:

a) The neon supply is to be connected to rated input voltage and the output is to be connected to a red neon tubing load;

b) The test load, L_1– L_4, is to be adjusted until the output voltage measured across each half of the load, is equal to 1/4 the maximum rms output voltage, ±10% as measured in accordance with 29.1.3 without capacitance.

c) When a user or service adjustable control is provided, that is capable of affecting the trip current or time, the control is to be adjusted to produce the highest trip current and the longest trip time.

d) During the test conditions specified below, the time required for the secondary ground-fault protection circuit to trip after reaching 15 mA shall be measured. Also, the rms output voltage and the current after the secondary ground-fault protection circuit trips, shall be measured. During all steps of testing, the secondary ground-fault protection circuit shall be resettable in accordance with 23.10.

Step 1 – Energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. Record the resistance of V_{R1} at which the secondary ground-fault protection circuit trips. For this result, adjust V_{R1} to one half of the resistance that was required to cause the secondary ground-fault protection circuit to trip, de-energize the neon supply and go to Step 2.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply and go to Step 3.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 2 – With V_{R1} set to one half of the resistance required to cause the secondary ground-fault protection circuit to trip in Step 1, energize the primary of the neon supply until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply and go to Step 3.

b) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 3 – Energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R2} to infinity, de-energize the neon supply and go to Step 4.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R2} to infinity, de-energize the neon supply and go to Step 4.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 4 – Change the test load from red neon tubing to a length of mercury/argon tubing in accordance with 41.6(b). Energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply and go to Step 5.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply and go to Step 5.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 5 – Energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R2} to infinity, de-energize the neon supply and go to Step 6.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, when in Steps 1, 3, and 4, the secondary ground-fault protection circuit did not trip and the fault current did not exceed 15 mA, refer to 29.2.2 – 29.2.5 and Exception No. 4 to 23.1. When in any of Steps 1, 3, or 4, the secondary ground-fault protection circuit did trip, increase the resistance of V_{R2} to infinity, de-energize the neon supply and go to Step 6.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 6 – Determine between Steps 4 and 5, which step resulted in the secondary ground-fault protection circuit taking longer to trip upon reaching 15 mA of fault current. If the ground-fault current for either step did not reach 15 mA, use the step that resulted in the higher current. Repeat this step, Step 4 or 5 with the switches SW1, SW2, and SW3 set in the positions specified in Test Conditions A and C – H, in Table 41.1.

Exception No. 1: Do not conduct test with switch SW1 open when the neon supply complies with the Exception to 23.2, and 41.2 – 41.5.

Exception No. 2: Switch SW2 is not to be provided when no return terminal or lead is provided.

Exception No. 3: A neon supply having an output frequency of 100 Hz or greater is only required to be tested with either a red neon tubing or mercury/argon tubing load adjusted as specified in 41.6(b) for applicable 41.6(d) test steps.

Figure 41.1
Secondary ground-fault test circuit for ground-referenced, mid-point neon supplies

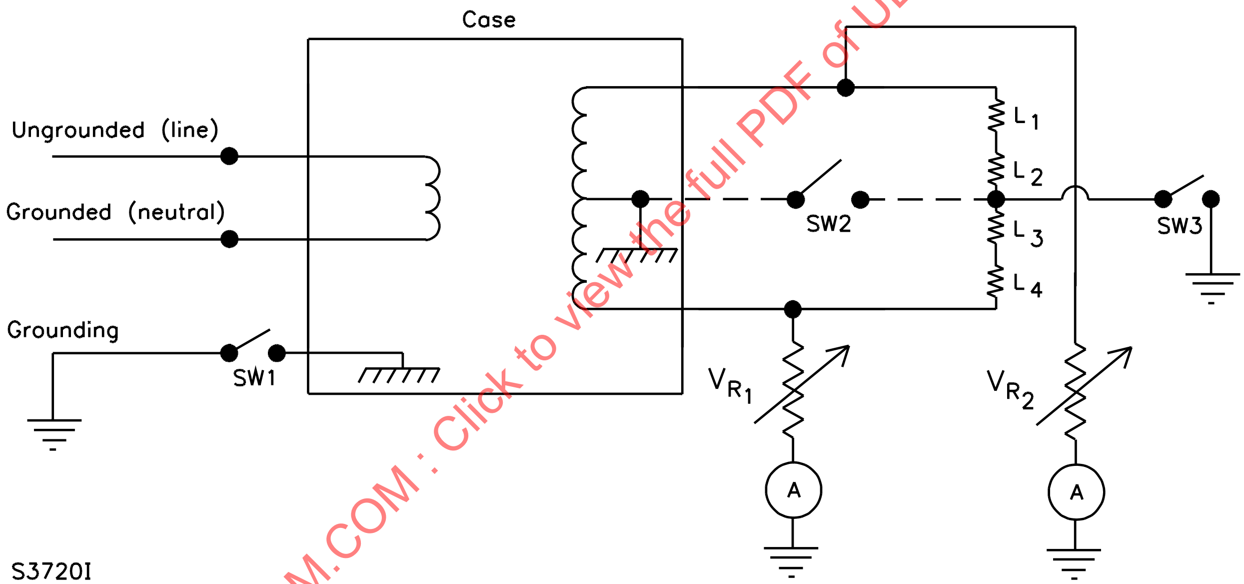


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Table 41.1
Test switch positions

Test condition	SW1[a]	SW2[b]	SW3
A	Closed	Closed	Closed
B	Closed	Closed	Open
C	Closed	Open	Open
D	Closed	Open	Closed

Table 41.1 Continued on Next Page

Table 41.1 Continued

Test condition	SW1[a]	SW2[b]	SW3
E	Open	Open	Closed
F	Open	Closed	Open
G	Open	Closed	Closed
H	Open	Open	Open

[a] Testing with switch SW1 open is to be omitted when the neon supply complies with the Exception to 23.2, and 41.2 – 41.5.

[b] Switch SW2 is to be omitted when a mid-point neon supply does not have a return terminal or lead in accordance with the Exception to 23.3.

41.7 A ground-referenced, end-point return neon supply, is to be connected to a test circuit as shown in Figure 41.2. At the start of the test, locate the ground-referenced output terminal or lead, and connect the variable, non-inductive type resistor, V_{R1}, to the output that is not ground referenced. V_{R1} is to be set at infinite resistance and switches SW1, SW2, and SW3 are to be set in accordance with the Test Condition B in Table 41.1. The test is to be conducted as follows:

a) The neon supply is to be connected to rated input voltage and the output connected to a red neon tubing load;

b) The test load L_1– L_3 shall be adjusted until the output voltage measured across the load is equal to 1/2 the maximum rms output voltage, ±10%, as measured in accordance with 29.1.3 without capacitance.

c) When a user or service adjustable control is provided, that is capable of affecting the trip current or time, the control is to be adjusted to produce the highest trip current and the longest trip time.

d) During the test conditions specified below, the time required for the secondary ground-fault protection circuit to trip after reaching 15 mA shall be measured. Also, the rms output voltage and the current after the secondary ground-fault protection circuit trips, shall be measured. During all steps of testing, the secondary ground-fault protection circuit shall be resettable in accordance with 23.10.

Step 1 – Energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. Record the resistance of V_{R1} at which the secondary ground-fault protection circuit trips. For this result, adjust V_{R1} to one half of the resistance that was required to cause the secondary ground-fault protection circuit to trip, de-energize the neon supply and go to Step 2.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} to infinity and go to Step 3.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 2 – With V_{R1} set to one half of the resistance required to cause the secondary ground-fault protection circuit to trip in Step 1, energize the primary of the neon supply until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply, and go to Step 3.

b) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 3 – Change the test load from red neon tubing to a length of mercury/argon tubing in accordance with 41.7(b). Energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} to infinity, de-energize the neon supply, and go to Step 4.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, when in Step 1, the secondary ground-fault protection circuit did not trip and the fault current did not exceed 15 mA, refer to 29.2.2 – 29.2.5, and Exception No. 4 to 23.1. When in Step 1, the secondary ground-fault protection circuit did trip, increase the resistance of V_{R1} to infinity, de-energize the neon supply, and go to Step 4.

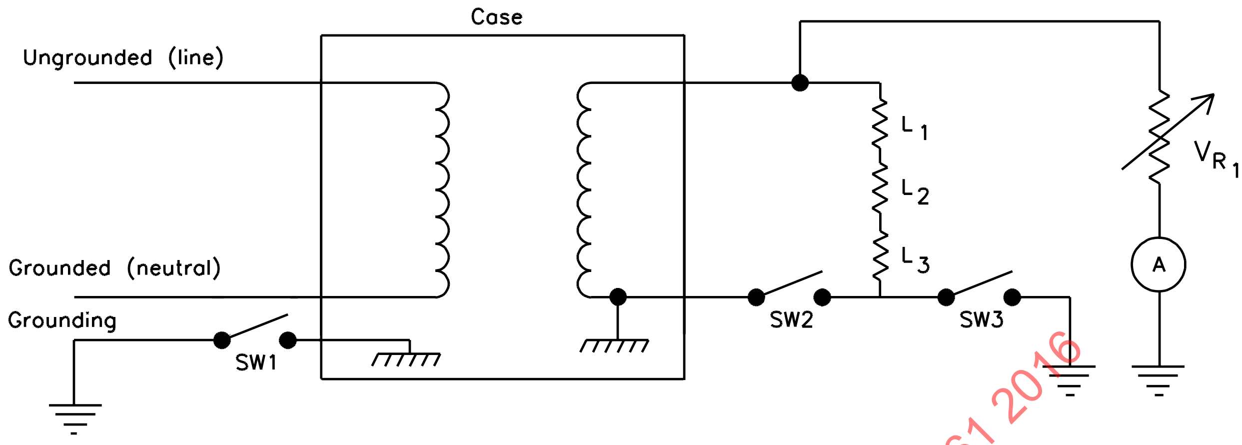
c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 4 – The test conditions in Step 3 above are to be repeated with the switches SW1 – SW3 set in the positions specified in Test Conditions A, and C – H, in Table 41.1.

Exception No. 1: Do not test with SW1 open when the neon supply complies with the Exception to 23.2, and 41.2 – 41.5.

Exception No. 2: A neon supply having an output frequency of 100 Hz or greater is only required to be tested with either a red neon tubing or mercury/argon tubing load adjusted as specified in 41.7(b) for applicable test steps in 41.7(d).

Figure 41.2
Secondary ground-fault test circuit for ground-referenced, end-point return neon supplies



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41.8 An isolated output mid-point neon supply, having an output of greater than 7500 V between any combination of terminals or leads, is to be connected to a test circuit as shown in Figure 41.3. At the start of the test, the variable non-inductive type resistors, V_{R1} and V_{R2}, are to be set at infinite resistance and the switches SW1– SW3 are to be set in accordance with Test Condition B in Table 41.1. The test is to be conducted as follows:

a) The neon supply is to be connected to rated input voltage and the output is to be connected to a red neon tubing load;

b) The test load L_1–L_4 is to be adjusted until the output voltage ±10%, measured across each half of the load, is equal to 1/4 the maximum rms output voltage as measured in accordance with 29.1.3 without capacitance.

c) When a user or service adjustable control is provided, that is capable of affecting the trip current or time, the control is to be adjusted to produce the highest trip current and the longest trip time.

d) During the test conditions specified below, the time required for the secondary ground-fault protection circuit to trip after reaching 15 mA shall be measured. Also, the rms output voltage and the current after the secondary ground-fault protection circuit trips, shall be measured. During all steps of testing, the secondary ground-fault protection circuit shall be resettable in accordance with 23.10.

Step 1 – Set the resistance of V_{R1} to zero ohms.

Step 2 – Energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. Record the resistance of V_{R2} at which the secondary ground-fault protection trips. For this result, adjust V_{R2} to one half of the resistance that was required to cause the secondary ground-fault protection circuit to trip, de-energize the neon supply, and go to Step 3.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 4.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 3 – With V_{R1} set to zero ohms and V_{R2} set to one half of the resistance required to cause the secondary ground-fault protection circuit to trip in Step 2, energize the primary of the neon supply until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 4.

b) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 4 – Set V_{R2} to zero ohms, energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 5.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 5.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 5 – Change the test load from red neon tubing to a length of mercury/argon tubing in accordance with 41.8(b). With V_{R1} set to zero ohms, energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 6.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 6.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 6 – Set the resistance of V_{R2} to zero ohms, energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 7.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, when in Steps 2, 4, and 5, the secondary ground-fault protection circuit did not trip and the fault current did not exceed 15 mA, refer to 29.2.2 – 29.2.5, and Exception No. 4 to 23.1. When in any of Steps 2, 4, and 5, the secondary ground-fault protection circuit did trip, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 7.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 7 – Determine between Steps 5 and 6 which step resulted in the secondary ground-fault protection circuit taking longer to trip upon reaching 15 mA of fault current. If the ground-fault current for either step did not reach 15 mA, use the step that resulted in the higher current. Repeat this step, 5 or 6, with the switches SW1 – SW3 set in the positions specified in Test Conditions A, and C – H, in Table 41.1.

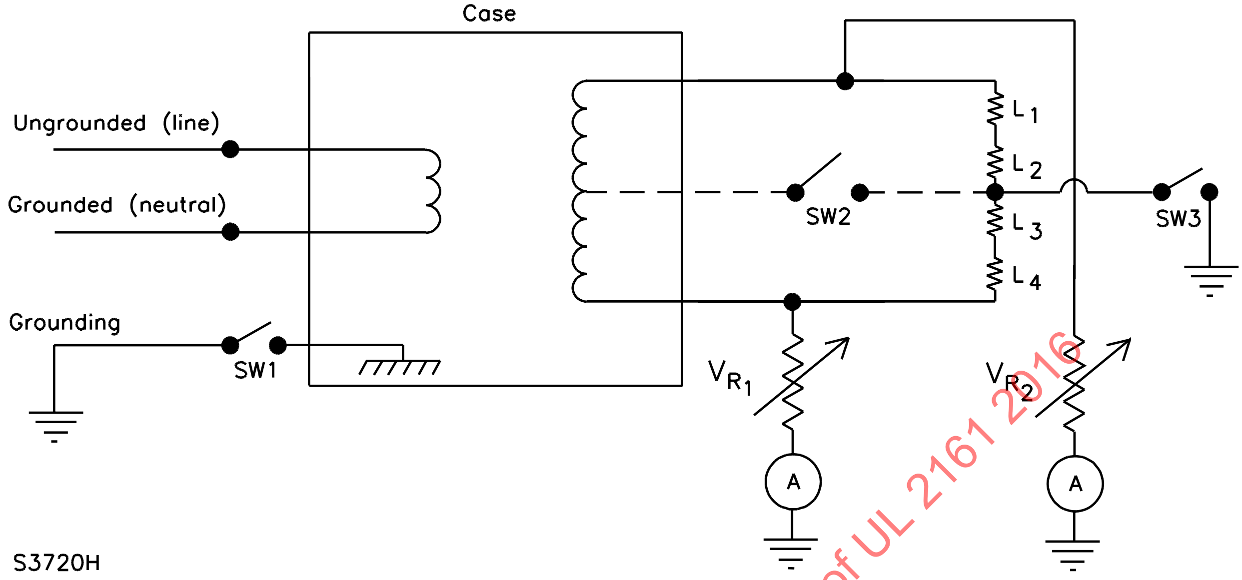
Exception No. 1: Do not test with SW1 open when the neon supply complies with the Exception to 23.2, and 41.2 – 41.5.

Exception No. 2: SW2 is not to be provided when no return terminal or lead is provided.

Exception No. 3: A neon supply having an output frequency of 100 Hz or greater is only required to be tested with either a red neon tubing or mercury/argon tubing load adjusted as specified in 41.8(b) for applicable test steps in 41.8(d).

Figure 41.3

Secondary ground-fault test circuit for isolated output, mid-point neon supplies



41.9 An isolated output end point return neon supply, having an output in excess of 7500 Vrms between any output terminals or leads, is to be connected to a test circuit as shown in Figure 41.4. At the start of the test, the variable non-inductive type resistors, V_{R1} and V_{R2}, are to be set at infinite resistance and switches SW1 – SW3 are to be set in accordance with Test Condition B in Table 41.1. The test is to be conducted as follows:

a) The neon supply is to be connected to rated input voltage and the output connected to a red neon tubing load;

b) The test load, L_1 – L_3, is to be adjusted until the output voltage measured across the load is equal to 1/2 the maximum rms output voltage, ±10%, as measured in accordance with 29.1.3 without capacitance.

c) When a user or service adjustable control is provided, that is capable of affecting the trip current or time, the control shall be adjusted to produce the highest trip current and the longest trip time.

d) During the test conditions specified below, the time required for the secondary ground-fault protection circuit to trip after reaching 15 mA shall be measured. Also, the rms output voltage and the current after the secondary ground-fault protection circuit trips shall be measured. During all steps of testing, the secondary ground-fault protection circuit shall be resettable in accordance with 23.10.

Step 1 – Set the resistance of V_{R1} to zero ohms.

Step 2 – Energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. Record the resistance of V_{R2} at which the secondary ground-fault protection circuit trips. For this result, adjust V_{R2} to one half of the resistance that was required to cause the secondary ground-fault protection circuit to trip, de-energize the neon supply, and go to Step 3.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, and go to Step 4.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the fault current reaching 15 mA. The results do not comply with 23.10(a).

Step 3 – With V_{R1} set to zero ohms and V_{R2} set to one half of the resistance required to cause the secondary ground-fault circuit to trip in Step 2, energize the primary of the neon supply until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 4.

b) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 4 – Set V_{R2} to zero ohms, energize the neon supply and then lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 5.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, and go to Step 5.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 5 – Change the test load from red neon tubing to a length of mercury/argon tubing in accordance with 41.9(b). With V_{R1} set to zero ohms, energize the neon supply and lower the resistance of V_{R2} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 6.

b) The resistance of V_{R2} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 6.

c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 6 – Set the resistance of V_{R2} to zero ohms, energize the neon supply and lower the resistance of V_{R1} until one of the following occurs:

a) The secondary ground-fault protection circuit reduces the output before the fault current reaches 15 mA or within 500 ms after the fault current reaches 15 mA and complies with 23.10. For this result, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 7.

b) The resistance of V_{R1} reaches zero ohms, the output current does not reach 15 mA, and the secondary ground-fault protection circuit does not trip. For this result, when in Steps 2, 4 and 5, the secondary ground-fault protection circuit did not trip and the fault current did not exceed 15 mA, refer to 29.2.2 – 29.2.5, and Exception No. 4 to 23.1. When in any of Steps 2, 4 or 5, the secondary ground-fault protection circuit did trip, increase the resistance of V_{R1} and V_{R2} to infinity, de-energize the neon supply, and go to Step 7.

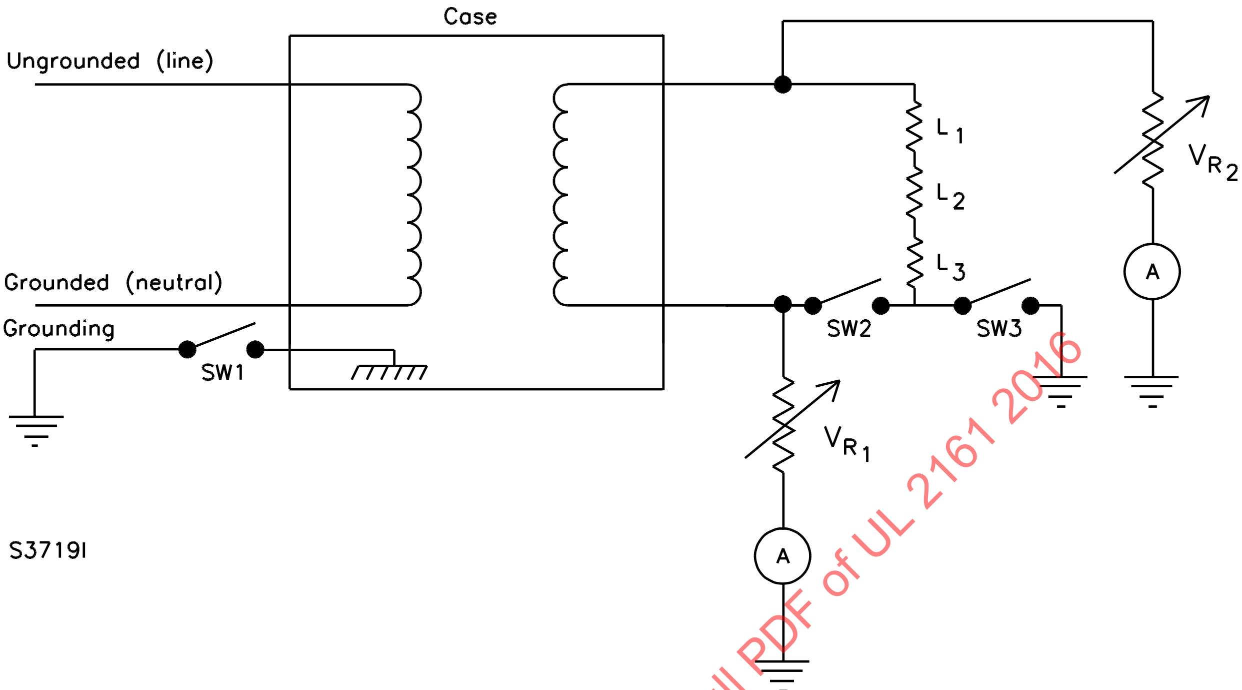
c) The secondary ground-fault protection circuit does not trip within 500 ms of the output reaching 15 mA. The results do not comply with 23.10(a).

Step 7 – Determine between Steps 5 and 6 which step resulted in the secondary ground-fault protection circuit taking longer to trip upon reaching 15 mA of fault current. If the ground-fault current for either step did not reach 15 mA, use the step that resulted in the higher current. Repeat this Step, 5 or 6 with the switches SW1 – SW3 set in the positions specified in Test Conditions A and C – H, in Table 41.1.

Exception No. 1: Do not test with SW1 open when the neon supply complies with the Exception to 23.2, and 41.2 – 41.5.

Exception No. 2: A neon supply having an output frequency of 100 Hz or greater is only required to be tested with either a red neon tubing or mercury/argon tubing load adjusted as specified in 41.9(b) for applicable test steps in 41.9(d).

Figure 41.4
Secondary ground-fault test circuit for isolated output, end-point return neon supplies



42 Secondary Ground-Fault Protection Circuit Abnormal Tests

42.1 General

42.1.1 The secondary ground-fault protection circuit of a neon supply shall comply with the secondary ground-fault parameters test in the Secondary Ground-Fault Parameters Test, Section 41, after being subjected to the conditioning specified in 42.1.3 – 42.7.4.

42.1.2 A neon supply having a circuit feature that limits or shuts off the output as a result of a test condition in this standard shall be made no longer operational unless the circuit is shown to continue to operate fully after being subjected to the abnormal test conditions specified in 42.2.1 – 42.7.4.

42.1.3 During the conditioning specified in 42.1.4 – 42.7.4, a sample of the neon supply is to be placed on a white tissue-paper-covered softwood surface and covered with a single layer of cheesecloth. During and after conditioning, the neon supply shall comply with 42.1.4.

42.1.4 Under the test condition described in the 42.2.1 – 42.7.4, a neon supply with secondary ground-fault protection shall not:

a) Result in ignition, glowing, or charring of cheesecloth or tissue paper (where charring is defined as rendering the cheesecloth or tissue paper to black or white ash);

b) Experience primary or input electrical breakdown as determined by the dielectric voltage-withstand test in 31.1.1 – 31.3.5; or