UL 879

STANDARD FOR SAFETY

Electric Sign Components

UL Standard for Safety for Electric Sign Components, UL 879

Ninth Edition, Dated October 9, 2009

Summary of Topics

This revision of ANSI/UL 879 dated April 22, 2022 includes the following changes in requirements:

– Components for use in LED signs and changing message signs; Table 1.1, 1.3.41.1, Section 2.14.9, 4.18.1.1 – 4.18.1.3, Table 4.4.0, 4.18.2.1 – 4.18.2.3, 4.18.3.1, 4.18.4.1, 4.18.5.1 – 4.18.5.6, 4.18.5.8, 4.18.8.1, 4.18.10.1, 4.18.11.4, Section 4.23, Appendix A

– Reference to generic RTI in UL 746B; 2.1.4.3, Table 2.5, Table 3.9

– Editorial revisions; 2.16.2, 3.2.2.1.3.2, Appendix B

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 18, 2021 and April 6, 2022.

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UL 879

Standard for Electric Sign Components

The first through seventh editions were titled Electrode Receptacles for Gas-Tube Signs.

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Ninth Edition

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This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through April 22, 2022.

The most recent designation of ANSI/UL 879 as an American National Standard (ANSI) occurred on April 22, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

NOTE – The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection there with. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from UL.

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APPENDIX B

1 General

1.1 Scope

1.1.1 These requirements cover components for use in signs and outline lighting systems intended for installation in accordance with the National Electrical Code, NFPA 70. Components covered by this standard include the types specified in 1.1.2, including electromechanical components that convey a message or outline the structural features of a building by electronically directing or rechanneling available light from other sources and involving all forms of illumination such as:

a) Fluorescent lighting,

b) High intensity discharge (HID) lighting,

c) Neon lighting,

d) Cold cathode lighting,

e) Light emitting diodes (LED), and

f) Electroluminescent lighting.

1.1.2 Examples of components intended to be covered by this standard include:

a) Materials used in signs and outline lighting such as structural panels, sign face materials, switch enclosures, sign frames, electrical enclosures, accessibility barriers, trim caps, water shields, coatings and lubricants, components related to material installation and the like.

b) Electrical components relating to illumination circuits operating at 1000 V and above such as electrode receptacles, lampholders, neon electrode enclosures, GTO sleeving, integrally sleeved GTO cable, GTO cable splice enclosures and insulating devices.

c) Electromechanical and electronic equipment for use in signs such as LED units, LED power sources, sign flashers, animating equipment, scrolling units, and sign rotating equipment.

1.1.3 This standard does not cover components covered by another standard, unless there are additional considerations that need to be addressed when the component is for use in signs and outline lighting.

1.1.4 These requirements do not cover:

a) Christmas tree and other decorative lighting devices

b) Exit lighting and luminaires and low level path marking and lighting systems

c) Fluorescent ballasts

d) Fluorescent lampholders

e) Incandescent luminaires

f) GTO cable

g) High intensity discharge ballasts

h) HID lighting luminaires

i) Incandescent lampholders

j) Incandescent lighting

k) Luminaires of any kind

l) Low voltage landscape lighting systems

m) Low voltage lighting fixtures for use in recreational vehicles

n) Low voltage marine lighting

o) Marine navigational lights

p) Marine type fixtures

q) Neon transformers and power supplies

r) Portable electric displays

s) Portable handlamps

t) Portable lamps and cabinet lamps

u) Portable luminaires

v) Portable sun/heat lamps

w) Stage and studio luminaires

x) Self-ballasted fluorescent lamps

y) Temporary lighting strings

z) Track lighting fixtures

1.2 Component identification requirements

1.2.1 All components shall be evaluated for factory installation only as specified in 1.2.2 and 1.2.3 or evaluated for factory and field installation as specified in 1.2.4 and 1.2.5.

1.2.2 A factory installed component is intended for use only under limited conditions, such as temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been investigated. Components currently identified as intended for factory installation only are identified in Table 1.1.

Table 1.1
Factory installed sign components

Electrode receptacles other than through wall housing type
Feed type lampholders over 1000 V – without conduit connection means
Interconnecting lampholders over 1000 V
Metallic electrode receptacle enclosure
Neon electrode enclosure
Glass cup receptacles
Conduit plug assembly
GTO cable sleeving
GTO cable with integral sleeving
GTO cable splice enclosure
Neon tube support
Sign face material – not enclosure rated
Enclosure sign face materials
Sign face tensioning systems
Structural materials
Dimmers, flashers, controllers and animators
LED display units
Electroluminescent displays
Switch enclosures
Sign rotating equipment
Clock mechanisms
Lubricant
LCD displays

1.2.3 Components for factory installation only as identified in Table 1.1 shall comply with the requirements in Sections 2 – 4.

1.2.4 A field and factory installed component shall be intended and suitable for use in field assembled skeletal neon signs and outline lighting installations in accordance with the National Electrical Code, NFPA 70. These components shall be of a construction that does not place unique limits on the use of the components such that they cannot be installed in accordance with the requirements of NFPA 70. Components currently identified as intended for use in field assembled skeletal neon signs and outline lighting are identified in Table 1.2.

1.2.5 Components for field and factory installation, as identified in Table 1.2, shall comply with the requirements in Sections 2 – 5 including maximum voltage rating, type of location, minimum temperature rating, and all other applicable requirements.

Table 1.2
Field installed and factory installed components

Field and factory installed components
Through wall electrode receptacles
Through wall housing receptacle grounding means
Lampholder systems over 1000 V
Electrode receptacle enclosure
Neon electrode splice and GTO cable polymeric enclosure systems (boots and sleeves)
Glass cup neon electrode receptacle and GTO cable splice enclosure systems
GTO cable splice enclosure
GTO cable with integral sleeving
GTO cable assemblies
Neon transformer enclosures
Neon tubing supports, cable supports and cable bushings
Sign dimmers, flashers, controllers and animating equipment

1.3 Glossary

1.3.1 For the purpose of this standard, the following definitions apply. Definitions provided might not be terms used in the standard, but are provided to establish a basis of understanding terms used by the sign industry, component manufacturers and others.

1.3.2 ACCESSIBILITY BARRIER – Material provided to limit access to the following. If all or part of the barrier also serves as an enclosure, see Enclosure, 1.3.22.

a) Uninsulated live parts,

b) Dead metal parts that are at a risk of being energized and are not grounded,

c) Live parts insulated with materials not intended to be subject to user contact, or

d) Moving parts that present a risk of injury.

1.3.3 ACCESSIBLE PART – See definitions for Part, 1.3.54.

1.3.4 ADHESIVE – Bonding material (i.e. epoxy, paste, cement) placed between parts to be fastened together that adheres to each part, and remains the securement medium between the parts.

1.3.5 BARRIER – See Accessibility Barrier 1.3.2, Insulating Barrier 1.3.37, Isolating Barrier 1.3.41, Thermal Barrier 1.3.68, and Water shield 1.3.73.

1.3.6 BLOCK-OUT PAINT – Used to coat a neon tube to block the emission of light from a neon tube. Generally applied over the electrode, it can also be applied at various points along the tube.

1.3.7 BONDING – Permanent joining of metallic parts to form an electrical conductivity path that provides electrical continuity between dead metal parts and the capacity to conduct any fault current which may occur.

1.3.8 BONDING CONDUCTOR – Electrically connects non-current carrying metal parts such as enclosure parts, frame parts and dead metal parts of electrical components to each other and the equipment grounding means.

1.3.9 ENCLOSURE, NEON – See the definition for neon electrode enclosure, 1.3.45.

1.3.10 CLASS 2 CIRCUIT – Wiring, conductors and components connected only to a Class 2 supply source. See Class 2 Supply Source, 1.3.11.

1.3.11 CLASS 2 SUPPLY SOURCE – Electrical source such as a transformer, power supply, or battery having an open-circuit voltage that is less than 30 Vrms. (42.4 V peak) or 60 V DC and having limited energy available in the circuit under load conditions, including short-circuit and extremely low resistance.

1.3.11.1 INHERENTLY LIMITED SUPPLY SOURCE – Transformer, power supply or battery having no discrete protective device that is relied upon to limit the output energy available from the supply. A power supply or battery with internal current and energy limiting circuitry shown to be reliable is eligible to be identified as inherently limited. Transformers, power supplies and batteries may be provided with protective devices as long as they are not relied upon to limit the output energy.

1.3.11.2 INHERENTLY LIMITED SUPPLY SOURCE – Transformer, power supply or battery having a discrete protective device that automatically interrupts the output when the current and energy output reaches a prescribed limit.

1.3.12 COLD-CATHODE TUBING – Neon tubing that is larger than 15 mm (0.6 inch) in diameter and that operates between 120 and 240 mA. Cold-cathode tubing is similar to other forms of neon tubing that do not require heating above ambient temperatures to initiate ionization resulting in the tube producing light.

1.3.13 COLLAR FERRULE – That portion of a neon tube electrode receptacle of a threaded sheet metal form that tightens over the receptacle for purposes of means of mounting the receptacle in place.

1.3.14 CURRENT CARRYING LIVE PART – See Part, 1.3.54.

1.3.15 DOUBLE BACK – A 180 degree return bend made in neon tubing near an electrode.

1.3.16 ELECTRIC DISCHARGE – Method of illumination whereby current is passed through a gas medium. This includes neon, cold cathode, fluorescent, and high-intensity-discharge types of illumination

1.3.17 ELECTRODE – Cold cathode or neon tube assembly consisting of metallic conducting elements. The electrode is joined to both ends of a cold cathode and neon tube.

1.3.18 ELECTRODE RECEPTACLE – A contact device intended to accept electrodes of neon tubing. An individual receptacle may or may not be provided with an integral outer housing of metal or other material.

1.3.19 ELECTRODE RECEPTACLE CAP – Material formed to cover the mouth of an electrode receptacle while permitting a neon tube to enter the mouth. The combination of neon tube and electrode receptacle cap function as a water shield to prevent the entrance of water into the mouth of the electrode receptacle.

1.3.20 ELECTRODE SPLICE ENCLOSURE – Component specifically intended to enclose a splice between a GTO Cable conductor and the leads of a neon tube electrode.

1.3.21 ELEVATION POSTS – See tube support, 1.3.70.

1.3.22 ENCLOSURE – Material provided to enclose electrical parts and components to contain a potential risk of fire. See Accessibility Barrier when an enclosure also serves as an accessibility barrier 1.3.2.

1.3.23 ENCLOSURE RATED SIGN FACE – Sign face that is designated as being suitable to enclose current carrying live parts.

1.3.24 EXPOSED LIVE PART – See part, 1.3.54.

1.3.25 EXTRA LOW VOLTAGE CIRCUIT (ELV) – Circuit with limited voltage and energy that reduces the risk of fire and shock in accordance with the requirements in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1.

1.3.26 FACTORY INSTALLED SIGN COMPONENT – Component intended for use in signs and outline lighting that is installed at the sign manufacturing location. The sign or outline lighting is provided with an enclosure or sign body for the attachment/assembly of the component. Factory assembled signs and outline lighting are determined to comply with the end product requirements at a manufacturing facility.

1.3.27 FIELD AND FACTORY INSTALLED SIGN COMPONENT – Component intended for use in 1) skeletal neon signs and outline lighting installations and 2) factory assembled signs and outline lighting.

1.3.28 FIELD WIRING TERMINAL – Terminal connection expected to be made in the field rather than as part of a manufacturing process.

1.3.29 FLEXIBLE SIGN FACE – Sign face that is not rigid enough to support itself.

1.3.30 GROUNDED CONDUCTOR – Supply circuit conductor intentionally connected to ground at the building supply source. Also known as "common" or "neutral".

1.3.31 EQUIPMENT GROUNDING CONDUCTOR – Conductor provided to bond dead metal of a product to earth ground.

1.3.32 GTO CABLE – Gas tube oil ignition cable. Rated 5 kV, 10 kV, or 15 kV for use between the secondary or output of a neon supply and neon tubing and between segments of neon tubing.

1.3.33 GTO CABLE SPLICE ENCLOSURE – Containment device intended to enclose the splice of two lengths of GTO cable that complies with the enclosure requirements.

1.3.34 GTO SLEEVING – A component specifically identified for use over GTO cable.

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

1.3.36 HAZARDOUS ENERGY LEVEL – Stored energy level of 20 J or more, or an available continuous power level of 240 VA or more, at a potential of 2 V or more.

1.3.37 INSULATING BARRIER – Barrier provided in place of a required electrical spacing and is in direct contact with live parts.

1.3.38 INSULATED LIVE PART – See definitions for Part, 1.3.54.

1.3.39 INTEGRALLY SLEEVED GTO CABLE – GTO cable that conforms to additional construction requirements specified in this standard.

1.3.40 ISOLATED LIVE PART – See definitions for Part, 1.3.54.

1.3.41 ISOLATING BARRIER – Barrier not in direct contact with live parts which is provided to maintain separation between circuits of opposite polarity or to reduce a required electrical spacing.

1.3.41.1 LED DISPLAY UNIT – An arrangement of discrete LEDs, LED array(s) or LED panel(s) assembled to display data in the form of images in changing message signs. LED display units are not intended to provide general illumination.

1.3.42 LIMITED POWER SOURCE (LPS) – Power supplies identified as “LPS” or where the output is considered limited power, are considered equivalent to power supplies with Class 2 outputs.

1.3.43 LOCATION OF USE DESIGNATION

1.3.43.1 DRY – Designation for a component that has been evaluated for use in an environment where the component is not normally subject to dampness or wetness. Examples include inside an indoor shopping mall, inside a retail store, and other similar places.

1.3.43.2 DAMP – Designation for a component that has been evaluated for use in exterior locations where protected overhead from rain and snow, or interior locations where subject to moderate degrees of moisture, primarily by humidity and condensation. Protection overhead is generally considered to be within an area formed by an imaginary line drawn from the outer edge of the eave, overhang or sign body inward at a 45° angle from vertical. Additionally, the interior of a sign body provided with a sign face and installed in an outdoor exposed location is a damp location. Examples include protected areas such as under a canopy and under a roofed porch.

1.3.43.3 WET – Designation of a component that has been evaluated for use in a location that is subject to precipitation, direct spray or splashing of water or other liquids. Examples include locations used for outdoor channel letters and outline lighting.

1.3.44 LUMINOUS TUBE – See the definition for Neon Tubing 1.3.46.

1.3.45 NEON ELECTRODE ENCLOSURE – Component designed to fit over the end of neon electrode to enclose the splice between the lead of the electrode and GTO cable lead.

1.3.45.1 NEON ENCLOSURE SYSTEM – A system of parts intended to enclose GTO wire, neon tubing electrode, and its connection in a wet location.

1.3.46 NEON TUBING – An industry term for electric-discharge lamps or tubing used in signs and outline lighting, including cold-cathode lamps, regulated by Article 600 of the National Electric Code, NFPA 70.

1.3.47 NEON TUBING CLEAR COAT – Clear coating of a vinyl type material applied over the length of a neon tube to protect other coatings and mechanically strengthen a neon tube.

1.3.48 NEON TUBING LUBRICANT – Compound applied to the end of a neon tube for the purpose of making it easier to slide a close fitting neon electrode enclosure over the end of an electrode.

1.3.49 NEON TUBING TINT – Coating applied to neon tubes to block the emission of one or more light frequencies to change the overall appearance of the light from a neon tube.

1.3.50 OPEN HOLE – 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.

1.3.51 OPENING – 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.

1.3.52 ORDINARY TOOLS – For the purposes of these requirements, ordinary tools are defined as flat blade and Phillips head screwdrivers, nut drivers, and pliers.

1.3.53 OUTDOORS – Identifies a location that could be either outdoor protected (now defined as a damp location), or outdoor exposed (now defined as a wet location). See definitions for Location of Use Designation, 1.3.43, for the definition of current terminology.

1.3.54 PART

1.3.54.1 ACCESSIBLE – An electrical or moving part that is accessible to a user during user servicing.

1.3.54.2 CURRENT CARRYING LIVE – An electrical part such as a wire or lampholder, that carries electrical and qualifies to be considered an insulated live part.

1.3.54.3 EXPOSED LIVE – Electrical or moving part that is accessible to a user during normal use.

1.3.54.4 ISOLATED LIVE – Electrical part that is isolated from ground reference as a result of an electrical component such as a ferromagnetic transformer.

1.3.54.5 INSULATED LIVE – Electrical part that is energized and surrounded by insulation that is suitable for the voltage involved.

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

1.3.56 PRESSURE WIRE TERMINAL – Wiring terminal that secures and makes electrical connection for one or more wires. This is accomplished by means of a tightening device that presses and captures a straight segment of the conductor(s) between conductive surfaces.

1.3.57 RIGID SIGN FACE – Material formed as a sign face that is rigid enough to be self supporting when secured in place and does not require a tensioning system.

1.3.58 SAFETY EXTRA-LOW VOLTAGE (SELV) CIRCUIT – Secondary circuit with limited voltage and energy that reduces the risk of fire and shock in accordance with the requirements in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1.

1.3.59 SIGN BODY – Portion of a sign that provides protection from the weather but is not an electrical enclosure.

1.3.60 SIGN FACE – Part of the overall exterior of a sign intended to convey a message or display an art form and transmits or reflects and internal light source. A sign face may function as a water shield and/or accessibility barrier. A sign face may also be enclosure rated.

1.3.61 SIGN FACE TENSIONING – Clamps, fasteners, and the like provided to secure a flexible sign face material across the sign and maintain tension on the sign face material.

1.3.62 SIGN DESIGNATION

1.3.62.1 FIXED – Intended to be permanently connected to an electrical source of supply.

1.3.62.2 PORTABLE – Meets all of the following:

a) When provided with mounting means, is removable from its intended mounting without the use of tools,

b) weighs 22.7 kg (50 lb) or less,

c) Product of its longest dimension times its weight does not exceed 575 kg-mm (1500 lb-in), and

d) Is connected to an electrical source of supply by a power-supply cord.

1.3.62.3 STATIONARY – Meets all of the following:

a) Intended to be fastened in place or located in a dedicated space (not portable);

b) Removable from its intended mounting with the use of no more than ordinary tools; and

c) Connected to an electrical source of supply by a power supply cord.

1.3.63 SKELETAL NEON SIGNS AND OUTLINE LIGHTING – Neon tubing is itself the sign or outline lighting and the body of the sign or outline lighting is the building or structure onto which the neon tubing is directly installed.

1.3.64 SLEEVING – 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.

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

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

1.3.67 STRAIN RELIEF DEVICE – Knot, bushing, or equivalent intended to prevent strain from being transmitted through that portion of a wire or cord outside a product to the termination point of the wire or cord inside the product.

1.3.68 THERMAL BARRIER – Provided to reduce the transfer of thermal energy from one component to another where maximum temperature considerations are required.

1.3.69 THROUGH WALL ELECTRODE RECEPTACLE – Neon receptacle with integral metal housing, intended for conduit connection of high voltage supply. These may also be referred to as metal enclosed electrode receptacles.

1.3.70 TUBE SUPPORT – Elevation post or standoff used to secure neon tubes in place.

1.3.71 UNGROUNDED CONDUCTOR – Supply conductor that is not connected to the ground system or grounding electrode. Commonly called the "live" or "hot" conductor.

1.3.72 USER SERVICEABLE PART – Component or part intended to be replaced or adjusted by the user of a sign.

1.3.73 WATER SHIELD – Material relied upon to reduce or prevent the entrance of water into a sign or onto current-carrying parts within a sign.

1.3.74 WEATHERPROOF – See wet location 1.3.43.3.

1.3.75 WIRE BINDING SCREW – Screw where the threaded portion acts as a post around which a single wire is to be wrapped.

1.3.76 WIRE – Consists of a metallic conductor provided with insulation along its length, the combination of which define the maximum voltage rating and current carrying abilities.

1.4 Components

1.4.1 Except as indicated in 1.4.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Appendix A for a list of Standards covering components generally used in the products covered by this Standard.

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

a) Involves a feature or characteristics not needed in the application of the component in the product covered by this Standard; or

b) Is superseded by a requirement in this Standard.

1.4.3 A component shall be used in accordance with its rating for the intended use.

1.4.4 Specific components are accepted as being incomplete in construction features, or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as temperatures not exceeding specified limits, and shall be used only under those specific conditions to which they have been investigated.

1.5 Undated references

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

1.6 Units of measurement

1.6.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information. See Appendix B for metric conversion multipliers.

1.6.2 Unless otherwise stated, all voltage and current values mentioned in this Standard are root-mean-square (rms).

2 Construction

2.1 Enclosure

2.1.1 General

2.1.1.1 Except as specified in 2.1.1.2, all insulated and uninsulated current-carrying parts shall be enclosed in metal, glass or polymeric material in accordance with the requirements in 2.1.2 through 2.1.4. Compliance is permitted to be determined in conjunction with other components as specified in 2.1.1.4.

2.1.1.2 Insulated and uninsulated current-carrying parts identified for use when connected to a voltage and power limited circuit are not required to be enclosed. A supply source is considered power limited when it has voltage, current and energy output limitations in accordance with 2.12.6.1.

2.1.1.3 All neon tubing and lamps are to be installed as intended when determining compliance with the enclosure requirements.

2.1.1.4 A component intended for installation in conjunction with another component found to comply with this standard, is permitted to rely on the other component to comply with the enclosure requirements.

2.1.2 Metal enclosures

2.1.2.1 A metal enclosure shall comply with the requirements in 2.1.2.2 through 2.1.2.9 and Table 2.1, Table 2.2 or Table 2.3.

Table 2.1
Thickness of cast-metal enclosures

Material/location	Minimum thickness of cast metal			
	Unreinforced		Reinforced[1)]	
	mm	(in)	mm	(in)
Cast metal	3.2	0.126	2.4	0.094
Cast malleable iron	2.4	0.094	1.6	0.063
At a threaded conduit hole	2.4	0.094	1.6	0.063
At an unthreaded conduit hole	2.0	0.079	1.2	0.047

Notes:

1. Reinforced – When the material is provided with integrally cast angles, channels, ribs, flanges or ridges.

2. Threads and Breakouts – Areas around threads, breakouts, or similar features are permitted to be thinner, providing the strength of structure is not affected, but in case thinner than permitted for the same length of sheet metal.

Table 2.2
Minimum thickness of uncoated and zinc coated steel

Specific construction		Uncoated steel				Zinc coated or galvanized steel			
		Unreinforced		Reinforced		Unreinforced		Reinforced	
		mm	(in)	mm	(in)	mm	(in)	mm	(in)
At opening for conduit connection		0.66	0.026	0.66	0.026	0.74	0.029	0.74	0.029
Length not more than 38 cm (15 in)	No electrical component support	0.41	0.016	0.33	0.013	0.48	0.019	0.41	0.016
	Electrical component support	0.41	0.016	0.41	0.016	0.48	0.019	0.48	0.019
Length more than 38 cm (15 in) and less than 66 cm (26 in)	No electrical component support	0.41	0.016	0.33	0.013	0.48	0.019	0.48	0.019
	Electrical component support	0.51	0.020	0.41	0.016	0.58	0.023	0.48	0.019
Length 66 cm (26 in) and less than 122 cm (48 in)	No electrical component support	0.51	0.020	0.41	0.016	0.58	0.023	0.48	0.019

Table 2.2 Continued on Next Page

Table 2.2 Continued

Specific construction		Uncoated steel				Zinc coated or galvanized steel			
		Unreinforced		Reinforced		Unreinforced		Reinforced	
		mm	(in)	mm	(in)	mm	(in)	mm	(in)
	Electrical component support	0.66	0.026	0.51	0.020	0.74	0.029	0.58	0.023
Length 122 cm (48 in) or more and less than 152.4 cm (60 in)	No electrical component support	0.81	0.032	0.66	0.026	0.84	0.035	0.74	0.029
	Electrical component support	1.07	0.042	0.81	0.032	1.07	0.042	0.81	0.032
Length 152.4 cm (60 in) or more and less than 185.4 cm (73 in)	No electrical component support	1.07	0.042	0.81	0.032	1.07	0.042	0.81	0.032
	Electrical component support	1.35	0.053	1.07	0.042	1.42	0.056	1.14	0.045
Length 185.4 cm (73 in) and more	With or without electrical component support	1.52	0.060	1.35	0.053	1.6	0.063	1.42	0.056

Notes:

1. Length – the longest straight line that can be drawn on any unsupported section of an enclosure. The longest straight line is measured in any direction regardless of the shape of the enclosure section in any direction. The longest straight line for an enclosure section that is frame supported in accordance with 2.1.2.8 and2.1.2.9, is measured in any direction on the enclosure panel between the frame supporting members.

2. Length and frame supported – A section of an enclosure secured to framing members not integral to the enclosure panel in accordance with 2.1.2.8 and 2.1.2.9.

3. Unreinforced – A section of an enclosure as described in 2.1.2.5 or that does not comply with the requirements in 2.1.2.3 and 2.1.2.4 for being a reinforced enclosure section.

4. Reinforced – A section of an enclosure that is provided with curves, ribs, breaks or flanged surfaces in accordance with 2.1.2.3 and 2.1.2.4.

5. No electrical component support – the minimum thickness required when no electrical components are secured to and supported by the enclosure surface.

Table 2.3
Minimum thickness of aluminum, copper or brass enclosures

Specific construction		Copper, brass, aluminum sheet and extruded aluminum			
		Unreinforced		Reinforced	
		mm	(in)	mm	(in)
At opening for conduit connection		0.81	0.032	0.81	0.032
Length not more than 38 cm (15 in)	No electrical component support	0.51	0.020	0.41	0.016
	Electrical component support	0.51	0.020	0.51	0.020
Length more than 38 cm (15 in) and less than 66 cm (26 in)	No electrical component support	0.51	0.020	0.41	0.016
	Electrical component support	0.64	0.025	0.51	0.020
Length 66 cm (26 in) and less than 122 cm (48 in)	No electrical component support	0.56	0.022	0.43	0.017
	Electrical component support	0.71	0.028	0.56	0.022

Table 2.3 Continued on Next Page

Table 2.3 Continued

Specific construction		Copper, brass, aluminum sheet and extruded aluminum			
		Unreinforced		Reinforced	
		mm	(in)	mm	(in)
Length 122 cm (48 in) and less than 152 cm (60 in)	No electrical component support	0.91	0.036	0.71	0.028
	Electrical component support	1.47	0.045	0.91	0.036
Length 152 cm (48 in) and less than 185 cm (73 in)	No electrical component support	1.47	0.045	0.91	0.036
	Electrical component support	1.91	0.075	1.47	0.045
Length 185 cm (73 in) or more	With or without electrical component support	2.41	0.095	1.91	0.075

Notes:

1. Length – the longest straight line that can be drawn on any unsupported section of an enclosure. The longest straight line is measured in any direction regardless of the shape of the enclosure section in any direction. The longest straight line for an enclosure section that is frame supported in accordance with 2.1.2.8 and 2.1.2.9, is measured in any direction on the enclosure panel between the frame supporting members.

Length and frame supported – A section of an enclosure secured to framing members not integral to the enclosure panel in accordance with 2.1.2.8 and 2.1.2.9.

3. Unreinforced – A section of an enclosure as described in 2.1.2.5 or that does not comply with the requirements in 2.1.2.3 and 2.1.2.4 for being a reinforced enclosure section.

4. Reinforced – A section of an enclosure that is provided with curves, ribs, breaks or flanged surfaces in accordance with 2.1.2.3 and 2.1.2.4.

5. No electrical component support – the minimum thickness required when no electrical components are secured to and supported by the enclosure surface.

2.1.2.2 The values for minimum metal thickness in Table 2.1, Table 2.2 and Table 2.3 apply to measurements made before the application of paints, varnishes and organic coatings. The values for the minimum metal thickness also apply to measurements made, for other than zinc coated or galvanized steel, before metallic coatings have been applied.

2.1.2.3 A reinforced construction as indicated in Table 2.1, Table 2.2 and Table 2.3, is an enclosure material provided with integral angles, channels, breaks, ribs, flanges or ridges, that provides a mechanical strength across the span of the material that is equivalent to unreinforced material of the thickness required for the same length.

2.1.2.4 For steel, copper, aluminum, brass or extruded aluminum to be considered as reinforced as specified in Table 2.2 and Table 2.3, the material shall be provided with one of the following reinforcement features. The reinforcement feature shall divide the enclosure into sections such that the longest dimension of all of the resulting sections is one third or less than the longest dimension of the undivided enclosure:

a) Flanges, angles or breaks that are 45° to 120° to the plane of the panel,

b) Ribs and ridges that are at least 3.2 mm (0.126 in) high from the plane of the panel with an internal angle of 45° to 120°,

c) Curves running across the shortest dimension, or

d) Channels having two 90° angles or breaks running in any direction.

2.1.2.5 The following constructions are not considered to be reinforced:

a) A single sheet with a formed edge flange around its perimeter,

b) A single sheet that is ribbed not meeting the angle criteria in 2.1.2.4,

c) A single sheet that is corrugated with the curves running parallel to the long dimension, and

d) A single sheet of sheet metal with reinforcement features, but is secured to a peripheral frame by a means that would allow the material to flex at its center. For example, securement by physical fit into a channel.

2.1.2.6 For a cast metal to be considered as reinforced as specified in Table 2.1, the material must be provided with integrally cast angles, channels, ribs, flanges or ridges.

2.1.2.7 The length dimensions specified in Table 2.1, Table 2.2 and Table 2.3 are measured as the longest straight line that can be drawn across any unsupported section of the material. The longest straight line for an enclosure section is measured in any direction regardless of the shape. The longest straight line for an enclosure section that has a supporting frame in accordance with 2.1.2.8 and 2.1.2.9, is measured in any direction on the enclosure panel between the supporting frame members.

2.1.2.8 A supporting frame is a structure of angle, channel or a rigid folded length of sheet metal that is not an integral part of the enclosure panel and complies with 2.1.2.9. The supporting frame must be rigidly attached to the enclosure material at regular intervals and to other materials to which the enclosure material is secured, and have essentially the same outside dimensions as the enclosure surface.

2.1.2.9 A supporting frame shall consist of:

a) Angle iron or aluminum having a cross sectional dimension of at least 13 by 13 mm (0.5 by 0.5 in) with a material thickness of 8.1 mm (0.266 in);

b) Flat metal bars which are minimum 9.5-mm (0.375-in) wide and 3.2-mm (0.125-in) thick; or

c) An internal metal structure such as a chassis, that is rigidly secured together to form a 3 dimensional structure onto which the enclosure material is secured at regular intervals.

2.1.3 Non-metallic inorganic enclosure

2.1.3.1 A non-metallic inorganic enclosure material, such as glass and ceramic, shall be minimum 2.5-mm (0.1-in) thick.

2.1.3.2 A non-metallic inorganic material that encloses live parts shall also comply with the requirements for an insulating barrier as specified in 2.2.1.

2.1.3.3 A non-metallic inorganic enclosure material shall comply with the Impact Test in 3.3.1.

2.1.3.4 A non-metallic inorganic enclosure material relied upon to house a heat producing component and intended for use in a damp and wet locations shall comply with the Environmental Conditioning Test as specified in 3.3.2.

2.1.3.5 A non-metallic inorganic enclosure material intended for use in wet locations shall comply with the Thermal Shock Test as specified in 3.3.3.

2.1.4 Polymeric enclosures other than neon electrode enclosures or GTO sleeving

2.1.4.1 An enclosure of polymeric material shall comply with the requirements specified in 2.1.4.2 – 2.1.4.7. Polymeric material includes thermoplastic and thermosetting materials and composite type materials bonded together by organic compounds. Thermosetting material is a polymeric material such as phenolic and epoxy that are cast rather than molded.

2.1.4.2 An enclosure material shall comply with the requirements in Table 2.4 and where applicable, additional requirements in Sections 4 and 5 specific component.

Table 2.4
Polymeric enclosure material requirements

Installation Type				Location Designation			Type of Sign Illumination				Flammability			
	Portable													
*P	Table Top	Wall only	Wall and Pendant or Pendant Only	Dry	Damp	Wet	*I	*F	HID	LED	Any V Rating	5 VA Rating	Min. RTI	UV
X				X			X					X	Measured Temperature	
X				X				X				X	Measured Temperature	X
X				X					X			X	Measured Temperature	X
X				X						X		X	Measured Temperature	
X					X		X					X	Measured Temperature +15°C (27°F)	
X					X			X				X	Measured Temperature +15°C (27°F)	X
X					X				X			X	Measured Temperature +15°C (27°F)	X
X					X					X		X	Measured Temperature +15°C (27°F)	
X						X	X					X	Measured Temperature +15°C (27°F)	X
X						X		X				X	Measured Temperature +15°C (27°F)	X
X						X			X			X	Measured Temperature +15°C (27°F)	X

Table 2.4 Continued on Next Page

Table 2.4 Continued

Installation Type				Location Designation			Type of Sign Illumination				Flammability			
	Portable													
*P	Table Top	Wall only	Wall and Pendant or Pendant Only	Dry	Damp	Wet	*I	*F	HID	LED	Any V Rating	5 VA Rating	Min. RTI	UV
X						X				X		X	Measured Temperature +15°C (27°F)	X
	X			X			X				X		Measured Temperature	
	X			X				X			X		Mea-sured Temperature	X
	X			X						X	X		Measured Temperature	
		X			X		X				X		Measured Temperature	
		X			X			X			X		Measured Temperature	X
		X			X					X	X		Measured Temperature	
			X	X	X	X	X	X	X	X	X		Measured Temperature +15°C (27°F)	X

* P – Permanent, I – Incandescent, F – Fluorescent and Neon

Notes:

1. An "X" provided in a column under Installation and Illumination Type in the row of a component, identifies the use of a component.

2. A component designated for a particular type of sign installation is considered a limited component provided with appropriate information identifying the conditions of its limited use. A component that carries no installation type limitation instruction is to comply with the more stringent temperature and flammability requirements.

3. A component designated for use in a permanently installed sign and is designated for use in a damp location is acceptable for installation in a wet location sign subject which is also considered subject to increased ambient conditions from external infrared radiation.

4. A component designated for use in a permanently installed sign and is designated for use in a wet location is considered to include being installed where subject to increased ambient conditions from external infrared radiation.

5. A component designated only for use in a portable sign and is designated for use in a damp location is considered to include being installed in a damp or wet location sign outdoors where subject to increased ambient conditions from external infrared radiation.

6. A component identified for use without regard to a particular type of illumination in a sign shall comply with the most stringent requirements for all types of illumination.

Table 2.4 Continued on Next Page

Table 2.4 Continued

Installation Type				Location Designation			Type of Sign Illumination				Flammability			
	Portable													
*P	Table Top	Wall only	Wall and Pendant or Pendant Only	Dry	Damp	Wet	*I	*F	HID	LED	Any V Rating	5 VA Rating	Min. RTI	UV
7. A component limited to being used in only portable wall type signs in a dry location is considered to be limited to locations where NOT subject to increased ambient conditions from external infrared radiation.														
8. A component designated for use in a portable combination wall and pendant, or pendant only installation type sign, designated for use in a dry location is considered to be subject to installation in windows where increased ambient conditions from external infrared radiation exist.														
9. The minimum Relative Temperature Index (RTI) is the maximum measured temperature determined in accordance with the Normal Temperature Test, 3.4.2.3. Where +15°C (27°F) is specified, the minimum RTI shall be 15°C (27°F) higher than the maximum measured temperature normalized to 25°C (45°F) to represent a higher ambient typical for certain types of signs.														
10. A component with no design limitation or instruction limitation for the type of illumination provided in a sign into which the component may be installed, shall have a polymeric material that is UV rated.														
11. Flammability – All V Type is inclusive of flammability ratings of V-2, V-1, V-0 and 5-VA and B.														
12. UV – Identifies a resistance to ultraviolet radiation rating for materials subject to ultraviolet radiation from the light source and/or external sources.														

2.1.4.3 The minimum temperature rating for a polymeric enclosure material determined in accordance with the standard for Polymeric Materials – Long Term Property Evaluations, UL 746B shall be the highest temperature of either:

a) The Relative Thermal Index Based Upon Historical Record; or

b) The Relative Thermal Index (RTI) with impact Based Upon Long-term Thermal-Aging Programs.

Table 2.5
Relative thermal indices based upon past field-test performance and chemical structure
Table deleted

2.1.4.4 The flammability rating of a polymeric enclosure material shall be determined as specified below:

a) By the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; or

b) By the Self Extinguishing 5VA testing procedure in 3.2.2.1.3, or the Self Extinguishing V-2 testing procedure in 3.2.2.1.2 as appropriate for the minimum flammability rating.

2.1.4.5 A thermoplastic type potting material that fully encapsulates live parts and also functions as an enclosure shall have a minimum flammability rating of V-2.

2.1.4.6 A polymeric enclosure material located within 0.8 mm (0.032 in) of any uninsulated live part or within 13 mm (0.5 in) of any unenclosed mechanical contacts that make and break current, including the brush contacts of motors shall:

a) Have a minimum PLC rating for hot-wire ignition (HWI) of 2, or comply with the Hot-Wire Ignition Test specified in 3.2.2.3 or the Glow-Wire End Product Test in 3.2.2.4, and

b) Have a minimum PLC rating for high-current arc resistance to ignition rating (HAI) of 2, or comply with the High-Current Arc Ignition Test of 3.2.2.5 or the End-Product Arc Resistance Test of 3.2.2.6.

2.1.4.7 A polymeric enclosure material shall have a minimum PLC rating for comparative tracking index (CTI) of 1, or comply with the Comparative Tracking Index Performance Level Index Test specified in 3.2.2.2.

2.2 Insulating barrier

2.2.1 Where a glass material is provided to function as an insulating barrier in direct contact with live parts over 1000 V, shall be of borosilicate glass and have no metal content such as lead or iron.

2.2.2 A polymeric material in direct contact with live parts that functions as an insulating barrier shall:

a) Have a flammability rating of at least HB or comply with the HB Testing Procedure specified in 3.2.2.1.4;

b) Have a temperature rating equal to or greater than its maximum operating temperature in the component;

c) For molded or formed thermoplastic parts, comply with the Mold Stress Relief Distortion Test of 3.4.1.1; and

d) Have a HWI (Hot wire Ignition), HAI (High Ampere Ignition) and CTI (Comparative Tracking Index) PLC values not greater than 2. A thermoset material such as epoxy is not required to have a HWI, HAI or CTI PLC rating.

2.3 Accessibility barrier

2.3.1 The following shall be made inaccessible to contact during normal use and user servicing by a material that complies with 2.3.3 – 2.3.6. Inaccessibility shall be judged in accordance with 2.3.2.

a) All uninsulated current-carrying parts having voltages in excess of 15 Vrms (21.2 Vpeak) in a component identified for use in a damp or wet location;

b) All uninsulated current carrying parts having voltages in excess of 30 Vrms (42.4 Vpeak) in a component identified for use in a dry location;

c) All current carrying parts having insulation less than 0.71-mm (0.028-in) thick and a continuous operating voltage of 600 V or less;

d) All insulated current carrying parts having a continuous operating voltage of greater than 600 V;

e) All splices in wiring having a voltage in excess of 15 Vrms (21.2 Vpeak) in a component identified for use in a damp or wet location and in excess of 30 Vrms (42.4 Vpeak) in a component identified for use in a dry location;

f) Any moving parts that could result in physical injury to a user, such as laceration, puncture or abrasion; and

g) Dead metal parts that are at a risk of being energized and are not grounded.

2.3.2 A part required to be inaccessible in accordance with 2.3.1 shall not be able to be contacted by the articulate probes shown in Figure 2.1 or Figure 2.2. All neon tubing and lamps are to be installed as intended when determining compliance with accessibility requirements. The probe is to be applied to any depth that an opening will permit and with a force not greater than 4.4 N (1 lb). The probe is to be rotated or angled before, during, and after insertion through an opening to any position that is necessary to examine the part. The probe is to be applied in any possible configuration, and, if necessary, the configuration is to be changed after insertion through an opening.

Figure 2.1

Articulate probe with web stop

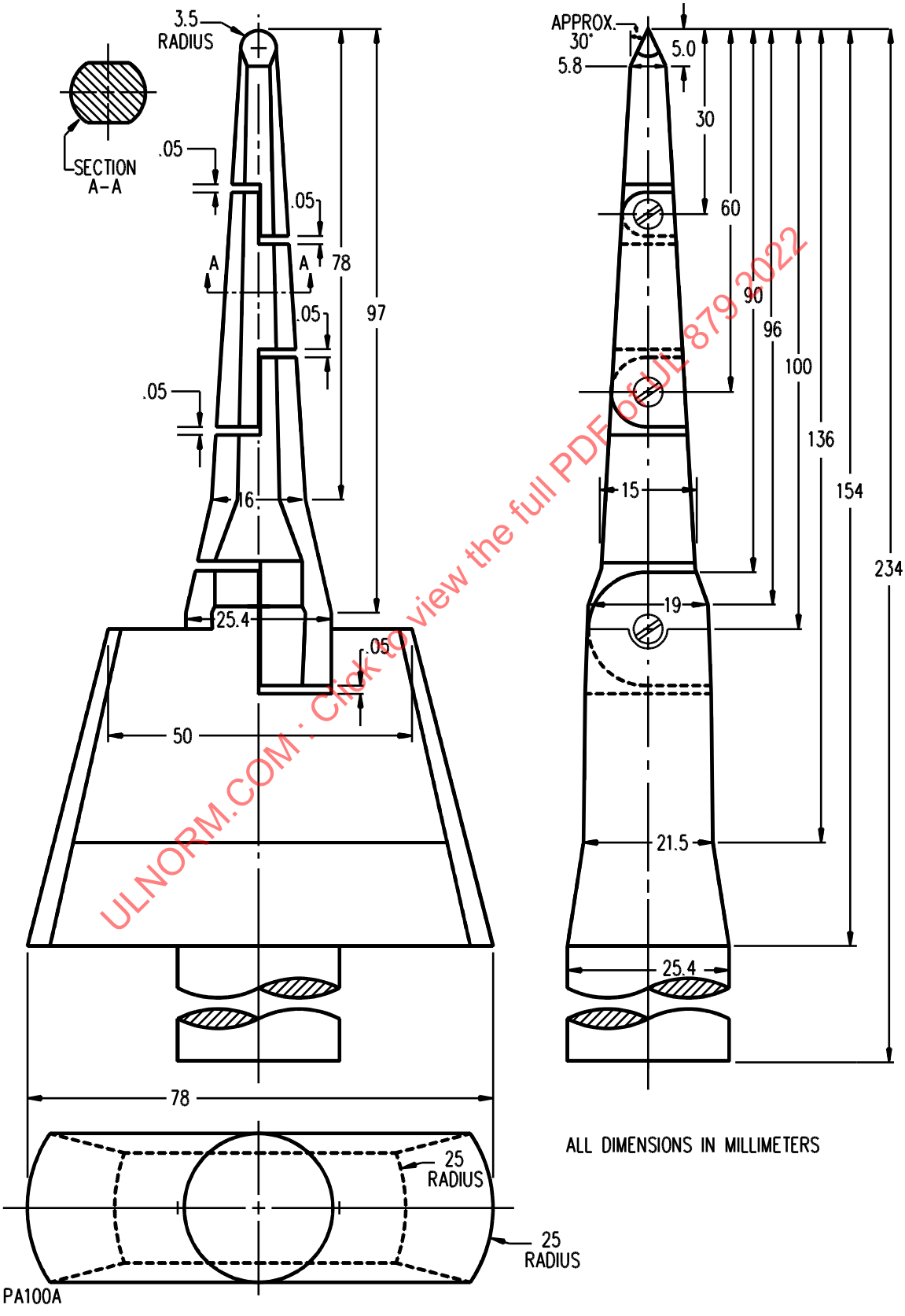
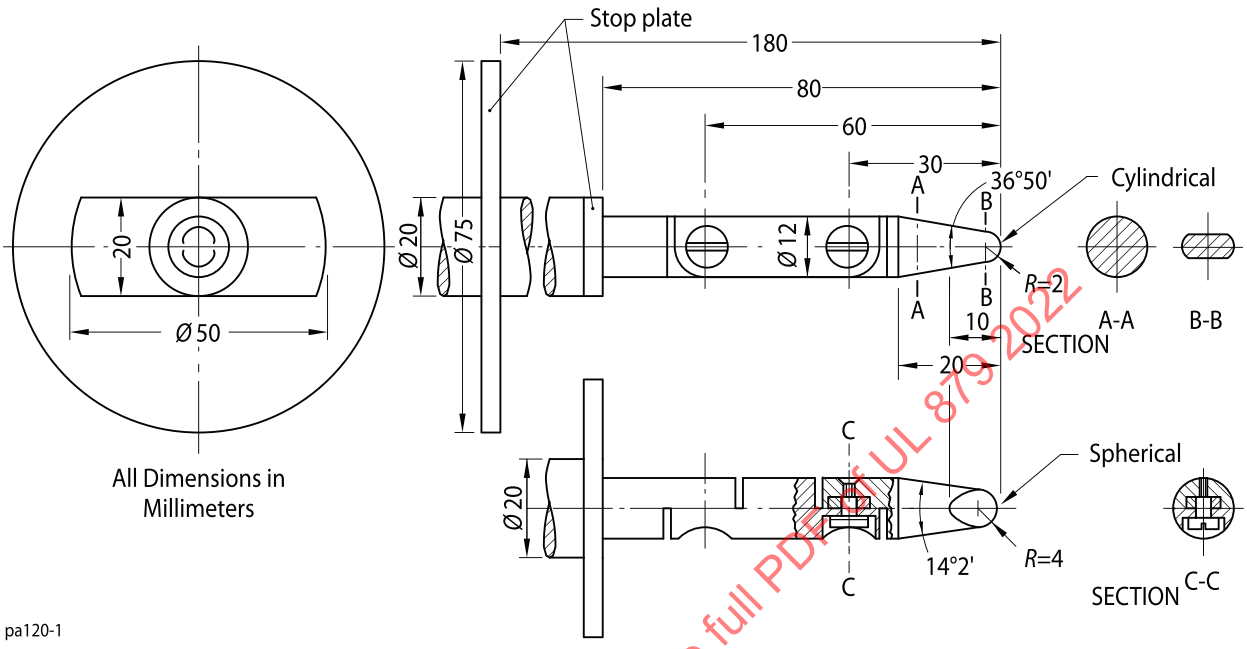


Figure 2.2

International Electrotechnical Commission (IEC) articulate accessibility probe with stop plate courtesy of IEC



2.3.3 A material that prevents access to a part that is required to be inaccessible in accordance with 2.3.1 and 2.3.2 shall be constructed of:

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

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

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

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

e) Polymeric material that complies with the applicable requirements in 2.3.5 and 2.3.6.

2.3.4 An accessibility barrier used to make live parts inaccessible shall be subjected to the dielectric voltage withstand tests specified in 3.4.2.5 while the barrier is being subject to the accessibility barrier test specified 3.4.1.7. The dielectric voltage withstand tests shall be applied between live parts and the user or service personnel side of the barrier to include the combination of barrier material, spacing between the barrier and live parts, and any other material between live parts and the user or service personnel side of the barrier. The dielectric withstand voltage shall be based on the operating voltage to ground of the live parts being made inaccessible.

2.3.5 A polymeric material used to form an accessibility barrier to prevent access to uninsulated live parts having a maximum voltage of 1000 Vrms or less shall comply with the following material requirements. A polymeric material used to prevent access to insulated and uninsulated current carrying parts in excess of 1000 Vrms (1414 Vpeak) to ground shall also comply with 2.3.6.

a) A polymeric material shall have a Relative Temperature Index that exceeds the maximum operating temperature of the barrier as measured by the Normal Temperature Test specified in 3.4.2.3;

b) A polymeric material shall have a minimum flammability rating of minimum HB for the thickness provided or, for material with a thickness that is less than required for the flammability rating, comply with the Slow Burning HB Testing Procedure specified in 3.2.2.1.4;

c) A polymeric material shall have a maximum PLC of 3 for hot wire ignition (HWI) and a maximum PLC of 3 for high-ampere arc ignition (HAI); and

d) Comply with the Mold Stress Relief Distortion Test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

2.3.6 A polymeric material provided to serve as an accessibility barrier preventing contact with insulated and uninsulated current carrying parts exceeding 1000 Vrms (1414 Vpeak) to ground, shall comply with the following:

a) The spacing requirements in accordance with 2.15; or

b) Comply with Material Dielectric Voltage Withstand Test specified in 3.2.2.16 or the test requirements in 2.3.4.

2.4 Openings and open holes

2.4.1 Open holes

2.4.1.1 An open hole in a material that encloses live parts or makes live or moving parts inaccessible shall:

a) Not permit contact with insulated and uninsulated current carrying parts when the Accessibility Probe is applied as specified in 2.4.1.6;

b) Not be larger than the dimensions specified in Table 2.6, unless provided with a baffle in accordance with 2.4.1.5;

c) Not be located in the enclosure of an open core and coil ballast or transformer unless the enclosure has only one likely orientation when mounted or installed and is baffled or louvered to prevent the potential escape of molten material while in that orientation.

Table 2.6
Maximum size of miscellaneous open holes

Opening shape	Maximum dimension		Maximum area	
	mm	(in)	mm^2	$(in)^2$
Slot	9.6	.375	9.68	1.5
Slot between two assembled parts	0.8	0.031	None	None
Square	12.7	0.5 width	None	None
Round	12.7	0.5 diameter	None	None
Irregular	12.7	0.5 per side	9.68	1.5

2.4.1.2 Open holes provided for draining moisture from a component intended for use in damp or wet locations shall be free of burrs. Circular drainage holes shall have a diameter of 6.4 – 12.7 mm (1/4 – 1/2

in). When not circular such holes shall have a minimum dimension of not less than 6.4 mm (1/4 in) and an area of 32.2 – 129.0 mm^2 (0.05 – 0.20 in^2).

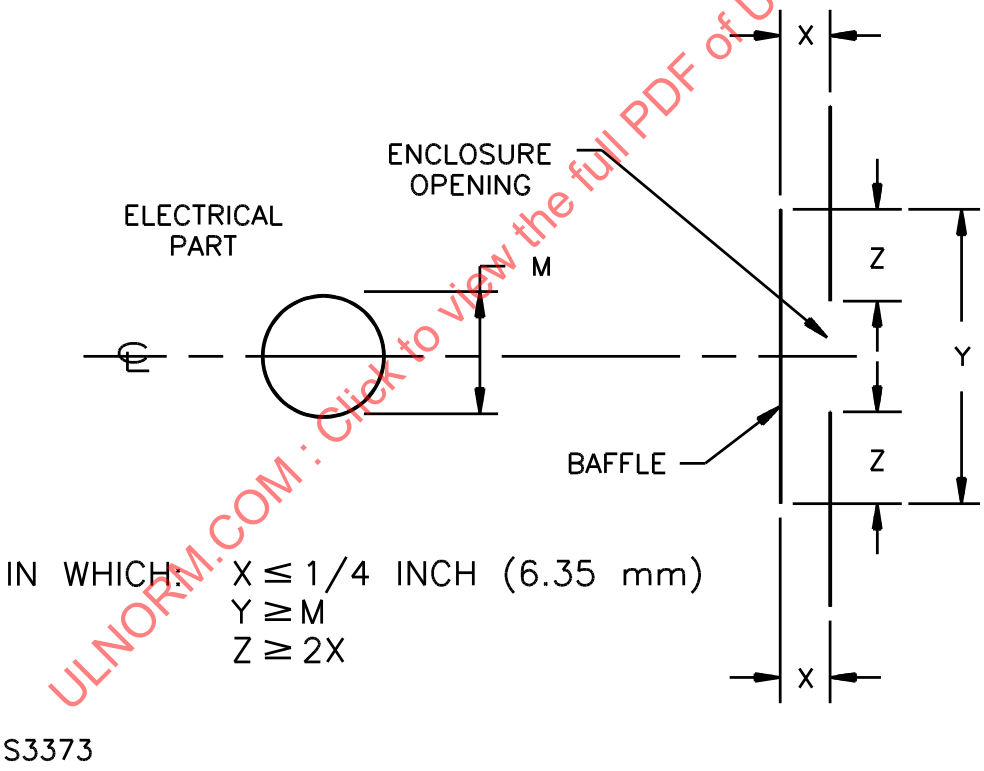
2.4.1.3 A hole for drainage shall be located in the bottom of the component or at the bottom edge of the back surface of the component. The location of the hole for drainage of water shall not be located where drainage is likely to occur onto other live parts when installed in a sign.

2.4.1.4 In a damp or wet location component, a horizontal surface that forms a trough shall be provided with one or more drain holes when a trough is arranged, formed, or located so that water pockets are not formed.

2.4.1.5 An open hole having dimensions larger than those specified in Table 2.6 is permitted when the open hole is baffled in accordance with Figure 2.3 to reduce access to live or moving parts.

Figure 2.3

Relationship of baffle and electrical part to prevent emission



2.4.1.6 The probes referenced in and illustrated in Figure 2.1 and Figure 2.2 are to be applied to any depth that the open hole will permit, and shall be rotated or angled before, during, and after insertion through the open hole to any position that is necessary to examine the enclosure. The probe shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the open hole. The probe shall be used as measuring instruments to judge the accessibility provided by an open hole, and not as instruments to judge the strength of a material. They shall be applied with the minimum force necessary to determine accessibility.

2.4.2 Openings

2.4.2.1 A cover over an open hole in an enclosure shall be provided with means (such as screws, spot welding, interlock tangs and the like) to firmly secure it in place. Friction alone is not sufficient.

2.4.2.2 A knockout shall be adequately secured and yet removable without undue deformation of the enclosure as determined by compliance with the Knockout Test as described in 3.4.1.2.

2.4.2.3 If more than one open hole is provided for the supply and output connections, all but one of the open holes shall be covered such that they exist as either knockouts or covered open holes.

2.4.2.4 A knockout provided over a supply or output conduit open hole shall completely cover the opening in which it is located and the clearance between the cover and the opening shall be no more than 0.25 mm (0.010 in) before painting. The knockout thickness shall comply with the enclosure requirements.

2.5 Sign body

2.5.1 Polymeric material of a component to be installed on a wet location end use product and relied upon to prevent the wetting of insulated current carrying parts during the Rain Test in 3.4.1.9 shall comply with one of the following:

a) Ultraviolet Radiation Exposure Conditioning in 3.2.1.5 followed by the Impact Test specified in 3.4.1.6; or,

b) Ultraviolet Light Exposure Test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

2.6 Gaskets and bushings

2.6.1 A gasket or bushing required to prevent water from entering an enclosure of splices, outdoor ballast, switch, or contact current carrying parts, including conductors, shall be secured to prevent its loosening during user maintenance by a clip, clamping ring, adhesive, or other mechanical means.

2.6.2 A gasket or bushing shall be made of neoprene or rubber composition gasket materials having a temperature rating suitable for the operating temperature as determined by the normal temperature test of 3.4.2.3 or shall withstand the flexibility and hardness test in 3.2.2.10.

2.6.3 The adhesive used to secure a gasket or bushing that is required to prevent water from entering the enclosure, and which is likely to be exposed or not compressed as intended during user maintenance, shall comply with the material adhesion test of 3.4.1.13.

2.7 Corrosion protection

2.7.1 All surfaces of ferrous metal parts including welds other than stainless steel and parts specified in 2.7.2, including hinges, bolts and fasteners, shall be protected against corrosion by galvanizing, painting, plating, corrosion resistant coating or enamel.

2.7.2 Laminations and other parts of iron or steel such as washers and screws that do not serve as an enclosure, accessibility barrier, water shield, or current-carrying part, are permitted without additional corrosion protection.

2.7.3 Edges and punched holes in prefinished steel, and hanger locations for painting or plating in ferrous metal, do not require any corrosion protection.

2.8 Mechanical joints and fastenings

2.8.1 The method of making a joint shall:

a) Provide strength and rigidity and prevent turning that would result in movement of conductors or wiring devices after the assembly is completed and;

b) Not result in reduction of spacings, loosening or displacement of parts, or other serious defects that causes a product to no longer comply with the requirements in this standard.

2.8.2 Adhesive relied upon to comply with enclosure, sign body, and accessibility barrier requirements and at any other location where the reliability of the securement means will affect a potential hazard, shall be rated for the surfaces and under the conditions specified in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or comply with the Material Adhesion Test in 3.4.1.13.

2.8.3 Solvent, ultrasonic welding, electromagnetic induction, and thermal welding are acceptable means of securement.

2.8.4 Thread-forming screws shown in Figure 2.4 shall not be used to secure a cover or component or be utilized as a terminal type screw that will be removed or replaced during field servicing.

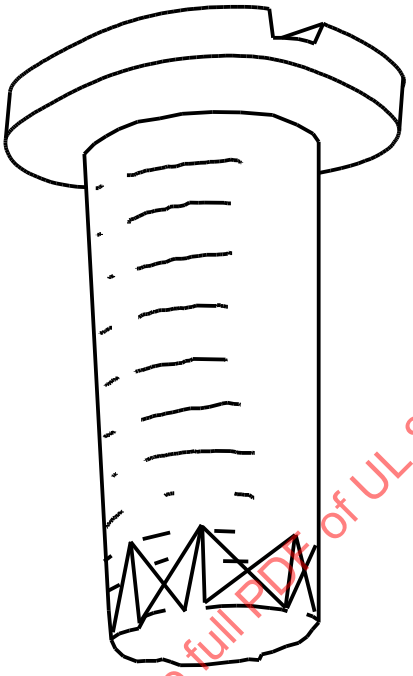
2.8.5 Self-threading and sheet metal screws used to secure electrical or enclosure component parts in place, or together, shall comply with the Self-threading Screw Torque Test in 3.4.1.4, when the screw threads into non-ferrous metal or polymeric materials.

2.8.6 Self-threading and sheet metal screws used for mounting or supporting a part that weighs more than 3.4 kg (7.5 lb) per screw shall comply with the Self-threading Screw Torque Test in 3.4.1.4.

2.8.7 Self-threading and sheet metal screws shall not have the threads extend into a wiring compartment more than 5 mm (0.2 in) unless all conductors are reliably positioned away from the projecting screws or the conductors are stranded and sufficiently loose to prevent damage to the insulation.

Figure 2.4

Thread-forming screw



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2.9 Sharp edges

2.9.1 An edge, projection, or corner of an enclosure, frame, barrier, guard, or the like, that is accessible to contact during and after installation or as part of user maintenance and servicing, shall not be sufficiently sharp to cause a cut-type injury when contacted during installation, intended use, or maintenance. An edge that has been smoothed or rounded to at least 120° back on itself is acceptable.

2.10 Supply connections

2.10.1 Permanently connected components

2.10.1.1 A sign component intended to be permanently installed shall have one of the following provisions for connection as follows:

a) Be provided with means for connection to a source of supply in accordance with 2.10.2 for branch circuit supply connected components, or

b) Be provided with leads or terminals for factory installation only.

2.10.2 Branch circuit supply connections

2.10.2.1 An electrical component intended for connection in accordance with the National Electrical Code shall have connection means that comply with 2.10.2.2 – 2.10.2.9 and either field wiring leads that comply with 2.10.4.1 – 2.10.4.1 or field wiring terminals that comply with 2.10.5.1 – 2.10.5.3.

2.10.2.2 Acceptable means for connection to a permanent wiring system shall be by providing an opening for conduit connection.

2.10.2.3 Unthreaded openings for conduit and the area surrounding the opening shall comply with the requirements in Table 2.7.

Table 2.7
Dimensions of unthreaded opening for conduit and diameter of the area surrounding the opening

Nominal trade size of conduit	Unthreaded opening diameter[1)]		On interior of component, minimum unobstructed diameter of flat surface surrounding conduit opening	
in	mm	(in)	mm	(in)
1/2	22.2	(0.875)	29.09	(1.11)
3/4	28.2	(1.109)	34.04	(1.34)
1	34.9	(1.375)	42.85	(1.69)
1 1/4	44.0	(1.734)	55.07	(2.14)

[1)] A plus tolerance of 0.82 mm (0.032 in) and a minus tolerance of 0.38 mm (0.015 in) applies to the knockout diameter. Knockout diameters are to be measured other than at points where a tab attaches the knockout.

2.10.2.4 A threaded opening for conduit shall comply with Table 2.8 and have one of the following configurations:

a) When tapped all the way through, the opening shall have at least 3.5 threads but no more than 5 threads and comply with the minimum unobstructed diameter of flat surface in Table 2.7 to accommodate the conduit bushing; or

b) When not tapped all the way through, the opening shall have at least 5 threads.

Table 2.8
Throat diameters for conduit openings

Nominal trade size of conduit	Minimum throat diameter		Maximum throat diameter	
in	mm	(in)	mm	(in)
1/2	13.4	(0.528)	15.8	(0.622)
3/4	17.7	(0.697)	20.8	(0.819)
1	22.4	(0.882)	26.7	(1.051)
1-1/4	29.7	(1.169)	35.1	(1.382)

2.10.2.5 A component provided with a means of conduit connection shall be shipped with provision to close all but one of the conduit openings.

2.10.2.6 Unless provided with a wiring compartment as specified in 2.10.2.7, an opening provided for the purpose of making field connections to a branch circuit supply, shall not be located within 152 mm (6 in) of the following:

a) Uninsulated live parts,

b) Low voltage circuitry,

c) Heat producing components,

d) Moving parts, and

e) Any electrical or mechanical component not specifically identified above that could result in an increased risk of fire or shock.

2.10.2.7 The area adjacent to an opening where branch circuit supply connections are to be made in the field and which has components located within 152 mm (6 in) of the opening, shall be enclosed within a wiring compartment having a volume of at least 98 cm^3 (6 in^3).

2.10.2.8 A field-wiring compartment intended for connection of a wiring system shall be attached to the product so that it will be prevented from turning.

2.10.2.9 An outlet box, terminal box, wiring compartment, or the like in which connections to the product will be made in the field shall be free from any sharp edge, including screw threads, a burr, a fin, a moving part, or the like, that may abrade the insulation on conductors or otherwise damage the wiring.

2.10.3 Field-wiring leads

2.10.3.1 A field wiring lead shall be of wire that complies with 2.12.3 and is no smaller than 18 AWG (0.82 mm^2).

2.10.3.2 The free length of a field wiring lead shall be 15.2 cm (6 in) or more. Where a wiring compartment is provided, the free length is measured from the point of entry of the lead into the wiring compartment to the free end.

2.10.3.3 The insulation of a lead intended for the connection of a grounded conductor (common or neutral) shall be white or gray throughout its length.

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

2.10.3.5 Strain relief shall be provided on field wiring leads so that stress on a lead will not be transmitted to the electrical connection inside a product. The acceptability of the strain relief means shall be determined by the Strain Relief Test specified in 3.4.1.3.

2.10.3.6 The insulation of a lead intended for the connection of a grounding conductor shall be green, or green with yellow stripe.

2.10.4 Field-wiring terminals

2.10.4.1 A pressure wire type terminal or a wire binding screw shall be of the type suitable for field wiring.

2.10.4.2 A terminal intended for connection of a grounded conductor of an ac supply shall be metal substantially white or silver in color or be marked in format S32-L3 with the words "NEUTRAL", "N", "W" or "White". No other terminal shall be substantially white or silver in color.

2.10.4.3 A terminal intended for connection of a dc supply where polarity of the supply connection is required shall be marked in format S32-L3 with the symbols "−" and "+" on or immediately adjacent to the supply terminals.

2.10.4.4 The integrity of the wire connection shall not rely on the dimensional stability of thermoplastic material unless the material has been evaluated for mechanical strength, resistance to impact, moisture absorptive properties, combustibility, resistance to arching, resistance to temperatures to which the

material is subject to under normal operating use, aging characteristics and those applicable requirements in the Standard for Polymeric Materials-Use in Electrical Equipment Evaluations, UL 746C.

2.10.5 Detachable and non-detachable cord-connected and direct plug-in

2.10.5.1 A sign component that is not intended to be permanently connected to a source of supply shall be provided with only one means of connection to the source of supply and shall be designated for use only in a portable end product and be provided with one of the following means of supply connection:

a) A component intended to be provided with a non-detachable type power supply cord shall have the cord permanently installed on the component,

b) A component intended to be provided with a detachable power supply cord shall be provided with an attachment cap having recessed male contacts, or

c) A component intended to be provided with a direct plug-in unit shall be provided with the appropriate type of connector to mate with the connector provided on the output cord of the direct plug-in unit.

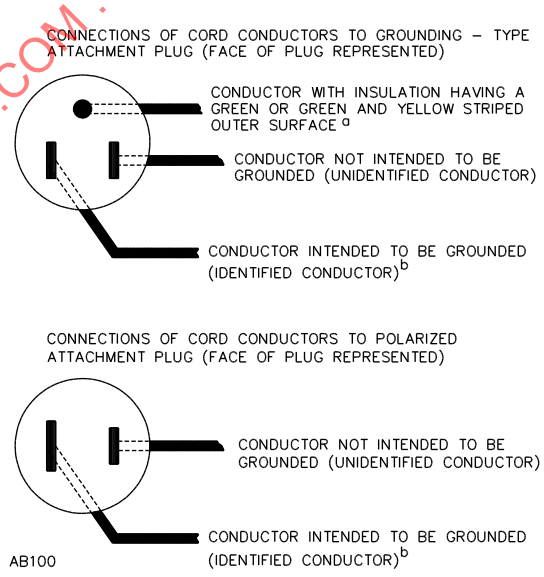
2.10.5.2 Unless a component complies with 2.10.5.6, a non-detachable power supply cord and a connector for a detachable supply cord shall be of the grounding (three-conductor) type.

2.10.5.3 A component that is provided with a non-detachable power supply cord shall employ a polarized or grounding-type attachment plug as shown in Figure 2.5.

2.10.5.4 A component that is provided with a detachable power supply cord shall employ a attachment cap that is polarized or of the grounding-type attachment type that will accommodate the configurations shown in Figure 2.5.

Figure 2.5

Connection to attachment plug



Notes to Figure 2.5:

a) In the figure, the blade to which the green conductor is connected may have a U-shaped or a circular cross section.

b) In the figure, the identified conductor is the conductor that is intended to be grounded.

2.10.5.5 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.

2.10.5.6 A component with no accessible dead-metal parts is not required to be provided with a supply cord of the grounding type, when marked in accordance with 2.16.6.

2.10.5.7 When a two-conductor flexible cord is provided for connection to the source of supply and polarity is required in accordance with 2.14.2, 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.

2.10.5.8 A power supply cord shall be minimum 18 AWG (0.82 mm^2).

2.10.5.9 The power supply cord provided on a sign component designated for dry location only shall be Type SP-2, Type SPE-2, Type SPT-2, or heavier. The power supply cord on a sign component designated for damp or wet locations, shall be of Type SO or harder usage and designated for outdoor use by a surface marking "W" or "Water Resistant".

2.10.5.10 All detachable and non-detachable supply cords shall be minimum 1.83 m (6 ft) and maximum 4.57 m (15 ft) in length. A non-detachable supply cord that is less than 1.83 (6 ft) in length and no less than 0.33 m (1 ft) in length is acceptable when the sign component is designated only for use in wall-mounted or hanging signs. The length shall be measured from the point where the cord emerges from the sign component, or after any strain-relief means provided, to the point where the cord enters an attachment plug.

2.10.5.11 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 Relief Test, 3.4.1.3.

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

2.10.5.13 Flexible supply cords shall be provided with a bushing at the point where the 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. The bushing shall be an insulating type if the cord is Type SVT or lighter.

2.10.5.14 The attachment plug of a cord-connected sign component shall be rated for a 15- or 20-A branch circuit. An attachment plug of a cord-connected sign component that supplies a neon circuit is permitted to be rated 30 A maximum.

2.10.5.15 The ampacity of the attachment plug of a power supply cord shall not be less than 125% of the input rating.

2.11 Equipment grounding and bonding

2.11.1 Parts required to be grounded

2.11.1.1 A dead metal part not intended to be electrically live is required to be conductively connected to ground in accordance with 2.11.1.4 unless the part is identified as not having a potential to become inadvertently energized in accordance with 2.11.1.2 or parts identified in 2.11.1.3.

2.11.1.2 A dead metal part is not considered to have a potential to become inadvertently energized when:

a) The dead metal part is within a compartment that contains an insulated or uninsulated live part and the insulated or uninsulated live part is located and reliably secured to provide the spacings required in 2.15.

b) The dead metal part is separated from insulated and uninsulated live parts by a rigid insulating material at least 3.2-mm (0.125-in) thick.

c) The dead metal part is separated from insulated and uninsulated live parts by a material that complies with the Material Dielectric Voltage Withstand Test specified in 3.2.2.16.

2.11.1.3 The following parts are not required to be bonded to ground:

a) Accessible non-current-carrying metal parts of components (for example, lampholders and switches) that are isolated from live parts;

b) Decorative parts, metal guards, and metal shades that do not enclose live parts; and,

c) Dead metal parts that enclose insulated or uninsulated live parts that are connected to a Class 2 power source that complies with 2.12.6.1; and

d) A dead metal part such as an adhesive-attached metal foil marking plate secured to the outside of an enclosure and mounting hardware external to a sign component.

2.11.1.4 Conductive connection to ground shall be either through a direct connection to a branch circuit ground or through bonding to a point on the sign component that is capable of being connected to a branch circuit ground.

2.11.2 Provision for grounding

2.11.2.1 The grounding means required in 2.11.1.1 shall be in the same location as the supply connection means and shall consist of a grounding conductor lead, a terminal connector, a wire binding screw, or the equivalent as specified in 2.11.3.1.

2.11.2.2 A grounding connection wire binding screw or stud, or grounding lead shall be provided with a star washer or other fastening means that will penetrate a non-conductive coating such as paint.

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

2.11.2.4 A grounding terminal or lead shall not be located on a removable part, unless the removal of the part during user maintenance does not interrupt the bonding continuity.

2.11.2.5 A ground connection means including a grounding terminal and grounding lead securement screw or terminal shall not be used for any other purpose.

2.11.2.6 The continuity of the grounding and bonding system shall not rely on the dimensional stability of thermoplastic material unless the material has been evaluated for mechanical strength, resistance to impact, moisture absorptive properties, combustibility, resistance to arching, resistance to temperatures to which the material is subject to under normal operating use, aging characteristics and those applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

2.11.3 Equipment grounding means

2.11.3.1 General

2.11.3.1.1 The point of connection by terminal or lead to the equipment grounding conductor shall be within 152 mm (6 in) of the supply connection opening and unlikely to be removed during normal maintenance and servicing.

2.11.3.2 Terminal

2.11.3.2.1 A grounding terminal shall be a pressure wire terminal, wire binding screw or wire binding stud. A pressure wire terminal shall be rated for the size and number of conductors and be suitable for field wiring or comply with the Pressure Wire Terminal Test in 3.4.1.5.1. A wire binding screw and stud shall comply with the requirements in this section.

2.11.3.2.2 A wire binding screw or stud provided for grounding shall:

a) Be limited to terminating a single size 10 AWG (5.3 mm^2) or smaller conductor.

b) Comply with Table 2.9.

c) Be a machine or thread-cutting screw, and, or the area around the screw or stud shall be provided with two raised areas in accordance with Figure 2.6. Other means of conductor captivation are acceptable as a result of a separate evaluation and complying with the test requirements in Solid-Wire Tightening Test in 3.4.1.5.2 and the Terminal Assembly Terminal Block Test in 3.4.1.5.3.

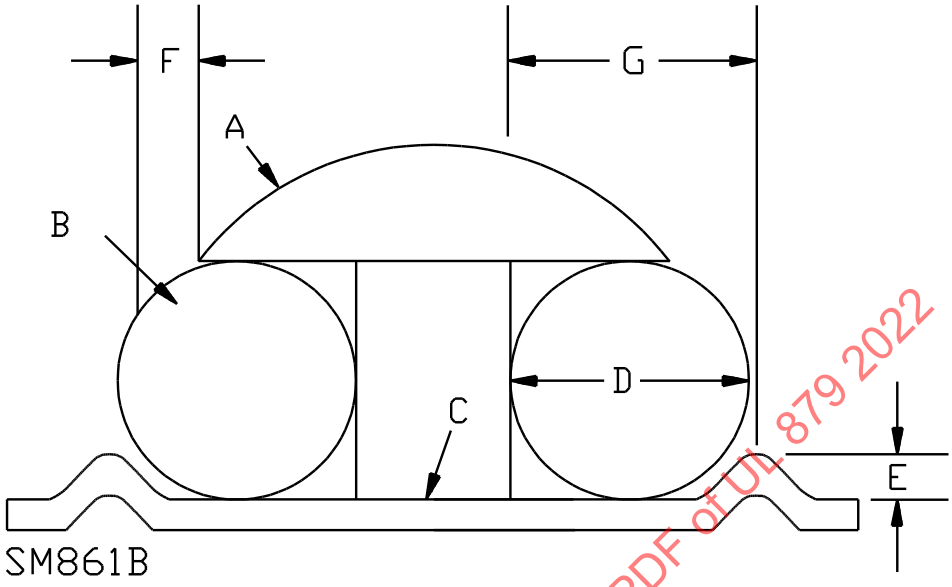
d) Have a cupped washer or similar provision, or the area around the screw or stud shall be provided with two raised areas in accordance with Figure 2.6. Other means of conductor captivation are acceptable as a result of a separate evaluation and complying with the test requirements in Solid-Wire Tightening Tests in 3.4.1.5.2 and the Terminal Assembly Terminal Block Tests in 3.4.1.5.3.

Table 2.9
Ground screw size

Screw size	Wire size AWG (mm^2)
M3.5 – No. 6	14 (2.1)
M4 – No. 8	14 (2.1) or 12 (3.3)
M5 – No. 10	14 (2.1) or 10 (5.3)

Figure 2.6

Terminal and conductor relationship



A – Wire-binding screw

B – Conductor

C – Baseplate

D – Maximum conductor diameter, but not less than 2 mm (0.08 in)

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

F – The horizontal dimension from the edge of the screwhead to the inside edge of the raised area = 0 to 1/4 D

G – The horizontal dimension from the center of the raised area to the edge of the screwhead = minimum 0.32 mm (0.125 in)

2.11.3.2.3 A field wiring grounding type wire binding screw or stud shall:

a) Comply with the Solid Wire Tightening Test in 3.4.1.5.2 and the Terminal Assembly Terminal Block Test in 3.4.1.5.3.

b) Have a base plate with no fewer than two full threads of contact; and

1) Metal not less than 0.76-mm (0.030-in) thick; or

2) Metal less than 0.76-mm (0.030-in) thick when a tapped hole for a screw having 1.25 threads per mm (32 or more threads per in) is provided.

c) Provide a conductive path that complies with the Ground Continuity Test of 3.4.2.6.

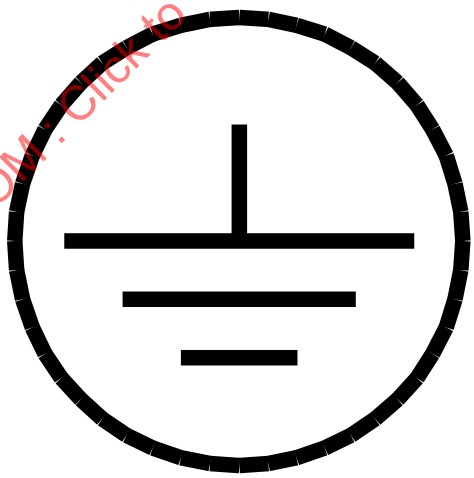
2.11.3.2.4 A wire binding stud shall be provided with a hexagonal nut. The nut shall be green in color or the area adjacent to the terminal shall be marked in accordance with 2.11.3.2.6.

2.11.3.2.5 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 cross slotted (Phillips) head.

2.11.3.2.6 A pressure wire terminal intended as connection of the equipment grounding conductor shall be plainly identified as "G," "GR," "GND," "Ground," "Grounding," or the like, or may be marked with the symbol shown in Figure 2.7.

Figure 2.7

Grounding symbol



2.11.3.3 Grounding lead

2.11.3.3.1 A grounding lead shall not be smaller than the gauge of the supply wires and no less than 18 AWG (0.82 mm^2) when connected to a branch circuit supply.

2.11.3.3.2 Have no insulation or insulation that is green with or without one or more yellow stripes and no other lead visible to an installer shall be so identified.

2.11.3.3.3 A grounding lead shall have a free length of at least 15.2 cm (6 in). The free length is measured from the point of entry of the lead into the wiring compartment or from a opening for the connection of a permanent wiring system to the free end of the lead.

2.11.3.3.4 A grounding lead shall be provided with strain relief means such that the grounding lead complies with the Strain Relief Test described in 3.4.1.3.

2.11.4 Grounding, cord-connected

2.11.4.1 A sign component having dead metal that is required to be grounded in accordance with 2.11.1 and provided with a flexible power supply cord shall have a flexible power supply cord of the grounding type. A sign component having no dead metal is not required to be provided with a grounding type flexible power supply cord when the component is marked in accordance with 2.16.6.

2.11.4.2 The grounding conductor of the flexible cord shall be connected to dead metal parts within the frame or enclosure of a sign component by means such as welding, soldering, a screw or stud, nut, and lock washer.

2.11.4.3 The means to secure the grounding conductor shall not serve any other function, such as that of an enclosure securement screw unless the securement means is completely potted such that it cannot be disconnected during servicing. The means to secure the grounding conductor shall be located on a part that is not normally removed for servicing.

2.11.4.4 A flexible cord used for supply connection required to be provided with an equipment-grounding conductor as specified in 2.11.4.1 shall be connected to a parallel-blade, 3-wire grounding attachment plug. The supply cord shall have one conductor identified as the equipment grounding conductor by having insulation colored green or green with a yellow stripe and one conductor identified as the grounded (neutral) conductor by having insulation colored white or gray.

2.11.5 Bonding to an equipment grounding means

2.11.5.1 All parts of a sign component required to be grounded shall be conductivity connected to the grounding terminal, lead, or pin of an attachment plug and shall comply with the Ground Continuity Test in 3.4.2.6.

2.11.5.2 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 14 AWG (2.1 mm^2).

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

2.12 Current-carrying parts

2.12.1 General

2.12.1.1 A current-carrying conductor shall be of silver, copper, a copper alloy, stainless steel, or other similar metal other than aluminum.

2.12.1.2 Ordinary iron or steel shall not be used as a current-carrying part.

2.12.2 Internal wiring

2.12.2.1 A conductor shall have insulation rated for the voltage, temperature, and condition of service to which it will be subjected under conditions of intended use.

2.12.2.2 Conductors within an enclosure, compartment, raceway, or the like shall be located or protected to prevent contact with any sharp edge, burr, fin, or the like that can damage the conductor insulation.

2.12.2.3 An opening through which insulated conductors pass in a sheet metal wall within the overall enclosure shall have an edge provided with smooth, rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation. An opening is permitted to be made smooth and rounded by:

a) Providing a bushing or grommet in the sheet metal opening; or

b) Rolling the sheet metal edge of the opening 120° or more; or

c) The edge of sheet metal is made to be thicker than 1.07 mm (0.04 in).

2.12.3 Wires and cords rated 1000 V and less

2.12.3.1 Other than as specified in 2.12.3.2, conductors shall be minimum 18 AWG (0.82 mm^2) of copper and provided with insulation and have insulation rated for the voltage, temperature, and condition of service to which it is subjected to under conditions of intended use in accordance with Table 2.10.

Table 2.10
National Electrical Code usage and conductor temperature ratings for flexible cords, building wire and fixture wire

Location	Usage	Description	Type	Rating rms Volts	Temperature		Notes
					°C	(°F)	
Dry		Equipment wire	FEPW	600	75	(167)	
			PFAH	600	250	(482)	
			RH	600	75	(167)	
			RHH	600	90	(194)	
			T	600	60	(140)	
			TFE	600	250	(482)	
			THHN	600	90	(194)	
			THHW	600	90	(194)	
			Z	600	90	(194)	2
			ZW	600	90	(194)	2
Dry	Not hard usage	Flexible cord	C	300	60	(140)	
			PD	300	60	(140)	
Dry or damp		Equipment wire	FFH-1	300	75	(167)	
			FFH-2	600	75	(167)	
			KF-2	600	200	(392)	
			KFF-1	300	200	(392)	

Table 2.10 Continued on Next Page

Table 2.10 Continued

Location	Usage	Description	Type	Rating rms Volts	Temperature		Notes
					°C	(°F)	
			KFF-2	600	200	(392)	
			HF	600	150	(302)	
			HF-1	300	200	(392)	
			HFF	600	150	(302)	1
			PAF1	600	250	(482)	
			PAFF	600	150	(302)	1
			PF	600	200	(392)	1
			PFF	600	150	(302)	1
			PGF	600	200	(392)	
			PGFF	600	150	(302)	
			PTF	600	250	(482)	
			PTFF	600	150	(302)	
			RFH-1	300	75	(167)	
			RFH-2	600	75	(167)	
			RFHH-2	600	90	(194)	2
			RHH	600	90	(194)	2
			RHH-3	600	90	(194)	2
			SF-1	300	200	(392)	
			SF-2	600	200	(392)	
			SFF-1	300	150	(302)	
			SFF-2	600	150	(302)	
			TF	600	60	(140)	
			TFF	600	60	(140)	
			THHN	600	90	(194)	2
			XHHW	600	90	(194)	2
			WF	300	150	(302)	
			WFF	300	150	(302)	
			Z	600	90	(194)	2
			ZF	600	150	(302)	
			ZFF	600	150	(302)	
			ZHF	600	200	(392)	
			ZW	600	90	(194)	2
Dry or damp	Not hard usage	Flexible cord	HPW	300	90	(194)	2
	Extra hard usage						
			S	600	60	(140)	
			S	600	75	(167)	1
			SE	600	60	(140)	
			SE	600	75	(167)	1

Table 2.10 Continued on Next Page

Table 2.10 Continued

Location	Usage	Description	Type	Rating rms Volts	Temperature		Notes
					°C	(°F)	
	Hard usage		SJ	300	75	(167)	1
			SJE	300	60	(140)	1
			SJO	300	60	(140)	
			SJOO	300	60	(140)	
			SJOO	300	75	(167)	1
			SJT	300	60	(140)	
			SJT	300	75	(167)	1
			SJT	300	90	(194)	1, 2
			SJT	300	105	(221)	1, 2
			SJTO	300	60	(140)	
			SJTOO	300	60	(140)	
			SPE-2	300	60	(140)	
			SPE-2	300	75	(167)	1
			SPE-2	300	90	(194)	1, 2
			SPE-2	300	105	(221)	1, 2
			SO	600	60	(140)	
			SO	600	75	(167)	1
			SO	600	90	(194)	1, 2
			SOO	600	60	(140)	
			SOO	600	75	(167)	1
			SOO	600	90	(194)	
Not hard usage			SPT-2	300	60	(140)	
			SPT-2	300	75	(167)	1, 2
			SPT-2	300	90	(194)	1, 2
Extra hard usage			ST	600	60	(140)	
			ST	600	75	(167)	
			ST	600	90	(194)	
			ST	600	105	(221)	
			STO	600	60	(140)	
			STOO	600	60	(140)	
	Not hard usage		SV	300	60	(140)	
			SVE	300	60	(140)	
			SVO	300	60	(140)	
			SVO	300	90	(194)	1, 2
			SVOO	300	90	(194)	
			STSVOO	300	60	(140)	1, 2
			SVT	300	75	(167)	

Table 2.10 Continued on Next Page

Table 2.10 Continued

Location	Usage	Description	Type	Rating rms Volts	Temperature		Notes
					°C	(°F)	
			SVT	300	90	(194)	1
			SVT	300	105	(221)	1, 2
			SVT	300	60	(140)	1, 2
			SVTO	300	60	(140)	
			SVTOO	300	60	(140)	
Dry, damp or wet		Wire	RHW	600	75	(167)	
			RUW	600	60	(140)	
			THW	600	75	(167)	
			YHWN	600	75	(167)	
			TW	600	60	(140)	
			XHHW	600	75	(167)	
			ZW	600	75	(167)	
Dry, damp or wet	Same as specified for cord type under dry or damp	Flexible cord	Any if marked as specified in note 3	As marked on cord	As marked on cord		2, 3

Notes:

1) The insulation temperature rating is marked on the surface of the flexible cord.

2) See 2.12.3.5 for increasing the insulation temperature rating using sleeving.

3) Flexible cord that is suitable for use in a wet location is surfaced marked with "W" or "Water Resistant".

2.12.3.2 Conductors of a size smaller than 18 AWG (0.82 mm^2), but not smaller than 24 AWG (0.21 mm^2), may be used under the following conditions:

a) Where they are completely enclosed;

b) Where they are not subject to movement under normal use; and

c) In the secondary of a transformer other than a neon transformer or neon power supply; or

d) In a circuit using solid-state devices.

2.12.3.3 A conductor or cord that can be flexed because of an adjustable, movable, or flexible part of a component shall be of the stranded type and shall be secured so it will not be cut or abraded under conditions of intended use, including relamping, servicing, and inspection of supply connections.

2.12.3.4 In a component construction that allows the conductor or cord to be pushed back into the component, the temperature rating of the conductor or cord shall be suitable for the operating temperature of any component it may contact.

2.12.3.5 An insulated conductor, including each insulated conductor of a cord, that is rated for 90°C (194°F), 105°C (221°F), or 125°C (257°F) shall be considered as rated for 150°C (302°F) if each conductor is individually provided with supplemental insulation consisting of snugly fitting woven glass fiber sleeving having at least a 0.25-mm (0.010-in) wall thickness, two layers of glass fiber tape that complies with a total thickness of at least 0.25 mm (0.010 in).

2.12.3.6 An insulated wire connector shall have a voltage rating at least as high as the voltage applied to the conductor.

2.12.3.7 An insulated wire connector having a voltage rating less than required for the application may be used if the splice, including the connector, is additionally covered with insulation rated for the voltage difference between the required voltage and the rated voltage of the connector. See Table 2.11.

Table 2.11
Appliance wiring material insulation type, voltage, and temperature ratings

Type of insulation	Minimum thickness of insulation							
	300 V				600 V			
	Without braid		With added impregnated braid cover		Without braid		With added impregnated braid or nylon cover [min 0.1 mm (0.004 in)]	
	mm	(in)	mm	(in)	mm	(in)	mm	(in)
Thermoplastic	0.33	(0.013)	0.33	(0.013)	0.69	(0.012)	0.38	(0.015)
Thermoset	0.33	(0.013)	0.33	(0.013)	0.69	(0.027)	0.69	(0.027)
Rubber	0.69	(0.027)	0.33	(0.013)	1.02	(0.040)	0.69	(0.027)
Neoprene	0.69	(0.027)	0.33	(0.013)	1.07	(0.042)	0.69	(0.027)
Silicon rubber	–	–	0.33	(0.013)	–	–	0.69	(0.027)
Fluoro-plastica	0.30	(0.012)	–	–	0.46	(0.018)	–	–
NOTE – The temperature marking of appliance-wiring material or miscellaneous wire consists of: 1) Colored threads; 2) Durable, continuous (unbroken), straight, longitudinal stripes printed in indelible ink on the surface of the insulation; or 3) Durable and legible indelible ink printing (or legible indent printing) in words in degrees Celsius on (or in) the surface of the insulation.								
The number and color of the threads or stripes are: one green for 75°C (167°F); one red for 90°C (194°F); one yellow for 105°C (221°F); one blue for 125°C (257°F); one brown for 150°C (302°F); one black for 200°C (392°F); two black for 250°C (482°F). If a stripe or thread is used to identify the temperature marking of an 80°C (176°F) thermoplastic-insulated wire (the identification is not required), the stripe or thread is green.								
[a] Polytetrafluoroethylene or fluorinated ethylene propylene.								

2.12.4 Wires and cords rated 1,000 V and less

2.12.4.1 A wire for circuits of 1,000 V and higher shall be GTO cable rated minimum 105°C (221°F) and 5,000, 10,000 or 15,000 V.

2.12.4.2 Only one GTO cable is permitted in a single fitting or compartment where spacings, as defined in Table 2.20 are not maintained.

2.12.4.3 The wire bending radius of a GTO Cable carrying over 1,000 V shall not be less than 19 mm (0.75 in) for 5 kV, 25 mm (1 in) for 10 kV, and 31 mm (1.25 in) for 15 kV.

2.12.5 Spring contact

2.12.5.1 A spring contact shall comply with 2.12.5.2 and be either:

a) Primarily copper with tin (phosphor/bronze),

b) Primarily of copper with beryllium (beryllium/copper),

c) Monel, which is primarily copper with nickel and other elements in trace amounts, or

d) Other conducting material shown to possess spring characteristics.

2.12.5.2 A spring contact shall have material and dimensional characteristics that comply with the Spring Contact Elongation and Compression Test specified in 3.4.1.17.

2.12.6 Secondary circuits

2.12.6.1 Accessibility and enclosure of secondary components

2.12.6.1.1 A current carrying part located in a circuit from a source of supply having a maximum open circuit voltage of no greater than the following in (a) or (b), under the conditions specified in 2.12.6.1 for Class 2 circuits, and exceeds the energy limitations specified in 2.12.6.1, is required to comply with enclosure and electrical current requirements in this standard.

a) 30 Vrms and 42.4 Vpeak in dry and damp locations, or

b) 15 Vrms and 21.2 Vpeak in wet contact locations.

2.12.6.1.2 A current carrying part located in a circuit having a source of supply having a maximum open circuit voltage of 15 Vac, 21.2 Vpeak and energy limited under the conditions specified in 2.12.6.3 for voltage and energy limited circuits is not required to comply with enclosure, accessibility, and electrical requirements in this standard.

2.12.6.1.3 A current carrying part located in a circuit with a maximum open circuit voltage of greater than 15 Vac, 21.2 Vpeak and no greater than 30 Vac, 42.4 Vpeak and energy limited under the conditions specified as in 2.12.6.3 for voltage and energy limited circuits is required to comply with accessibility requirements when designated for use in wet locations and is not required to comply with enclosure and electrical requirements.

2.12.6.1.4 A current carrying part located in a circuit derived from having a source of supply that alters the voltage and/or current of the circuit such that the output from a voltage and energy limited circuit no longer complies with the voltage and energy limitation requirements in 2.12.6.3, shall comply with the applicable enclosure, accessibility and electrical requirements.

2.12.6.1.5 A current carrying part connected to a voltage and energy limited circuit and located in the same compartment as a current carrying part that does not comply with the voltage and energy limitations in 2.12.6.1.2 shall comply with one of the following conditions:

a) Comply with the spacing requirements in 2.15;

b) Be provided with a grounded metal barrier between the two current carrying parts with each part secured in a manner that maintains them on opposite sides of the barrier; or

c) The current carrying parts in each circuit are provided with insulation rated for the highest voltage of both circuits.

2.12.6.2 Secondary circuit greater than 30 V

2.12.6.2.1 A current carrying part located in a circuit having a source of supply with a maximum open circuit voltage greater than 30 Vrms and 42.4 Vpeak and energy levels in excess of the limitations specified for Class 2 in 2.12.6.1, is required to comply with all of the enclosure, accessibility, and electrical requirements in this standard.

2.12.6.2.2 A current carrying part located in a circuit having a source of supply that is energy limited in accordance with 2.12.6.1 and Table 2.12 and Table 2.13, that has an open circuit voltage in excess of 30 Vrms or 42.4 Vpeak is required to comply with accessibility and other electrical voltage requirements in this standard.

2.12.6.3 Class 2 and Class 3, voltage and power limited supply source

2.12.6.3.1 For a supply source to be identified as Class 2 or Class 3, each circuit from a source shall comply with the voltage, current and volt-ampere limitations specified Table 2.12 or Table 2.13 and comply with 2.12.6.3.2 – 2.12.6.3.5 and the test requirements in 3.4.2.13.

2.12.6.3.2 A Class 2 and Class 3 circuit shall be defined as either inherently limited or non-inherently limited.

2.12.6.3.3 A Class 2 and Class 3 ac power source shall have no conductive connection and be isolated from its supply source. Isolation is to be by isolating transformer either at the input or output of the supply source and all feedback circuits that are conductively connected to the output shall be isolated from the supply source by isolating components such as isolating transformers and optical isolators.

2.12.6.3.4 A Class 2 dc power source is permitted to have a conductive connection between its output and its input supply when its source of supply is from a dc source having a maximum open circuit voltage equal to or less than that required of the Class 2 source as specified in 2.12.6.3.5.

2.12.6.3.5 The maximum output voltage of an inherently limited or non-inherently limited Class 2 or Class 3 supply source shall not, under any load condition (including no load) between the designated output(s), be more than the voltages specified in Table 2.12 and Table 2.13. For Class 2 combinations of ac and dc see Figure 2.8 maximum voltage. Voltage ranges are for sinusoidal ac in dry locations or where wet contact (wet locations) is not likely to occur. For nonsinusoidal or wet contact conditions, see note 2 of Table 2.12. Voltages ranges are for continuous dc in dry locations or where wet contact (wet locations) is not likely to occur. For interrupted dc or wet contact conditions, see note 2 of Table 2.13.

Table 2.12
Class 2 and Class 3 alternating-current power source limitations

Power source		Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)			
		Class 2			Class 3	Class 2		Class 3	
Source voltage V_{max} (volts)[1) 2)]		0 – 20	Over 20 – 30	Over 30 – 150	Over 30 – 100	0 – 20	Over 20 – 30	Over 30 – 100	Over 100 – 150
Power limitations VA_{max} (volt-amperes)[1)]		–	–	–	–	250[3)]	250	250	N/A
Current limitations I_{max} (amperes)[1)]		8.0	8.0	0.005	$150/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amperes)		–	–	–	–	5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum nameplate rating	VA (volt-amperes)	$5.0 \times V_{max}$	100	$0.005 \times V_{max}$	100	$5.0 \times V_{max}$	100	100	100
	Current (amperes)	5.0	$100/V_{max}$	0.005	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$

[1)] V_{max}, I_{max}, and VA_{max} are determined with the current-limiting impedance in the circuit (not bypassed) as follows:

Table 2.12 Continued on Next Page

Table 2.12 Continued

Power source	Inherently limited power source (overcurrent protection not required)		Not inherently limited power source (overcurrent protection required)	
	Class 2	Class 3	Class 2	Class 3
V_{max}: Maximum output voltage regardless of load with rated input applied. I_{max}: Maximum output current under any non-capacitive load, including short circuit, and with overcurrent protection bypassed if used. Where a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after five seconds. VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed if used. Current limiting impedance shall not be bypassed when determining I_{max} and VA_{max}. 2) For nonsinusoidal ac, V_{max} shall not be greater than 42.4 Vpeak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used or V_{max} shall not be greater than 15 V for sinusoidal ac and 21.2 Vpeak for nonsinusoidal ac. 3) If the power source is a transformer, VA_{max} is 350 or less when V_{max} is 15 or less.				

Table 2.13
Class 2 and Class 3 direct-current power source limitations

Power source			Inherently limited power source (overcurrent protection not required)				Not inherently limited power source (overcurrent protection required)			
			Class 2			Class 3	Class 2		Class 3	
Source voltage V_{max} (volts) [1) 2)]		0 – 20	Over 20 – 30	Over 30 – 60	Over 60 – 150	Over 60 – 100	0 – 20	Over 20 – 60	Over 60 – 100	Over 100 – 150
Power limitations VA_{max} (volt-amperes)[1)]		–	–	–	–	–	250[3)]	250	250	Not applicable
Current limitations I_{max} (amperes)[1)]		8.0	8.0	$150/V_{max}$	0.005	$150/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amperes)		–	–	–	–	–	5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum nameplate rating	VA (volt-amperes)	$5.0 \times V_{max}$	100	100	$0.005 \times V_{max}$	100	$5.0 \times$ max	100	100	100
	Current (amperes	5.0	$100/V_{max}$	$100/V_{max}$	0.005	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$

[1)] V_{max}, I_{max}, and VA_{max} are determined with the current-limiting impedance in the circuit (not bypassed) as follows:

V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any non-capacitive load, including short circuit, and with overcurrent protection bypassed if used. Where a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after five seconds.

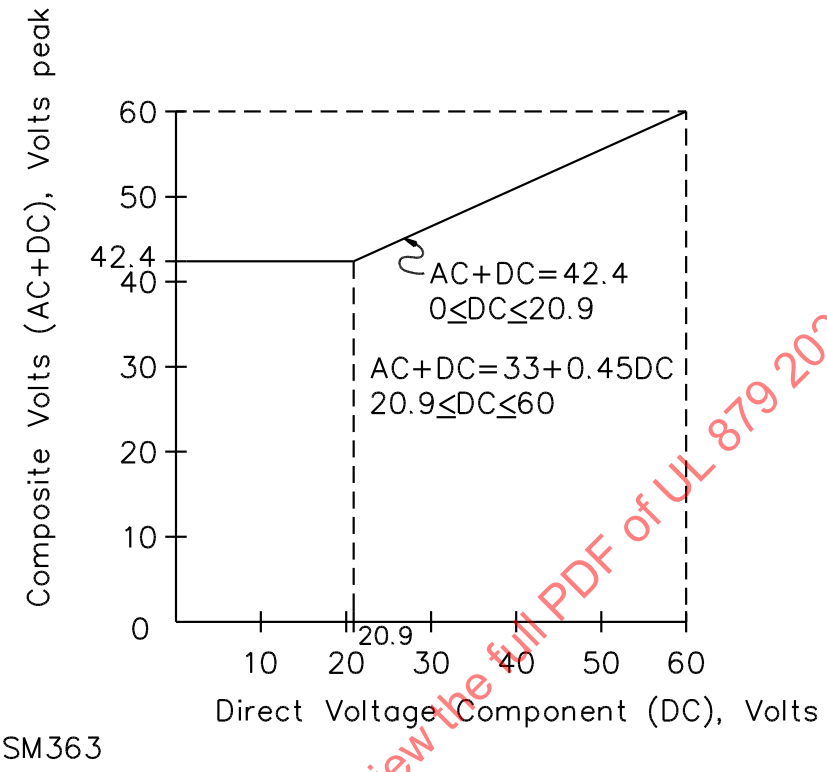
VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed if used. Current limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[2)] For dc interrupted at a rate of 10 to 200 Hz, V_{max} shall not be greater than 24.8 Vpeak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used or V_{max} shall not be greater than 30 V for continuous dc; 12.4 Vpeak for dc that is interrupted at a rate of 10 to 200 Hz.

[3)] If the power source is a transformer, VA_{max} is 350 or less when V_{max} is 15 or less.

Figure 2.8

Maximum Voltage for a Class 2 Source having both AC and DC Components



2.13 Insulating materials

2.13.1 Material that is not an integral part of a component and is within 0.8 mm (0.032 in) of uninsulated live parts shall be of non-absorptive, noncombustible material such as porcelain, phenolic complying with Table 2.14 or another material that complies with the Material Dielectric Voltage Withstand Test specified in 3.2.2.16 and has:

a) A minimum hot-wire ignition rating (HWI) of 15 s, or comply with the Hot–Wire Ignition Test of 3.2.2.3 or the Glow-Wire End Product Test of 3.2.2.4, and

b) A minimum hot-current arc resistance to ignition rating (HAI) of 15 arcs, or comply with the High Current Arc Ignition (HAI) Test specified in 3.2.2.5 or the End Product Arc Resistance Test specified in 3.2.2.6.

2.13.2 Ordinary vulcanized fiber may be used for insulating bushings, separators and barriers, but not as the sole support for uninsulated live parts.

Table 2.14
Minimum thickness of insulating materials

Material	Minimum thickness of barrier		Damp and wet location sign components	Dry location sign components only
	mm	(in)		
Fiber	0.8	(1/32)	No	See Note 1
Phenolic composition	0.8	(1/32)	No	See Note 2
Cold-molded composition	0.8	(1/32)	No	Yes
Porcelain				
Glazed	3.2	(1/8)	Yes	Yes
Unglazed	3.2	(1/8)	Only as tubes on insulated wires	Yes
Mica	0.8	(1/32)	Yes	Yes
Glass	3.2	(1/32)	Yes	Yes

Notes:

1. The spacings to fiber from secondary parts (insulated and uninsulated) must comply with those specified in Table 2.18 – Table 2.21 for spacings between primary and secondary parts with no risk of contact between the fiber and a secondary lead that is installed or to which a connection is made in the field.

2. The spacing (over-surface or through-air) to the barrier or liner from an insulated secondary part must not be less than 6.4 mm (0.25 in), and the spacing (over-surface or through-air) to the barrier or liner from an uninsulated secondary part is not less than 6.4 mm (0.25 in) for secondary potentials of 0 – 5,000 V, 9.5 mm (0.375 in) for secondary potentials of 5,001 – 10,000 V, or 12.7 mm (0.5 in) for secondary potentials of 10,001 – 15,000 V. There is to be no contact between the phenolic composition and a secondary lead that is installed or to which a connection is made in the field.

3. Unglazed and cold molded composition is acceptable in dry locations only when not in contact with secondary parts (insulated or uninsulated) and inaccessible to contact by a secondary lead that is to be installed or to which a connection is made in the field.

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

2.14 Electrical components

2.14.1 General

2.14.1.1 Electrical components shall have a rms voltage rating at least equal to the maximum voltage that would be applied.

2.14.1.2 An electrical component shall have a rms Ampere rating at least equal to the maximum rms amperage it would be subjected to in normal use.

2.14.1.3 A component such as a switch, a fuseholder, a receptacle, and the like that during use is likely to rotate is to be mounted securely and shall be prevented from turning by means other than friction between surfaces.

2.14.2 Circuit interrupting devices

2.14.2.1 A circuit interrupting device such as a switch, flasher, controller, sign animating equipment and the like, shall have a voltage rating equal to or in excess of its supply voltage and:

a) A current rating greater than the total current drawn by the load, and when making and breaking an inductive or tungsten load, be "L," or "AC General Use" rated for an AC circuit and "T," rated for a DC circuit; or

b) A current rating exceeding the load by the multiplying factor in Table 2.15 when making or breaking the circuit; or

c) Comply with the circuit interrupting overload and endurance test in Circuit Interrupting Devices Tests in 3.4.2.11 when making and breaking an inductive or tungsten load.

2.14.2.2 A switch or overcurrent-protective device of the single-pole type shall be located only in the ungrounded conductor of the source of supply.

2.14.2.3 A single pole switch shall not be connected in the grounded (neutral) circuit.

2.14.2.4 A switch marked with an Off position and intended to function as a disconnect switch in a sign, shall when in the Off position, disconnect the supply source by causing an air gap between opposing contacts in a circuit.

2.14.2.5 A circuit breaker or supplementary protector provided in a component and in a vertical position, the down position shall be the off position.

Table 2.15
Switch derating factors

Switching load	Switch type				
	AC general use ac only	"L" rated ac only	"T" rated ac/dc	AC ampere rated only	AC/DC ampere rated
Transformer and ballast	1	1	1	2	2
Tungsten filament	1	1	1	3	3
Receptacle	1	1	1	3	3

Notes:

1. An AC general use switch is typically a wall type switch normally used in a building and mounted to outlet boxes. An AC general use switch is also of the through cord type used on power supply cord connected products.

2. A switch, other than the AC general use type, that has been investigated for the control of inductive loads is marked with the letter "L" in conjunction with the current rating at which the inductive rating applies' for example, "1 A, 125 V, L".

3. A switch that has been investigated for the control of tungsten loads, is marked with the letter "T" in conjunction with the dc current rating at which the tungsten rating applies. A tungsten load is primarily an incandescent light source.

4. Switches with an AC, AC and DC or DC current rating with no "L", "T", or "AC General Use" marking are typically special use switches intended for resistive loads.

2.14.3 Overcurrent protective devices

2.14.3.1 Where a fuse is provided, it shall be mounted in a fuseholder of the proper type and rating or be soldered by pigtail style leads directly to a printed wiring board or be mounted using surface mount technology (SMT).

2.14.3.2 Unless a fuse within a component is made to be inaccessible, a fuse identification and ampere rating shall be marked on or adjacent to the fuse and fuseholder as specified in 2.16.7.

2.14.3.3 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.

2.14.3.4 A supplementary protector or circuit breaker connected in the supply circuit with more than one ungrounded conductor shall open all ungrounded conductors.

2.14.4 Thermal protective devices

2.14.4.1 A thermal protective device relied on to comply with the performance requirements of this standard shall:

a) Comply with the requirements of other appropriate standards listed in Appendix A of this standard as appropriate for the type of thermal protective device used,

b) Comply with the Circuit Interrupting Devices Tests specified in 3.4.2.11, and

c) Be located where it is capable of being either mechanically secured or physically trapped so as to be subject to consistent heat sensing.

2.14.5 Thermistors

2.14.5.1 A thermistor, Positive Temperature Coefficient (PTC) or Negative Temperature Coefficient (NTC) resistance, provided to limit the output of a unit to within the required current or power levels, or with maximum temperature requirements or otherwise used to obtain acceptable test results shall comply with the requirements of other appropriate standards listed in Appendix A of this standard and shall have a Calibration Class of C1 or C2.

2.14.6 Printed wiring boards

2.14.6.1 Unless permitted by 2.14.6.2 or 2.14.6.3, a printed wiring board shall have a minimum flammability rating of V-2, V-1, V-0, or 5VA.

2.14.6.2 A printed wiring board containing circuitry that is derived from and continues to comply with the Class 2 voltage and energy limitations shall have a minimum flammability rating of HB.

2.14.6.3 A printed wiring board containing circuitry that is encapsulated in a potting material shall have a minimum flammability rating of HB.

2.14.6.4 A component that is mounted on a printed wiring board shall be secured so that it cannot be displaced by a force likely to be exerted on it during assembly, intended operation, or servicing of the device. A component of a printed-wiring assembly that is covered by potting compound or is secured by surface mount technology (SMT) is determined as having the required mechanical securement.

2.14.6.5 A conformal coating on a printed wiring board shall comply with the conformal-coating requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or;

a) Be at least 0.4-mm (1/64-in) thick; and

b) Comply with the requirements in 3.4.1.14.1 and 3.4.1.14.2.

2.14.7 Motor

2.14.7.1 A motor, other than a motor powered from a Class 2 source, shall be protected from overheating due to overload and locked-rotor conditions by either impedance protection or a form of over current or thermal protection that complies with the requirements for the device type with a calibrated opening current or temperature.

2.14.8 Capacitors

2.14.8.1 A capacitor connected across the input supply line for electromagnetic interference suppression shall comply with the requirements for across the line type devices.

2.14.8.2 A capacitor, other than the type specified in 2.14.8.1 and 2.14.8.3, shall be rated for the appropriate voltage and the maximum available fault current (AFC) to which it may be subjected, as follows:

a) A value of 10,000 A minimum when connected directly across the branch circuit;

b) A value of 200 A minimum when connected in series with a ballast coil; or

c) The maximum current available to the capacitor under capacitor short-circuit condition, as determined by investigation.

2.14.8.3 A dry metalized-film type capacitor operating at a maximum of 330 V is not be required to have a maximum available fault current rating.

2.14.8.4 A component incorporating a capacitor with terminals that are accessible shall:

a) Have a maximum rating of 0.06 F and a maximum operating potential of 500 Vpeak; or

b) Provide means to discharge the capacitor within 1 min after removal of the capacitor voltage, in accordance with 2.14.8.5 to 2.14.8.7.

2.14.8.5 The means to discharge the capacitor may consist of a bleeder resistor or a closed loop of the circuit that is not opened by lamp removal or operation of a switch, fuse, or similar device.

2.14.8.6 The voltage across the capacitor terminals at the end of 1 minute shall be reduced to a value of 50 V or less, and the energy stored shall be less than 20 J, as determined by the equation:

$$J = 5 \times 10^{-7} C V^{2}$$

where:

J is the energy stored in joules;

C is the capacitor rating in microfarads; and

V is the capacitor peak voltage in volts.

2.14.8.7 The maximum value of a bleeder resistor shall be determined by the equation:

$$R \times K / C$$

where:

R is the resistance value in MΩ;

K is the resistor factor determined from Table 2.16; and

C is the capacitor rating in μF.

Table 2.16
Bleeder resistor factor (K)

Capacitor voltage		Factor (K)
RMS V	Peak V	
0 – 70	0 – 100	85
71 – 78	101 – 110	76
79 – 85	111 – 120	70
86 – 92	121 – 130	63
93 – 99	131 – 140	55
100 – 106	141 – 150	54
107 – 120	151 – 170	50
121 – 141	171 – 200	44
142 – 169	201 – 240	39
170 – 197	241 – 280	35
198 – 230	281 – 325	32
231 – 265	326 – 375	30
266 – 318	376 – 450	27
319 – 353	451 – 500	26
354 – 495	501 – 700	23
496 – 707	701 – 1000	19
Note – For a transformer type ballast, the voltage value to be applied from this table is the rms voltage rating of the capacitor as specified on the ballast.		

2.14.8.8 An oil-filled capacitor shall be provided with an expansion spacing between any other part of the sign component and the capacitor terminals in accordance with 2.14.8.9, unless marked otherwise on the capacitor.

2.14.8.9 The minimum expansion spacing perpendicular to the capacitor terminal shall be:

a) 11 mm (0.44 in) for a maximum of 300 V; or

b) 13 mm (0.50 in) for a voltage more than 300 V.

2.14.9 Power sources

2.14.9.1 A power source for LED units shall comply with the requirements of other appropriate standards or comply with applicable requirements in 4.18.

2.14.9.2 A power source shall be required to operate at its rated input and output ratings.

2.14.10 Transformers

2.14.10.1 A transformer shall comply with the requirements of other appropriate standards listed in Appendix A of this standard.

2.15 Spacings

2.15.1 Unless otherwise permitted in 2.15.2, 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) Field wiring terminals, dry, damp or wet location use – see Table 2.17;

b) Live parts not including field wiring terminals:

1) Spacings – For damp or wet location use, see Table 2.18, and

2) Spacings – For dry location use only, see Table 2.19.

c) Spacings are not required for the components and circuitry as specified in 2.15.2.

2.15.2 The requirements of 2.15.1 are not applicable to the following components and circuitry:

a) Parts encapsulated in a potting compound,

b) The inherent spacings of discrete components,

c) Circuitry operating within Class 2 limits,

d) Spacings between traces on a printed-wiring board when:

1) The printed-wiring board has a flammability rating of V-0 and complies with the Abnormal Tests in 3.4.2.7, and

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

e) Spacings in circuitry involving other than field-wiring terminals and live parts to accessible dead-metal are not prohibited from being evaluated to the spacing requirements in the Standard for Safety for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as amended in 2.15.4, in lieu of the spacings in Table 2.17 – Table 2.18,

f) Spacings on a printed-wiring board assembly provided with a conformal coating are not required to comply with Table 2.18 – Table 2.19 when the spacings comply with Table 2.20 before the printed-wiring board assembly is coated and the coating complies with the requirements for Printed Wiring Boards with Conformal Coatings, 2.14.6.5.

Table 2.17
Spacings at field wiring terminals

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

Table 2.18
Spacings, damp and wet locations, live parts and terminals other than field wiring terminals

Voltage range	Through-air spacing		Over-surface spacing	
	mm	(in)	mm	(in)
0 – 15	3.2	(0.126)	6.4	(0.252)
16 – 30	3.2	(0.126)	6.4	(0.252)

Table 2.18 Continued on Next Page

Table 2.18 Continued

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

Table 2.19
Spacings, dry locations only, live parts, other than field wiring branch circuit supply terminals

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

Note – 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 0.58 mm (0.0230 in) plus 0.005 mm (0.0002 in) 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 2.20
Spacings, dry, damp and wet locations, live parts, other than field wiring branch circuit supply terminals, on printed wiring boards with conformal coating or potting

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

2.15.3 The spacings between uninsulated and insulated live parts of opposite polarity and between insulated parts, regardless of conformal coating, shall be as specified in Table 2.21. The spacings between insulated live parts and the plane of a mounting surface in a sign shall be as specified in Table 2.21. To be considered an insulated live part, the insulation either must be an integral part of a separately investigated component or comply with 2.13, Insulating Materials.

Table 2.21
Spacings, live parts, uninsulated to insulated, insulated to insulated and insulated to dead metal regardless of conformal coating or potting

Voltage range	Uninsulated to insulated		Insulated to insulated		Insulated to dead-metal	
	mm	(in)	mm	(in)	mm	(in)
0 – 600	Not applicable		Not applicable		Not applicable	
601 – 1,000	19.1	(0.75)	6.4	(0.252)	3.2	(0.126)
1,101 – 2,500	19.1	(0.75)	9.5	(0.375)	6.4	(0.252)
2,501 – 5,000	19.1	(0.75)	12.7	(0.50)	6.4	(0.252)
5,001 – 10,000	28.4	(1.12)	19.1	(0.75)	9.5	(0.375)
10,001 – 15,000	38.1	(1.50)	25.4	(1.00)	12.7	(0.50)
Note – Insulated in accordance with Table 2.14						

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

a) For dry location only components, the Pollution Degree shall be 2;

b) For damp or wet location components, the Pollution Degree shall be 3;

c) Hermetically sealed or encapsulated enclosures, or printed-wiring boards with conformal coating are identified as Pollution Degree 1;

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

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

f) To apply Clearance B (controlled overvoltage), a component 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) Performance Level Category (PLC) of 1.

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

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

2.16 Markings

2.16.1 A marking shall be legible and use one or more of the following methods:

a) Lettering on a pressure-sensitive label;

b) Paint stenciled lettering;

c) Ink-stamped machine lettering;

d) Ink-hand-stamped lettering;

e) Indelibly printed lettering;

f) Die-stamped lettering;

g) Embossed lettering;

h) Molded or cast lettering; or

i) Other legible means.

2.16.2 A marking shall comply with the format designation and location as specified in Table 2.22 and Table 2.23. Format designation and location such as S24-L3 is 2.4-mm (0.094-in) letter height in Univers bold font located where visible during installation and be nonpermanent in a dry location and permanent in a damp or wet location.

Table 2.22
Format minimum size designation for marking height and typeface

Size designation	Letter height		Typeface, upper case
	mm	(in)	
S16	1.6	(0.062)	Not specified
S24	2.4	(0.094)	Universal bold
S32	3.2	(0.125)	Not specified

Table 2.23
Format location designation for marking

Location designation	Description	Label exposed to a dry environment	Label exposed to a damp/wet environment
L2	Visible during installation	Type N	Type P
L3	Visible during installation and inspection of wire connections near supply connections	Type N	Type P

Note:

Type P – Permanent label or nameplate

A label that is intended to remain in the applied position for the lifetime of the sign under conditions of normal use.

Uses: Information required for user maintenance over the expected life of the product.

Material: Metal, plastic, or other suitable material with an adhesive suitable for the temperature involved and comply with 3.4.1.13.

Type N – Non-permanent label or nameplate

A label that is intended to remain in place only for the purpose of installation.

Uses: Certification mark, manufacturer's identification, product identification

Material: Paper with an adhesive suitable for the temperature involved.

2.16.3 A sign component shall be plainly marked in S24-L2 with the name or trademark of the manufacturer or other descriptive marking by which the organization responsible for the product may be identified, the model designation, and date code of at least month and year of manufacture.

2.16.4 A component produced or assembled at more than one factory shall have a distinctive marking – which may be in code by which it is able to be identified as manufactured at a particular factory.

2.16.5 Text enclosed by parentheses "Verbatim" indicates that the marking shall consist of only the exact words shown or a marking including these words and conveying the original intent.

2.16.6 A cord-connected component not provided with a grounding-type cord in accordance with 2.11.4 shall be marked verbatim in format S24 – L2 "CAUTION – No Grounding Provided, Do Not Use In A Sign Having Any Metal Required to be Grounded".

2.16.7 A fuse replacement marking shall be provided adjacent to a fuseholder providing fuse identification and ampere rating. The wording shall be FUSE (identification) ___ A.

3 Tests – General

3.1 General

3.1.1 The tests applicable to a component are specified in Sections 4 and 5 of this standard.

3.1.2 Unless specified for a particular conditioning or test procedure, all conditioning and tests are to be conducted on parts that have been molded or formed in the configuration provided in the sign component.

3.2 Polymeric material evaluation

3.2.1 Polymeric material conditioning

3.2.1.1 Accelerated aging – wire, cable, GTO sleeving and neon electrode enclosures

3.2.1.1.1 Samples are to be conditioned in an air-circulating oven set to maintain a temperature in accordance with Table 3.1 based on the maximum service temperature measured during the Normal Temperature Test in 3.4.2.3 for 168 h.

Table 3.1
Oven aging temperature and time

Maximum service temperature		Oven time and temperature		
°C	(°F)	°C	(°F)	Time in h
60	(140)	100	(212)	70
75	(167)	100	(212)	168
80	(176)	113	(235)	168
90	(194)	121	(250)	168
105	(221)	136	(277)	168

3.2.1.2 Accelerated aging with thermal cycling conditioning – wire, cable, GTO sleeving and neon electrode enclosures

3.2.1.2.1 Three samples are to be subjected to conditioning for 336 h in a full-draft circulating-air oven and 168 h in ambient conditions. During the first 168 h, the samples are to be conditioned in the oven set to maintain a temperature of 155 ±1.0°C (302 ±1.8°F). After 168 h, the samples are to remain in the oven except with the circulating air oven de-energized and allowed to cool to ambient conditions for 24 h. After 24 h, the oven in which the samples have remained is to be operated again at a temperature of 155 ±1.0°C (302 ±1.8°F) for 24 h. This 24 h alternating cycle of elevated ambient and normal ambient is to be repeated 6 more times until the 504 h of conditioning has been completed.

3.2.1.2.2 Following the conditioning, the samples are to be retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h before being subjected to any other conditioning or testing.

3.2.1.3 Thermal cycling exposure

3.2.1.3.1 Three samples are to be subjected to five cycles of exposure. Each cycle shall be for a total of 74 h. Each cycle shall consist of three 24-h periods of conditioning and between each 24-h period of conditioning, the samples are to be placed in a room temperature ambient for 1 h. The first 24-h period shall consist of being in an ambient temperature of 100°C (212°F). The second 24-h period shall be in an ambient of 97% relative humidity at 60°C (140°F). The last 24-h period shall be in an ambient of minus 40°C (minus 40°F). After the 5 cycles are completed, the samples are to be placed in a room temperature ambient for 1 h before being subjected to any tests.

3.2.1.4 Ozone exposure conditioning

3.2.1.4.1 Three samples are to be mounted in the specimen holder in a looped position as specified in Procedure B of the Standard Test Method for Rubber Deterioration, ASTM D518-86. The ozone test chamber is to be as specified in the Standard Test Method for Rubber Deterioration – Surface Ozone

Cracking in a Chamber, ASTM D1149-86. The specimen holder is to be as specified in the Standard Test Method for Rubber Deterioration – Surface Cracking, ASTM D518-86.

3.2.1.4.2 The mounted samples are to be subjected to an ozone partial pressure of 10,000 – 15,000 mPa for 70 h and a temperature of 40 ±2°C (104 ±3.6°F).

3.2.1.4.3 Following the conditioning, the samples are to be retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h before being subjected to any other conditioning or testing.

3.2.1.5 Ultraviolet radiation exposure conditioning

3.2.1.5.1 Three samples of a material shall be subjected to ultraviolet radiation using the following equipment:

a) Twin enclosed carbon-arc, Type D, in accordance with Standard Practice for Operating Light Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G23. Exposure Method 1, continuous exposure to water spray, with a programmed cycle of 20 min consisting of a 17-min light exposure and a 3-min exposure to water spray with light shall be used. The apparatus shall operate with a black-panel temperature of 63 ±3°C (145.4 ±5.4°F), or

b) Xenon-arc, Type B, in accordance with Standard Practice for Operating Light Exposure Apparatus (Xenon-Arc Type) With and Without Water for exposure of Nonmetallic Materials, ASTM G26. Exposure Method 1, continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of 120 min consisting of 102 min light exposure and 18 minute exposure to water spray with light shall be used. The apparatus shall operate with a 6500 W, water cooled xenon-arc lamp, borosilicate glass inner and outer optical filters, a spectral irradiance of 0.35 W/m^2 nm at 340 nm and a black-panel temperature of 63 ±3°C (145.4 ±5.4°F).

3.2.1.5.2 The samples are to be mounted vertically on the inside of the cylinder in the ultraviolet-light apparatus, with the width of the specimen facing the arc and so that they do not touch each other. For twin enclosed carbon-arc, the samples are to be exposed for a total of 720 h. For xenon-arc, the samples are to be exposed for a total of 1000 h.

3.2.1.5.3 Following the conditioning, the samples are to be retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h before being subjected to any other conditioning or testing.

3.2.1.6 Humidity conditioning

3.2.1.6.1 Three test samples are to be exposed to an ambient temperature of 40 ±2°C (104 ±3.6°F) while the relative humidity is adjusted six times between 20±5 and 93±5%. The test cycle sequence is to consist of alternating periods of minimum and maximum relative humidity. Each cycle is to consist of 8-h exposure to each of the specified humidity levels. The time required to reach each level is not to exceed 1 h.

3.2.1.6.2 Following the conditioning, the samples are to be retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h before being subjected to any other conditioning or testing.

3.2.1.7 Cold conditioning

3.2.1.7.1 Three samples shall be conditioned for 24 ±1/2 h in a minus 40 ±2°C (minus 40 ±3.6°F) and minus 54 ±2°C (minus 65 ±3.6°F) ambient.

3.2.1.7.2 Following the conditioning, the samples are to be retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h before being subjected to any other conditioning or testing.

3.2.1.8 Ozone, ultraviolet radiation, heat and moisture conditioning

3.2.1.8.1 Three samples are to be subjected to 1440 h of conditioning. The three samples to be conditioned are to be installed according to the installation instructions as part of the ultraviolet radiation generator and the ozone generator consisting of the components specified in 3.2.1.8.2 and 3.2.1.8.4. The ultraviolet radiation and ozone generators are to be constructed as specified in 3.2.1.8.3 and 3.2.1.8.5. The two generators are to be inserted into a chamber and operated as specified in 3.2.1.8.6 – 3.2.1.8.9.

3.2.1.8.2 Ultraviolet radiation generator consists of the following components:

a) Four 10-mm (0.4-in) double back electrode enclosures,

b) Two 10-mm (0.4-in) straight electrode enclosures,

c) Three 122-cm (4-ft) lengths of 10-mm (0.4-in) diameter, 6500 White Mercury Tubing,

d) Two lengths of 30.4-cm (12-in) long GTO cable,

e) Two lengths of 76.2-cm (30-in) long GTO cable,

f) Two lengths of 25.4-cm (10-in) long GTO cable sleeving, and

g) Two lengths of 71.1-cm (28-in) long GTO cable sleeving.

3.2.1.8.3 The ultraviolet radiation generator is to be assembled as follows:

a) A 76.2-cm (30-in) length of GTO Cable is to be slid through the backside of a straight electrode enclosure and extended beyond the opening of the electrode enclosure and 38-mm (1.5-in) of GTO cable insulation stripped off.

b) The electrode leads of one end of a 6500 White mercury tube are to be spliced to the stripped end of each of the 30.4-cm (12-in) GTO cables. The electrode enclosure is then to be positioned over the tube to enclose the splice.

c) The other end of each of the mercury tubes is to be inserted into a double back electrode enclosure base.

d) A 76.2-cm (30-in) length of GTO cable is to be inserted parallel to the mercury tube into each of the double back electrode enclosure bases and the electrode leads spliced to the 76.2-cm (30-in) GTO cable leads.

e) A 71-cm (28-in) length of GTO sleeving is to be slid over the 76.2-cm (30-in) GTO cable and mated to the electrode enclosure base.

f) The electrode enclosures are to be assembled in accordance with the manufacturer's installation instructions.

g) To the other end of each 76.2-cm (30-in) GTO cable another double back electrode enclosure base is to be slid over the GTO cable and 38 mm (1.5 in) of the end of the cable stripped of insulation.

h) Each end of the third piece of mercury tube is to be inserted into the double back electrode enclosures that were earlier placed on the 76.2-cm (30-in) GTO cable attached to end of the mercury tubes.

i) Each end of the 76.2-cm (30-in) GTO cable is to be spliced to the electrode leads of the mercury tube.

3.2.1.8.4 The ozone generator is to consist of the following components:

a) Two 15 mm (0.6-in) straight electrode enclosures,

b) Two lengths of 122-cm (48-in) long GTO cable,

c) One length of 152-cm (60-in) long GTO cable,

d) Two lengths of 30.4-cm (12-in) long GTO cable sleeving, and

e) Two lengths of 114-cm (45-in) long GTO cable sleeving.

3.2.1.8.5 The ozone generator is to be assembled as follows:

a) The 152-cm (60-in) length of GTO Cable is to be slid into the two 30.4-cm (12-in) lengths of GTO Cable sleeving.

b) One end of each of the 122-cm (48-in) lengths of GTO Cable is to be slid into a 114-cm (45-in) length of GTO sleeving.

c) Each end of the 152-cm (60-in) GTO cable is to be inserted into the opening in a straight electrode enclosure as intended for assembly in accordance with the manufacturer's installation instructions.

d) The GTO cable is to be inserted until the end extends beyond the neon tube opening of the electrode enclosure by 38 mm (1.5 in).

e) The last 25.4 mm (1 in) of cable insulation is too be stripped off the cable. A 122-cm (48-in) cable is to be spliced to each end of the 152-cm (60-in) cable extending through the electrode enclosure.

f) After being spiced together, the straight electrode enclosures are to be slid toward the 122-cm (48-in) cables until the splice and the 30.4-cm (12-in) length of GTO sleeving inserts into the straight electrode enclosure.

g) Each 114-cm (45-in) GTO Cable Sleeving is to be slid up to the electrode enclosure and mated with the collar of the straight electrode enclosure.

3.2.1.8.6 The two generators are to be inserted next to each other into a 3-m (10-ft) length of 2½-in diameter trade size EMT. From each end of the EMT at a distance of 15.2 cm (6 in), a 6.35-mm (1/4-in) hole shall be made into which a 30.4-cm (12-in) long, 1/4-in OD, copper tube can be inserted. This tube shall be provided with a removable tape seal at the top. Where sleeving is inserted into the neon tubing opening of a electrode enclosure base and where the GTO Cable Sleeving is not continuous from electrode enclosure to electrode enclosure, RTV Silicone is to be used to make a seal to prevent the entrance of water into the assembly.

3.2.1.8.7 Each assembly is to be connected to the output terminals of a midpoint ground referenced 15 kV, 30 mA gas-tube sign transformer. The mercury tube is to be connected across the output of a transformer and the input voltage of the transformer adjusted to obtain 24 mA of current through the mercury tube. The assembly with no mercury tube is to have only one end connected to another 15 kV transformer and the other end capped off, enclosed, insulated and not connected to the transformer.

3.2.1.8.8 The EMT containing the assemblies is to be wrapped with a pipe heating cable and then with thermal insulation. The pipe heating cable shall be energized and adjusted to cause the EMT to have an average outside temperature of 90°C (194°F).

3.2.1.8.9 Both assemblies are to be operated continuously for 60 days. Five days each week, 8 drops of tap water are to be added to each of the holes drilled 15.2 cm (6 in) from each end of the EMT assembly. The cover is to be replaced.

3.2.1.9 Material compatibility conditioning

3.2.1.9.1 Six test assemblies are to be constructed in accordance with the manufacturer's installation instructions using the materials that may potentially interact with each other. The assemblies are to include any other peripheral components associated with the assembly that represents field conditions.

3.2.1.9.2 The six assemblies are to be subjected to the following aging/exposure cycle:

a) Oven – The samples are to be thermally aged in a forced air oven set at a temperature of 155°C (311°F) for 336 h. After 336 h, the samples are to be removed from the oven and allowed to cool to room temperature. Unless designated for use in dry locations only, the assemblies are then to be subjected to the cold shock and moisture conditions specified below.

b) Cold Ambient – The samples are to be subjected to cold ambient conditioning in a 20°C (38°F) ambient for 2 h or until the samples reach thermal equilibrium. After 2 h the samples are to be removed from the cold and within 2 min set into a humidity chamber as specified below.

c) Moisture – The samples are to be placed in a humidity chamber maintained at 88 ±2% at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F) for 48 h. The samples are to be arranged to prevent condensation from dripping on the samples or collecting inside the samples.

3.2.2 Material tests

3.2.2.1 Flammability test

3.2.2.1.1 General

3.2.2.1.1.1 The tests in this section are for determining that a material is self-extinguishing type, V-2, V-1, V-0, or 5-VA and 5-VB, the slow burning type, HB, and the thin material vertical burning type, VTM-2, VTM-1, or VTM-0 as identified in Table 3.2.

Table 3.2
Flammability ratings

Flammability rating	Identifying characteristic
V-2	Material has flaming drip that falls to cotton below test sample, self extinguishes within 1 minute and drip is permitted to ignite cotton. The test flame is permitted to penetrate the test sample where the test flame was applied.
V-1	Material has flaming drip that falls but the drip self extinguishes before reaching cotton below test sample. The test flame can penetrate the test sample where the test flame was applied.
V-0	Material does not drip and self extinguishes within 1 min. The test flame can penetrate the test sample where the test flame was applied.
5VA	Material self extinguishes within 1 minute and the test flame does not penetrate the test sample where the test flame was applied.
HB	Material does not self extinguish and burns horizontally at a rate of no greater than 25 mm (1 in) per 1-1/2 min.
VTM-2	Material has flaming drip that falls to, and can ignite, cotton below the test sample, self extinguishes within 250 s and does not continue to glow for more than 1 min.

Table 3.2 Continued on Next Page

Table 3.2 Continued

Flammability rating	Identifying characteristic
VTM-1	Material has flaming drip that falls to, but cannot ignite, cotton below the test sample, self extinguishes within 250 s and does not continue flame for more than 1 min.
VTM-0	Material has flaming drip that falls to, but cannot ignite, cotton below the test sample, self extinguishes within 50 s and does not continue to flame for more than 30 s.

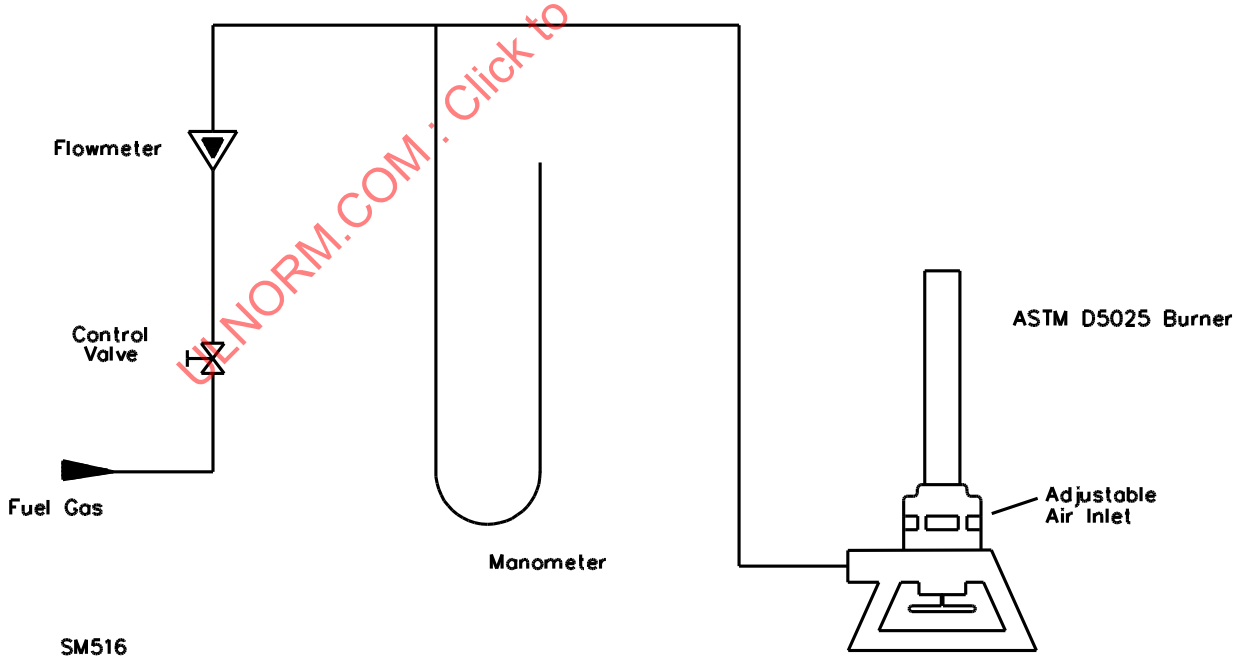
3.2.2.1.1.2 The flammability tests specified in this section are to be applied to complete components or parts thereof. Consideration shall be given to leaving in place components or other parts that might influence the flammability of the material. Additionally, the flammability tests specified in this section are to be applied to each color of a formed sample of the polymeric material that is to be covered or test samples of each color of material to be covered. Flammability testing of white, black, blue and yellow colored material are permitted to represent other colors of materials.

3.2.2.1.1.3 Three samples of each color of the formed part or test samples of the minimum thickness of the formed part are to be tested. Each sample is to be conditioned in a full draft circulating air oven for 7 days at a temperature that is 10°C (18°F) greater than the maximum use temperature, but not less than 70°C (158°F) prior to testing. Prior to subjecting the samples to the test flame, the samples are to be conditioned for a minimum of 4 h at 23 ±2°C (73 ±3.6°F) and 50 ±5% relative humidity.

3.2.2.1.1.4 The burner supply arrangement for each test shall be as shown in Figure 3.1 using either a Bunsen or Tirrill burner.

Figure 3.1

Burner supply arrangement



3.2.2.1.1.5 The test flame for each flammability rating test shall be as specified in Table 3.3 with the flame in the vertical position.

Table 3.3
Test flame

Flammability rating	Flame height		Flame conditions
	mm	(in)	
V-2, V-1, V-0	19	(3/4)	Small yellow flame with blue cone
V-2, V-1, V-0	12	(1/2)	Small yellow flame with blue cone
5VA	127	(5)	Yellow flame, no blue cone
HB	12 or 19	(1/2 or 3/4)	Small yellow flame with blue cone
VTM-2, VTM-1, VTM-0	20	(3/4)	Blue flame, no yellow tip

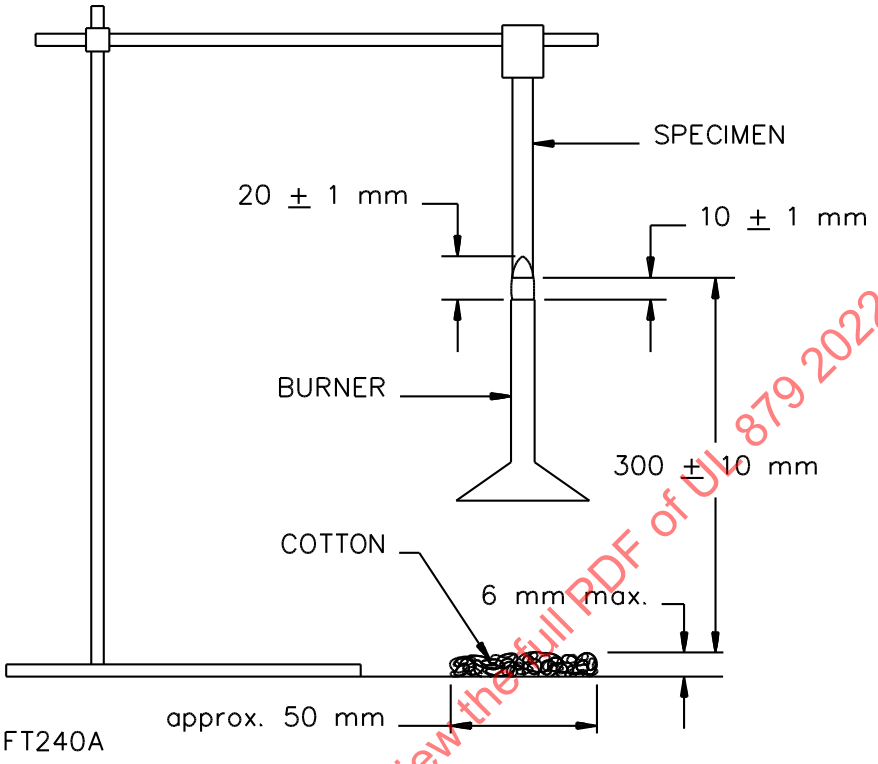
3.2.2.1.2 Self extinguishing V-2, V-1, and V-0 testing procedure

3.2.2.1.2.1 The three samples are to be subjected to one of two test flames produced from a Bunsen or Tirrill burner. For a 19-mm (0.75-in) test flame the burner is to have a tube length of 100 ±10 mm (3.9 ±0.39 in) and an inside diameter of 9.5 ±0.3 mm (0.37 ±0.012 in). For a 12-mm (0.5-in) test flame, the burner shall have a tube at least 35-mm (1.4-in) long having an inside diameter of 0.5 ±0.1 mm (0.02 ±0.004 in) and an outer diameter not exceeding 0.9 mm (0.035 in) and no air ports. The burner for the 19-mm (0.75-in) test flame is to be supplied by technical grade methane gas with regulator and meter for uniform gas flow or natural gas having a heat content of approximately 37 MJ/m^3 (1000 Btu/ft^3) in the arrangement shown in Figure 3.1. The gas supply for the 12-mm (0.5-in) test flame is to be butane having a purity of at least 95% and a heat content of approximately 122 MJ/m^3.

3.2.2.1.2.2 Each sample is to be mounted in the Vertical Flame Test Setup shown in Figure 3.2 and the 19-mm (0.75-in) or 12-mm (0.5-in) flame is to be applied to the part being tested twice. The 12- and 19-mm (0.5- and 0.75-in) flame is to be applied for 30 s each time with a 1-min interval of no flame between each application of the flame. The test flame is to be applied to the center of the part or sample to be tested, and not at an edge or near an opening of the part or sample.

Figure 3.2

Vertical burning test for V-0, V-1, and V-2 classification

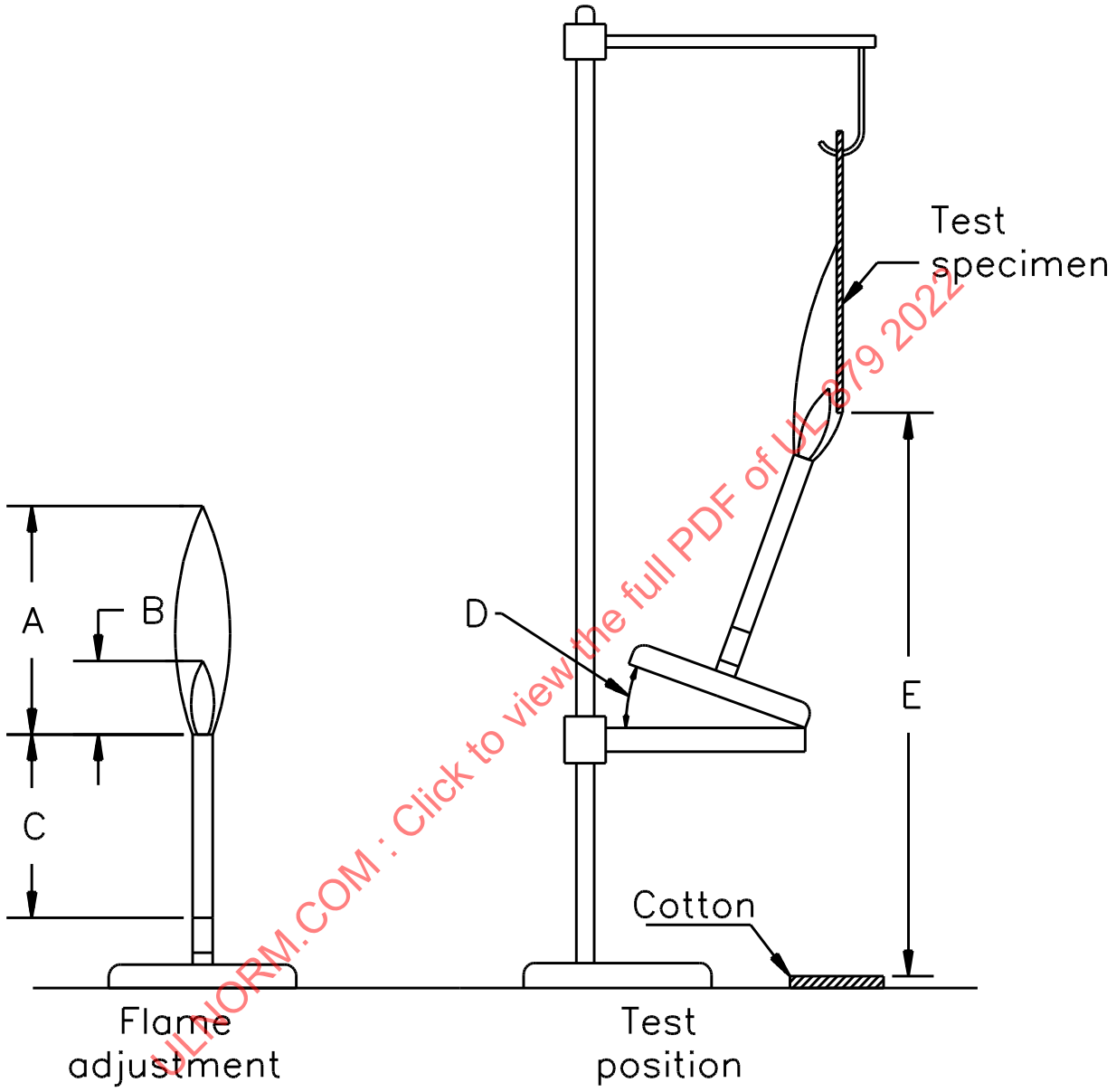


3.2.2.1.3 Self extinguishing 5 VA testing procedure

3.2.2.1.3.1 The test conditions are to be the same as for the V-2, V-1, and V-0 Testing Procedure except a 127-mm (5-in) flame test is to be used and a layer of surgical cotton is to be located 305 mm (12 in) below the point of application of the test flame. See Figure 3.3

Figure 3.3

Five-inch flame test



Notes:

A – Flame height is 127 mm (5 inch) in the vertical position

B – Inner flame cone height is 40 mm (1.5 in)

C – Burner tube length is 89 – 101 mm (3.50 – 4 in)

D – Burner base test mounting angle is 20° from the horizontal

E – Cotton location is 305 mm (12 in) directly below test specimen

3.2.2.1.3.2 The 127-mm (5-in) flame is to be applied for 5 s each time with a 5-s interval of no flame between each application of the flame. This cycle shall be repeated 5 times.

3.2.2.1.3.3 The material must not be:

a) Consumed as a result of the application of the test flame; and

b) Not continue to burn for more than one minute after the application of the test flame.

3.2.2.1.3.4 A material that complies with 3.2.2.1.3.3 is identified with respect to flammability by the criteria specified in Table 3.3.

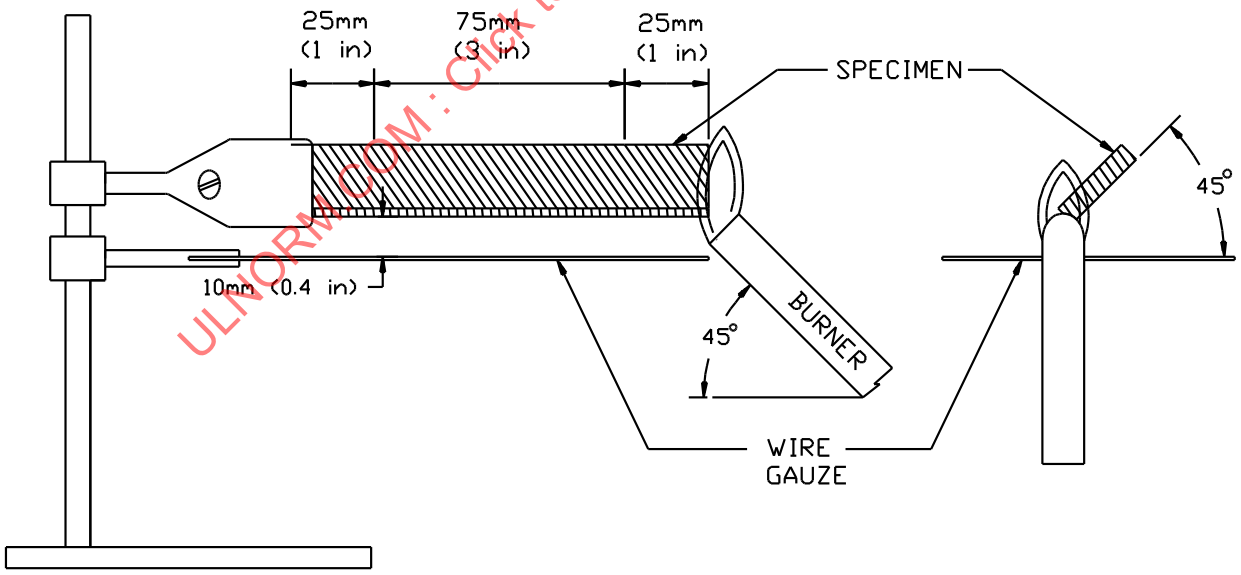
3.2.2.1.4 Slow burning HB testing procedure

3.2.2.1.4.1 Three samples of the material that are 125 ±5-mm (4.9 ±0.2-in) long by 13.0 ±0.5-mm (0.5 ±0.2-in) wide and provided in the minimum thickness of the formed part, but no less than 3.0-mm (0.12-in) thick, shall be conditioned for 168 h in an air circulating oven set at 70 ±1°C (158 ±1.8°F) and then cooled in a desiccator for at least 4 h at room temperature prior to testing.

3.2.2.1.4.2 The samples are to be measured and marked 25 mm (1 in) from each end of the test samples and secured in a horizontal position as shown in Figure 3.4. The 12- or 19-mm (0.5 or 0.75-in) flame specified in Table 3.3, from a burner as specified in 3.2.2.1.2.1, shall be applied to one (the end not secured) end of the test sample for 30 s or less if the sample burns past the first mark 25 mm (1 in) from the end where the flame is being applied.

Figure 3.4

Horizontal burning test setup



3.2.2.1.4.3 The burning rate of the material is to be determined by measuring the time it takes for the material to burn from the first mark to the second mark on the sample. The time is to be measured from the moment the flame reaches the first mark until the moment it reaches the second mark.

3.2.2.1.4.4 The samples are considered to be HB if the flame does not burn past the second mark or does so after more than 72 s if the test sample is greater than 3.0-mm (0.12-in) thick or 60 s if 3.0-mm (0.12-in) thick or less.

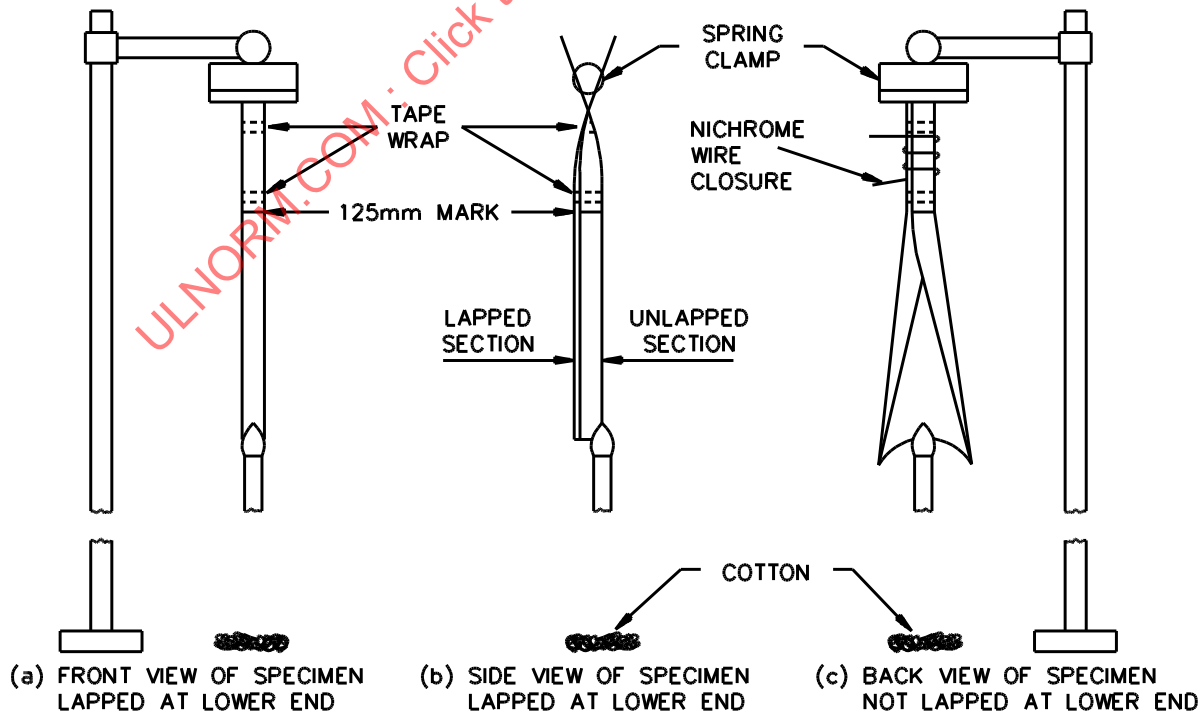
3.2.2.1.5 Thin material vertical burning VTM-2, VTM-1 and VTM-0 testing procedure

3.2.2.1.5.1 Ten colored test samples are each to be cut to 200 mm (7.9 inches) in length by 50 mm (1.9 inches) in width and shall be marked by a line across the sample width, 125 mm (4.9 in) from one end. The longitudinal axis of the sample is to be wrapped tightly around the longitudinal axis of a 12.7 ±0.5 mm (0.5 ±0.02-in) diameter mandrel to form a lapped cylinder 200-mm (7.9-in) long with the 125-mm (4.9-in) line exposed. The overlapping ends of the sample are to be secured within the 75-mm (2.9-in) portion above the 125-mm (4.9-in) mark (upper tube section) by pressure sensitive tape. The mandrel is then to be removed.

3.2.2.1.5.2 When testing stiff specimens, reinforce or replace the pressure-sensitive tape by wrapping nichrome wire around the top 75 mm (2.9 in) of the specimen. When required to test different generic materials, although capable of being wrapped and taped around the mandrel, there are varying degrees of flaring out of the untaped end, some of which results in an unlapped "U" type specimen. These various forms are considered acceptable to test if the upper end is capable of being formed into the cylinder. See Figure 3.5.

Figure 3.5

Thin material vertical burning test setup



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3.2.2.1.5.3 Five of the test samples are to be conditioned in accordance with the Standard Practice for Conditioning Plastics for Testing, ASTM D 618 (ISO 291) at 23 ±2°C (73.4 ±3.6°F) and 50 ±5% relative humidity for a minimum of 48 h. The other 5 samples are to be conditioned in an air-circulating oven for 168 h at 70 ±1°C (158 ±1.8°F) and then cooled in a desiccator for at least 4 h at room temperature. Once removed from the desiccator, the specimens are to be tested within 30 min.

3.2.2.1.5.4 Cotton for the test procedure shall be conditioned in a desiccator for at least 24 h prior to testing and be used for the test within 30 min of being removed form the desiccator.

3.2.2.1.5.5 The gas burner for the test shall be as specified in 3.2.2.1.2.1 with the methane gas supply to the burner arranged as in Figure 3.1. The gas shall be adjusted to produce a flow rate of 105 ml/min with a back pressure less than 10 mm water. See the Standard Practice for Confirmation of 20 mm (50 W) and 125 mm (500 W) Test Flames for Small-Scale Burning Tests on Plastic Materials, ASTM D5207.

3.2.2.1.5.6 Adjust the burner to produce a blue flame 20 ±1-mm (0.8 ±0.04-in) high. The flame is obtained by adjusting the gas supply and air ports of the burner until a 20 ±1-mm (0.8 ±0.04 in) yellow-tipped blue flame is produced. Increase the air supply until the yellow tip just disappears. Measure the height of the flame again and readjust it if necessary.

3.2.2.1.5.7 The test flame shall be calibrated in accordance with the Standard Practice for Confirmation of 20 mm (50 W) and 125 mm (500 W) Test Flames for Small-Scale Burning Tests on Plastic Materials, ASTM D5207 at least once a month and when the gas supply is changed, test equipment is replaced, or when data is questioned.

3.2.2.1.5.8 Apply the flame centrally to the middle point of the bottom edge of the unlapped specimen so that the top of the burner is 10 ±1 mm (0.4 ±0.04 in) below that point of the lower end of the specimen. Maintain the flame at that distance for 3 ±0.5 s, moving the burner as necessary in response to any changes in the length or position of the specimen (see Exception). If the specimen drips molten or flaming material during the flame application, tilt the burner at an angle of up to 45°. Withdraw it just sufficiently from beneath the specimen to prevent material from dropping into the barrel of the burner while maintaining the 10 ±1-mm (0.4 ±0.04-in) spacing between the center of the top of the burner and the remaining portion of the specimen, ignoring any strings of molten material. After the application of the flame to the specimen for 3 ±0.5 s, immediately withdraw the burner at a rate of approximately 300 mm/s to a distance at least 150 mm (5.9 in) away from the specimen. Simultaneously use the timing device to commence measurement of the after flame time, t_1, in seconds. Record t_1.

Exception: For specimens that are not lapped at their lower end when suspended from the pinched upper end, the flame is to be applied in line with the longitudinal axis of the specimen.

3.2.2.1.5.9 As soon as flaming of the specimen ceases, even if the burner has not been withdrawn to the full 150-mm (5.9-in) distance from the specimen, immediately place the burner under the specimen and maintain the burner at a distance of 10 ±1 mm (0.4 ±0.04 in) from the remaining portion of the specimen, while moving the burner clear of dropping material as necessary. After this application of the flame to the specimen for 3 ±0.5 s, immediately remove the burner at a rate of approximately 300 mm/s to a distance of at least 150 mm (5.9 in) from the specimen and simultaneously commence measurement of the after flame time, t_2, and the afterglow time, t_3, of the specimen. Record t_2 and t_3.

3.2.2.1.5.10 The following are to be observed and recorded:

a) After flame time after first flame application, t_1.

b) After flame time after second flame application, t_2.

c) After glow time after second flame application, t_3.

d) Whether or not specimens burn up to the 125-mm (4.9-in) mark.

e) Whether or not specimens drip flaming particles, which ignite the cotton indicator.

3.2.2.1.5.11 If only one sample from a set of 5 samples does not comply with the requirements for a specific rating in Table 3.4 or the total number of seconds of flaming is in the range of 51 – 55 s for VTM-0 or 251 – 255 s for VTM-1 or -2, an additional 5 samples shall be tested. All samples of the second set shall comply with the appropriate requirements in Table 3.4 to comply with the material classification.

Table 3.4
Thin material vertical flame material classifications

Criteria conditions	VTM-0	VTM-1	VTM-2
After flame time for each individual specimen t_1 or t_2	≤ 10s	≤ 30s	≤ 30s
Total after flame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤ 50s	≤ 250s	≤250s
After flame plus afterglow time for each individual specimen after the second flame application ($t_2 + t_3$)	≤ 30s	≤ 60s	≤ 60s
After flame or afterglow of any specimen up to the 125-mm (4.9-in) mark	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

3.2.2.2 Comparative tracking index performance level test

3.2.2.2.1 The comparative tracking Index performance level determination specified in this section is to be applied to each color of a formed sample of the polymeric material that is to be covered or test samples of each color of material to be covered. The test sample is to be a sample of the material made to have a flat surface of at least 101 by 101 mm (4 by 4 in) and be of at least the thickness of the minimum thickness of the formed part into which the material is to be used.

3.2.2.2.2 The voltage that causes a permanent electrically conductive carbon path on a polymeric material with the application of 50 drops of electrolyte that is applied at the rate of one drop every 30 s shall be determined under the conditions specified in the Standard Test Method for Comparative Tracking Index of Electrical Insulation Materials, ASTM D 3638-85 (IEC 112).

3.2.2.2.3 The assigned PLC for a CTI Range – Tracking Index (Volts) is as specified in Table 3.5.

Table 3.5
Comparative tracking index assigned PLC

Maximum tracking index voltage	Minimum tracking index voltage	Assigned PLC
Above 600	600	0
600	400	1
400	250	2
250	175	3
175	100	4
100	0	5

3.2.2.3 Hot-wire ignition (HWI) test

3.2.2.3.1 Five samples of a polymeric enclosure material shall be subjected to the hot-wire ignition test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C,

and Evaluation of Properties of Polymeric Materials-Second Edition; General Instruction No 1, CSA C22.2 No. 0.17.

3.2.2.3.2 The average time to ignition shall be not less than 15 s.

3.2.2.4 Glow-wire end product test

3.2.2.4.1 The test apparatus shall be in accordance with 3.2.2.4.9.

3.2.2.4.2 Components may, under fault conditions or overload conditions, attain a temperature that ignites or affects the enclosure or electrical parts in their vicinity. The glow-wire test simulates thermal stresses that may be produced by sources of heat or ignition, for short periods, in order to evaluate the risk of fire.

3.2.2.4.3 Test specimens less than 0.25 mm (0.010 in) or more than 6.4-mm (0.25-in) thick shall not be acceptable for this test method.

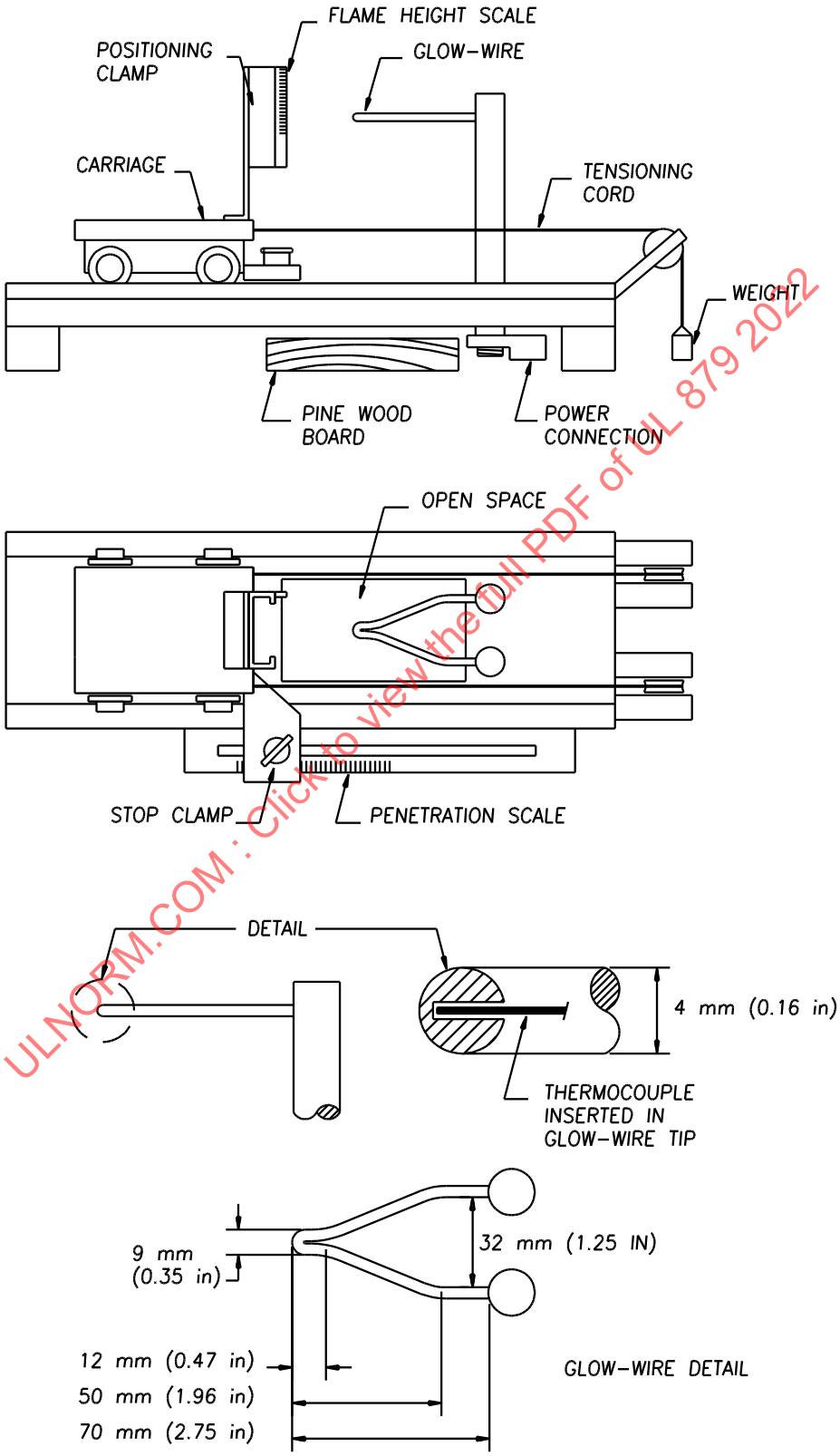
3.2.2.4.4 The test specimen shall be a complete subassembly or component. If it is necessary to cut off a suitable part to perform the test, the test conditions shall not be significantly different from those occurring in normal use with regard to shape, ventilation, effect of thermal stress, and possible flames, burning, or glowing particles falling in the vicinity of the specimen.

3.2.2.4.5 Three test specimens shall be conditioned at a temperature of 23 ±2°C (73.4 ±3.6°F) and a relative humidity of 50% for a period of 40 h prior to the glow-wire test. The glow-wire test shall be conducted at an ambient temperature of 25 ±5°C (77 ±9°F).

3.2.2.4.6 The specimen shall be fixed to the positioning clamp of the glow-wire test apparatus shown in Figure 3.6, so that heat losses due to the supporting means are insignificant. The tip of the glow-wire shall be applied to the part of the surface of the specimen that is likely to be subjected to thermal stresses in normal use. In cases where the areas subjected to the thermal stress during normal use are not specified in detail, the tip of the glow-wire shall be applied at the location where the section is thinnest, but no less than 15 mm (0.6 in) from the upper edge of the specimen. If possible, the tip of the glow-wire shall be applied to flat surfaces and not to grooves, knockouts, narrow recesses, or sharp edges.

Figure 3.6

Glow-wire test apparatus



3.2.2.4.7 Before each test the tip of the glow-wire shall be cleaned of any residue from previous tests.

3.2.2.4.8 The tip of the glow-wire shall be electrically heated to the temperature specified in Table 3.6 for the conditions involved, as measured by the calibrated thermocouple. Before the test is started, the temperature and the heating current shall be constant for a period of at least 60 seconds. Adequate screening is to be provided so that heat radiation does not influence the specimen during this period or during calibration.

Table 3.6
Glow wire test temperatures

Temperature		Parts of insulating material in contact with current-carrying parts or retaining them in position	Parts of insulating material for enclosures and covers not retaining current-carrying parts in position
°C	(°F)		
550 ±10	(1,022 ±18)	To ensure a minimum level of ignition of parts likely to contribute to a risk of fire.	To ensure a minimum level of ignition of parts likely to contribute to a risk of fire.
650 ±10	(1,202 ±18)	Equipment for attended use.	Fixed accessories in installations.
750 ±10	(1,382 ±18)	Equipment for attended use under more stringent conditions. Fixed accessories in installations.	Equipment attended use under more stringent conditions. Equipment intended for use near the supply point of a building.
850 ±10	(1,562 ±18)	Equipment for unattended use continuously loaded.	Equipment for unattended use continuously loaded.
950 ±10	(1,742 ±18)	Equipment for unattended use, continuously loaded under more stringent conditions. Equipment intended for use near the supply point of the building.	Equipment for unattended use, continuously loaded under more stringent conditions.

3.2.2.4.9 The Glow-wire test apparatus is to be as shown in Figure 3.6 which is an excerpt from Glow-wire Tests and Guidance, IEC Publication 695-2-1. Refer to the IEC Publication for complete apparatus details and operation.

3.2.2.4.10 The glow-wire shall consist of a specified loop of a nickel/chromium (80/20) wire with a nominal diameter of 4 mm (0.16 in). The loop shall be formed so as to prevent fine cracking at the tip.

3.2.2.4.11 A sheathed fine-wire thermocouple, having an overall diameter of 0.5 mm (0.02 in) and wires of NiCr and NiAl, Type K, with the welded point located inside the sheath, shall be used for measuring the temperature of the glow-wire. The sheath shall consist of a metal resistant to the temperature of at least 960°C (1,760°F). The thermocouple shall be arranged in a pocket hole, 0.6 mm (0.24 inch) in diameter, drilled in the tip of the glow-wire.

3.2.2.4.12 The instrument for measuring the thermovoltage shall be capable of reading 1,000°C (1,832°F) with an accuracy of 1°C (1.8°F).

3.2.2.4.13 The glow-wire shall be electrically heated with a low-voltage transformer, and the current required to heat the tip to a temperature of 960°C (1,760°F) shall be between 120 A and 150 A. A voltage adjustment method shall be provided to allow continuous adjustment of the power level to achieve the desired glow-wire tip temperature.

3.2.2.4.14 The positioning clamp shall be designed to support the test specimen and apply the glow-wire to the specimen in a horizontal plane with a force of 0.8 to 1.2 N (0.18 to 0.27 lb). The force shall be maintained at this value when the glow-wire or the specimen is moved horizontally towards the other. The mechanism shall allow at least 7-mm (0.275-in) penetration of the glow-wire into the specimen, and a stop mechanism shall be provided to mechanically limit penetration to a distance of 7 mm (0.275 in).

3.2.2.4.15 To evaluate the risk of spread of fire or the falling of glowing particles from the specimen, a piece of flat, smooth, white pine wood board, approximately 10-mm (0.4-in) thick and covered with a single layer of tissue paper, in loose contact, shall be located at a distance of 200 ±5 mm (7.8 ±0.2 in) below the glow-wire. The tissue paper shall be undyed, soft, strong, and lightweight, weighing between 12 and 30 gm/m (0.004 and 0.009 oz/ft).

3.2.2.5 High-current arc ignition (HAI) test

3.2.2.5.1 Three samples of a polymeric enclosure material shall be subjected to the high-current arc ignition test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and Evaluation of Properties of Polymeric Materials-Second Edition; General Instruction No 1, CSA C22.2 No. 0.17.

3.2.2.5.2 The average number of arcs to result in ignition for three samples tested shall not be less than 15.

3.2.2.6 End-product arc resistance test

3.2.2.6.1 The test current shall be based upon the maximum normal operating current. The voltage used for the test shall be equal to the available voltage at the live part. The arc shall be established between the live part and any adjacent part where breakdown is likely to occur. The arc shall be used to ignite materials forming parts of the enclosure or to ignite materials located between the parts of different potential. The arc shall be established by means of a copper or stainless steel conductive probe. The conductive probe shall be used to create arc tracking or a carbon build-up across the surface of the insulating material at the minimum rate of 30 arc separations per minute. There shall be no ignition of the insulating material.

3.2.2.7 Tensile strength and ultimate elongation test

3.2.2.7.1 The tensile strength and elongation tests are to be conducted on both unconditioned and conditioned samples having the minimum thickness for the material being used. The conditioned sample measurements shall not be less than 60% of the unconditioned sample measurements. Tensile strength and ultimate elongation tests are to be conducted on straight flat, tubular, or "dog bone" shaped specimens, or on flat straight segments from a sample. The elongation test is not required on composite materials.

3.2.2.7.2 "Dog Bone" shaped samples for testing are to be prepared by being subjected to buffing or skiving equipment as specified in the Standard Practice for Rubber – Preparation of Pieces for Test Purposes from Products, ASTM D3183-84.

3.2.2.7.3 "Dog bone" shaped Dies A, C or D are to be used for composite materials. The Dies are as specified in the Standard Test Methods for Rubber Properties in Tension, ASTM D412-92. A micrometer or equivalent is to be used for measuring "Dog Bone" shaped samples as specified in Method A in the Standard Practice for Rubber – Measurement of Dimensions, ASTM D3767-84. Standard sheets may not require buffing or skiving. Die D is to be used only when a specimen is too narrow to use Die C.

3.2.2.7.4 The minimum of three measurements is to be used as the thickness of the sample. A micrometer or equivalent is to be used for measuring flexible cellular material as specified in the Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber, ASTM D1056-91.

3.2.2.7.5 A bench marker, if required, is to be as specified in the Standard Test Methods for Rubber Properties in Tension, ASTM D412-92.

3.2.2.7.6 The tensile test equipment is to be as specified in the Standard Test Methods for Rubber Properties in Tension, ASTM D412-92.

3.2.2.7.7 An extensometer, scale, or other device is to be capable of indicating the elongation with an accuracy of 5 mm (0.2 in).

3.2.2.7.8 For elongation, two benchmarks, 25 mm (1 in) apart, are to be marked on the central portion of each specimen. If an extensometer is used that does not require bench marks, the bench marks may be omitted.

3.2.2.7.9 Tensile strength and ultimate elongation of the samples are to be determined in accordance with 3.2.2.7.10 – 3.2.2.7.13 using a power-driven testing machine as specified in the Test Methods for Rubber Properties in Tension, ASTM D412-92.

3.2.2.7.10 The rate of travel of the power-actuated grip is to be:

a) 127.0 ±6.4 mm (5 ±1/4 in) per minute for Composite Gasket Material, and

b) 508.0 ±25.4 mm (20 ±1 in) per minute for all other gaskets and seal materials.

3.2.2.7.11 The elongation, if required, is to be measured by means of a scale, extensometer, or other device indicating the elongation with an accuracy of 2.5 mm (0.1 in).

3.2.2.7.12 Each sample is to be placed in the grips of the power-driven testing machine so that the benchmarks are between and not covered by the grips. The movable grip is to be adjusted to make the specimen taut but not under tension. The grips are to be separated at the rate specified in 3.2.2.7.10 until rupture. During separation, the distance between benchmarks is to be measured and recorded at the point of rupture to the nearest 2.5 mm (0.1 in).

3.2.2.7.13 Calculations are to be made for each of the specimens and averaged using the following formulas. Specimen measurements for the calculation of the area are to be made before aging and exposure.

a) Tensile strength, psi equals F/A where:

F is the maximum observed force in pounds; and

A is the cross-sectional area of the unstressed specimen in inches-squared. See (b) – (e).

b) Cross-sectional area of die-cut or straight specimen equals W × T where:

W is the width of the constricted portion of the die-cut or straight specimen in inches; and

T is the minimum thickness of the specimen in inches.

c) Cross-sectional area of tubular specimen equals 0.7854 ($D^2 - d^2$) where:

D is the outside diameter in inches; and

d is the internal diameter in inches.

d) Cross-sectional area for irregular shaped specimens equals W / 163.87G where:

W is the grams mass (to the nearest 0.005 g) of a specimen length or lengths totaling 254 mm (10 in);

G is the specific gravity of the compound determined by means of the following: $G = W_1 / (W_1 + W_3 - W_2)$ in which:

W_1 is the gram mass on the balance pan of the specimen (to the nearest 0.005 g),

W_2 is the gram mass of the fully immersed specimen and its partially immersed suspending wire (to the nearest 0.005 g); and

W_3 is the gram mass of the partially immersed suspending wire.

See the Test Method for Specific Gravity and Density of Plastics by Displacement, ASTMD792-91 for details and explanation.

e) Elongation percent equals $[(L - L_o) / L_o] \times 100$ in which:

L is the measured distance between the bench marks at rupture; and

L_o is the original distance between the bench marks.

3.2.2.8 Breaking strength and tear resistance tests

3.2.2.8.1 Twenty four samples of a flexible material each 4 by 8 in (122 by 244 cm) are to be prepared. Twelve samples of material are to have the longer dimension in the warp direction and the other half of the samples in the woof direction.

3.2.2.8.2 Twelve samples that have not been conditioned, 6 with the longer dimension in the warp direction and 6 in the woof direction are to be subjected to the Breaking Strength and Tear Resistance Tests specified in 3.2.2.8.4 and 3.2.2.8.5. The other 12 samples are to be subject to the conditioning as required in Sections 4 and 5 for the particular component and then subjected to the Breaking Strength and Tear Resistance Tests specified in 3.2.2.8.4 and 3.2.2.8.5.

3.2.2.8.3 The force required to break and the force required to tear the test samples after conditioning shall not be less than 50% or the force required to break and tear the test samples that have not been subjected to conditioning.

3.2.2.8.4 Breaking strength is to be measured on 12 samples, 3 warp cut and 3 woof cut of both the unconditioned and conditioned specimens. Each specimen is to be mounted between the jaws of an Instron testing machine with a 25.4 by 25.4-mm (1 by 1-in) area gripped by the flat jaw surfaces. The jaws are then to be separated at a rate of 12 in/min until the material breaks.

3.2.2.8.5 Tear resistance is to be measured on 12 previously untested samples, 3 warp cut and 3 woof cut of both the unconditioned and conditioned specimens. Each specimen is to be mounted between the jaws of an Instron testing machine with a 25.4 by 25.4-mm (1 by 1-in) area gripped by the flat jaw surfaces. The jaws are then to be separated at a rate of 2 in/min until the material tears.

3.2.2.9 Polymeric sheet material impact test

3.2.2.9.1 Three samples of a rigid polymeric material are to be cut into squares of 31 by 31 cm (12 by 12 in). Each square of material is to be secured to a pine wood frame of 25 mm (1 in) by 50 mm (2 in) trade sized wood having the same outside dimensions by wood screws at each corner and at the center point of each side. Three samples are to be subjected to a 7 J (5 ft-lb.) impact created by dropping a steel sphere, 51 mm (2 in) in diameter and weighing 0.54 kg (1.18 lbs.), from the height necessary to produce the desired impact force. The steel sphere is to be suspended by a cord and swung as a pendulum from the prescribed distance or dropped through the vertical distance necessary to produce the desired impact force.

3.2.2.9.2 There shall be no cracking or breaking as a result of the impact.

3.2.2.10 Flexibility and hardness test

3.2.2.10.1 The hardness test is to be conducted on solid elastomer, the elastomer portion of coated fabrics and thermoplastic material and shall not show a reduction of flexibility or hardness of greater than 10 units between unconditioned and after conditioning.

3.2.2.10.2 The apparatus is to be as specified in the Standard Test Method for Rubber Property – Durometer Hardness, ASTM D2240-91 and Tests for Rubber Deterioration in an Air Oven, ASTM D573-88.

3.2.2.10.3 Three samples are to be as specified in the Standard Test Method for Rubber Property – Durometer Hardness, ASTM D2240-91. Three samples are to be subjected to the test procedure described in 3.2.2.10.4.

3.2.2.10.4 The test is to be as specified in the Standard Test Method for Rubber Property – Durometer Hardness, ASTM D2240-91. The samples are to be placed in a 23 ±2°C (73 ±3.6°F) ambient for at least 1/2 h before being tested. The hardness is the average results of the 3 samples.

3.2.2.11 Compression set test

3.2.2.11.1 The compression set test is to be conducted on solid elastomer material, the elastomer portion of coated fabrics and both open and closed flexible cellular material. The deflection as determined in 3.2.2.11.2 – 3.2.2.11.6 shall be no greater than 50%.

3.2.2.11.2 The apparatus is to be as specified in the Standard Test Methods for Rubber Property – Compression Set, Method B, ASTM D395-89 (1994) for solid elastomer materials and as specified in the Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber, ASTM D1056-91 for open and closed flexible cellular material.

3.2.2.11.3 Three specimens are to be prepared for each test. The specimens are to be Type 1 or plied discs cut from sheet material as specified in:

a) The Standard Test Methods for Rubber Property – Compression Set, ASTM D395-89, for solid elastomer materials, and

b) The Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber, ASTM D1056-91, for open and closed flexible cellular material.

3.2.2.11.4 For solid elastomer material the test is to be as specified in Method B, in the Standard Test Methods for Rubber Property – Compression Set, ASTM D395-89. The deflection is to be 25% and the test time and temperature are to be 22 ±1/2 h at 70 ±1°C (158 ±1.8°F). The recovery period is to be 30 min at 23 ±2°C (73.4 ±3.6°F).

3.2.2.11.5 For open and closed cell material the test is to be as specified in the Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber, ASTM D1056-91. The test time is to be 22 ±1/2 h.

a) For open cell materials the temperature is to be 70 ±1°C (158 ±1.8°F). The recovery period is to be 30 min at 23 ±2°C (73.4 ±3.6°F).

b) For closed cell materials the temperature is to be 23 ±2°C (73.4 ±3.6°F). The recovery period is to be 24 h at 23 ±2°C.

3.2.2.11.6 The average percent compression set is to be calculated as follows:

$$Compression\ \ set, \% = \frac{(t_0 - t_1)}{t_0 - t_s} \times 100$$

where:

t_o = Original thickness,

t_1 = Thickness of specimen after specified recovery period, and

t_s = Thickness of spacing bar used.

3.2.2.12 Adhesive laminations bond strength test

3.2.2.12.1 The average force to separate both unconditioned samples and conditioned samples bonded together by adhesive shall not decrease by more than 50% when subjected to the testing specified in 3.2.2.12.2.

3.2.2.12.2 Thirty samples of a material relying on adhesive to secure laminated layers or one material to another are to be prepared for evaluating the reliability of an adhesive bond. The 30 samples are to be divided into 6 groups of five samples. Each group of five samples is to be subjected to the following conditioning:

a) Placed in room ambient conditions with no other conditioning;

b) Placed in an air-circulating oven with the oven temperature set to 118°C (244.4°F) and conditioned in the oven for 300 h;

c) Placed in a humidity chamber set to a humidity of 95 to 100% at a temperature of 60°C (140°F) for a period of 7 days;

d) Placed in a refrigeration unit set to a temperature of −35°C (−31°F) for a period of 24 h;

e) Placed for 24 h in a 60°C (140°F) ambient, then immersed in 25°C (77°F) water for 24 h, then 8 h in a −35°C (−31°F) ambient, followed by 96 h in a 95 to 100% humidity atmosphere set to a temperature of 35°C (95°F); and

f) Placed in a 25°C (77°F) ambient during the duration of the other conditioning.

3.2.2.12.3 After each conditioning cycle, the samples are to be allowed to cool to room temperature. The layers of the laminated material, or the parts being adhered together, are to be separated sufficiently to allow a 1 by 1 in area to be mounted into the jaws of an Instron testing machine. The jaws shall then be separated at a rate of 0.5 in/min. The force required to separate the laminates from the body of the material is to be recorded.

3.2.2.13 Torque, bending moment and conduit pullout tests

3.2.2.13.1 Three 31 by 31 cm (12 by 12 in) samples of rigid polymeric material are to be provided in the minimum thickness to be used. The samples are to be mounted to a 4 by 1-1/2 in trade size outlet box. An open hole sized to accommodate a trade size ½-in conduit fitting is to be made in the center of the sample at a point that is also the center of the outlet box. A trade size ½-in conduit fitting with a 2.4-m (8-ft) length of conduit secured to it, is to be inserted into the open hole and secured in the manner intended. The sample is to be mounted so that the surface of the sample to be tested is vertical to the ground. A torque of 200 lb-in is to be applied to the conduit for one minute. The test is to be repeated applying sufficient weight to the conduit to result in a 300 lb-in bending moment being applied to the union between the conduit fitting

and the sample surface. The test is to be repeated with a 200 lb (890 N) force applied to the conduit normal to the surface of the material for 5 min.

3.2.2.13.2 The material shall continue to secure the conduit and fitting in place and not crack or permanently distort after the application of the torque and bending moment.

3.2.2.14 Component support test

3.2.2.14.1 Three samples of a panel material having the minimum material thickness intended for component support shall, after being subjected to the component support test, not show any sign that the material stripped from the threads in the panels.

3.2.2.14.2 The shortest coarse threaded sheet metal screw anticipated for mounting of components shall be used to secure component parts to each panel. Each sheet metal screw shall be drawn up as tightly as possible using a 20.3 cm (8-in) screwdriver having a blade of the proper type and sized and applying a force of 3.4 J (30 lbf-in). The screws are to be then withdrawn and reinserted again into each sample and again drawn up as tightly as possible. The screw is then to be removed and each panel material examined to determine that the threads have not been displaced and each screw examined to determine whether panel material has been deposited between the threads of the screws.

3.2.2.15 Electrostatic field material test

3.2.2.15.1 One test sample of each color of material consisting of a flat sheet of the polymeric material to be tested measuring 101 by 101 mm (4 by 4 in) of the same thickness as the thinnest portion of the area surrounding a high voltage conductor is to be obtained. The sample is to be placed in an area where at least 101 mm (4 in) of air space is provided from any ground plane. To the center of each side of the sample, a 50 by 50 mm (2 by 2 in) by 6.4-mm (0.25-in) thick square plate of aluminum is to be placed against the surface of the test sample with only the force necessary to make contact with the material. The side of the aluminum plate facing away from the material is to be provided with a slight depression in the center into which a rigid copper alloy, 3.2-mm (0.125-in) diameter probe is placed. Through the probes, each plate is to be connected by 15 kV-rated GTO cable to the output of a 15 kV, 30 mA, 60 Hz midpoint ground referenced neon transformer.

3.2.2.15.2 The primary voltage of the transformer supply is to be adjusted to result in a voltage of 15 kV being applied between the plates. The transformer shall be operated with the opposing outputs applied between the plates for 60 days. After 60 days the sample is to be removed and visually examined for any physical degradation.

3.2.2.15.3 A dielectric voltage withstand test is to be conducted after conditioning across the polymeric material by applying a voltage of 17,000 V at 60 Hz between two in diameter probes. The probes shall be brass rods located on opposite sides of the test sample in the center and then at a point where the corner of the aluminum plate was against the test sample. The brass rods shall have 1/2-in diameter spherical heads that press onto the surface of the test sample with no more force than is necessary to make contact with the material. The test voltage is to be applied between the brass rods on each side of the test sample and maintained for one minute.

3.2.2.15.4 There shall be no permanent degradation of the material after conditioning and no dielectric breakdown of the material to be considered acceptable.

3.2.2.16 Material dielectric voltage withstand test

3.2.2.16.1 An insulating material between current carrying parts or an insulating material used to prevent user contact with live parts shall, with out any indication of dielectric breakdown, withstand a dielectric voltage-withstand potential applied across the material and combination of material and air. When a

material is insulating between live parts having a potential difference of 1000 V or less or preventing user contact to a voltage of 1000 V or less, the test shall be as specified in 3.2.2.16.2. When a material is insulating between live parts having a potential difference of greater than 1000 V or preventing user contact to a voltage of greater than 1000 V, the test shall be as specified in 3.2.2.16.3.

3.2.2.16.2 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.

3.2.2.16.3 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.

3.2.2.17 Water immersion test

3.2.2.17.1 The immersion test is to be conducted on samples of each color of a formed sample of the polymeric material that is to be covered or test samples of each color of material to be covered.

3.2.2.17.2 Three samples of the finished part are to be dried in a calcium chloride desiccator for 24 h, then weighed and immersed in distilled or deionized water at 70 ±1.0°C (158.0 ±1.8°F) for 7 days. Following the immersion conditioning, the samples are to be wiped free of surface water and weighed to determine the amount of moisture that was absorbed.

3.2.2.17.3 The test samples shall not increase in weight by more than 10%.

3.2.2.18 Icing test

3.2.2.18.1 An enclosure material intended to be flexed when exposed to wet locations shall while ice laden be able to be flexed as intended without damage to the material. The enclosure material shall be undamaged after the ice has melted.

3.2.2.18.2 The enclosure is to be mounted in a room that can be cooled to minus 6.7°C (20°F). A metal test bar, 25.4 mm (1 inch) in diameter and 610-mm (2-ft) long, is to be mounted in a horizontal position in a location where it will receive the same water spray as the enclosure being tested. Provisions are to be made for spraying the entire enclosure from above with water at an angle of approximately 45 degrees from the vertical. The water is to be 0 – 2.8°C (32 – 37°F). The spraying facility shall provide at least 3.8 – 7.6 L (1 – 2 gallons) per hour per 928 cm^2 (1 ft^2) of area to be sprayed. The room temperature is to be lowered to 1.7°C (35°F). The spray of water is to be started and continued for at least 1 h, maintaining the room temperature at 0.56 – 2.8°C (33 – 37°F). The room temperature is then to be lowered to minus 6.7 – minus 2.8°C (20 – 27°F) while continuing the water spray. The rate of change in the room temperature is not critical and is to be whatever is obtainable with the cooling method employed. The water spray is to be controlled to cause ice to build up on the bar at a rate of approximately 6.4 mm (1/4 in) per hour and is to be continued until 19 mm (3/4 in) of ice has formed on the top surface of the bar. The spray is then to be discontinued, but the room temperature is to be maintained at minus 6.7 – minus 2.8°C (20 – 27°F) for 3 h so that all parts of the enclosure and the ice coating have reached the same temperature.

3.2.2.18.3 The sample is to be flexed to operate the mechanism through its full length of travel. If necessary, a hand tool may be used to remove ice to gain access to the enclosure material. The use of the hand tool shall not result in functional damage to the enclosure or the mechanisms.

3.3 Inorganic, nonmetallic tests

3.3.1 Impact test

3.3.1.1 Three samples of a component having an inorganic, non-metallic material shall be subjected to a 4.1 J (3 ft-lb.) impact. The impact is to be produced using a steel sphere 51 mm (2 inch) in diameter and weighing 0.54 kg (1.18 lb.) from a height of 775 mm (30.5 in) on any surface that is exposed. There shall be no breaking or cracking as a result of the impact.

3.3.2 Environmental conditioning test

3.3.2.1 Three samples of the component having an inorganic, non-metallic material shall be immersed in distilled or deionized water at 70 ±1.0°C (158.0 ±1.8°F) for 7 days. Following the immersion conditioning, the samples are to be placed within 2 min of being removed from water to an ambient of minus 40°C (104°F) for 24 h. The samples are then to be removed from the cold ambient and placed in an oven having a 100°C (212°F) ambient for 24 h. After 24 h in a hot ambient, the samples are to be placed within 2 min into an ambient of 97% relative humidity at 60°C (140°F). for 24 h. Following humidity conditioning, the samples are to be placed, within 2 min of being removed from the humid ambient into an ambient of minus 40°C (104°F) for 24 h. After 24 h of cold conditioning, the samples shall comply with the dielectric voltage withstand test specified in 3.4.2.5.

3.3.3 Thermal shock test

3.3.3.1 An inorganic, non metallic material relied upon to insulate between live parts and between live parts and dead metal that is intended to house a heat producing component such as a neon tube electrode shall be heated to 120°C (248°F) in an air circulating oven. The sign component, with insulating material in place shall then be subject to 1 gallon of water having a temperature of between 1°C (33°F) and 5 ±1°C (41 ±1.8°F) water. The temperature of the water is to be obtained by adding enough ice to a sprinkling can to reach the required temperature. The water in the sprinkling can is to be poured over the component at a rate that is controlled by the disc at the end of the spout until the water is gone. The sprinkling can shall have:

a) A capacity of at least 1 gallon (3.79 L);

b) A spout with a minimum disk diameter of 76.2 mm (3 in); and

c) At least 50 holes, each with a minimum diameter of 2.0 mm (0.079 inch) in the disk; as appropriate.

3.3.3.2 After conditioning, the samples shall comply with the dielectric voltage withstand test specified in 3.4.2.5.

3.4 Product tests

3.4.1 Material tests

3.4.1.1 Mold stress relief distortion test

3.4.1.1.1 A polymeric enclosure and a wet location polymeric sign body material shall, after being subjected to the conditioning specified in 3.4.1.1.2, comply with the applicable enclosure or sign body requirements specified in 4.13 – 4.14.

3.4.1.1.2 Three samples are to be conditioned in a full-draft circulating-air oven for 7 h at 10°C ±1.0°C (18°F ±1.8°F) higher than the required minimum temperature rating from Table 4.3 part 2, or the maximum

operating temperature of the polymeric material to be tested, or 70°C (158°F), whichever is greater. After conditioning, any distortion of the polymeric material is to be evaluated for compliance with enclosure requirements specified in 4.14. Following conditioning, wet location polymeric sign bodies are to be subjected to the Rain Test specified in 3.4.1.9.

3.4.1.2 Knockout test

3.4.1.2.1 A knockout provided in an enclosure shall remain in place and the clearance between the knockout and the opening shall not be more than 0.25 mm (0.010 in) when measured 1 h after removal of the application of the force specified in 3.4.1.2.2.

3.4.1.2.2 A force of 4.5 kg (10 lb) shall be applied to a knockout for 1 minute by means of a 6.4-mm (0.25-in) 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 most likely to cause 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 2.4.1.1 and Table 2.6 when measured 1 h after removal of the force.

3.4.1.3 Strain relief test

3.4.1.3.1 General

3.4.1.3.1.1 The strain relief means for a power supply cord shall withstand the pull specified in 3.4.1.3.2.1 and for a field wiring lead shall withstand the pull specified in 3.4.1.3.3.1 without being displaced and without damaging the insulation on the power supply cord and field wiring lead.

3.4.1.3.1.2 A strain relief means that relies on a polymeric material for strain relief shall be subjected to the strain relief test both before and after being subject to the mold stress relief distortion test specified in 3.4.1.1.

3.4.1.3.1.3 The pull on the leads or power supply cord is to be applied by a weight suspended from the cord, or lead. The component with the strain relief means is be supported so that the strain relief means will be stressed from any angle the construction of the unit permits.

3.4.1.3.2 Power supply cord

3.4.1.3.2.1 The strain relief means for a power supply cord shall withstand a direct pull of 156 N (35 lb).

3.4.1.3.3 Field wiring lead

3.4.1.3.3.1 The strain relief means for a field wiring lead shall withstand a direct pull of 89 N (20 lb).

3.4.1.4 Self-threading screw torque test

3.4.1.4.1 A self threading screw that is required to be tightened during installation shall be able to withstand a tightening torque of 3.49 N-m (30 lbf-in) without resulting in the screw threads stripping or being pulled from its anchorage.

3.4.1.5 Terminal tests

3.4.1.5.1 Pressure wire terminal test

3.4.1.5.1.1 There shall be no indication that a conductor end is damaged or cut in any way and no damage to a pressure wire terminal or its mounting as a result of being subjected to the test in 3.4.1.5.1.2.

3.4.1.5.1.2 A pressure wire terminal shall be tested with the maximum rated and the minimum cross section conductors. The pressure wire terminal or terminal block onto which it is mounted 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 2-Nm (18-lb-in) 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.

3.4.1.5.2 Solid-wire tightening test

3.4.1.5.2.1 Application of the normal clamping action of a wire-binding screw and stud-and-nut type terminal, shall not impair the integrity of the joint.

3.4.1.5.2.2 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 1.8 Nm (16 lb-in), without causing (a) or (b). 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.

a) The wire to be forced from the connector or

b) Damage to any part of the terminal block.

3.4.1.5.3 Terminal assembly terminal block test

3.4.1.5.3.1 Following the test described in 3.4.1.5.3.2, 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.

3.4.1.5.3.2 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 2-Nm (18-lb-in) 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.

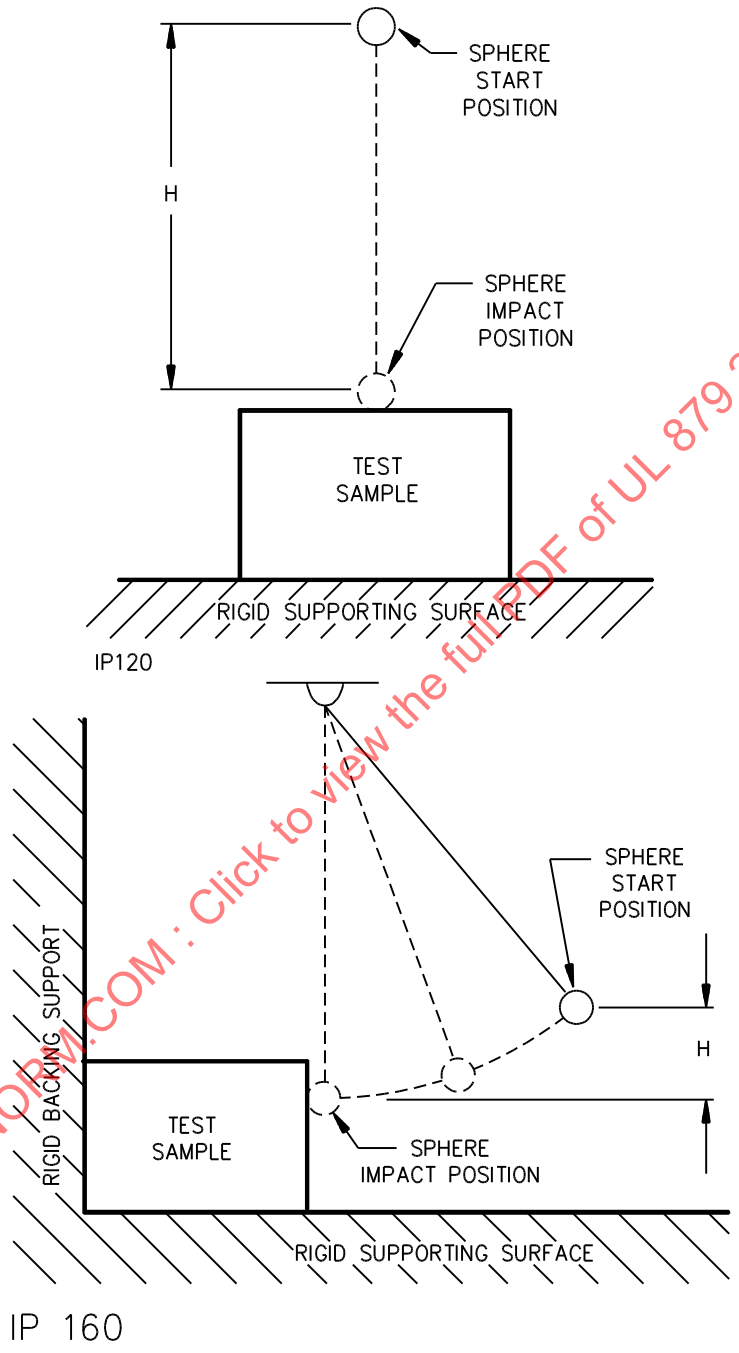
3.4.1.6 Impact test

3.4.1.6.1 Three samples of a component for use in dry locations having a polymeric enclosure or sign body shall be subjected to impact testing in an ambient of 25°C ± 5°C (77 ±9°F). Three samples of a component intended for use in damp or wet locations shall be cooled to a temperature of minus 35.0 ±2.0°C (minus 31.0 ±3.6°F) and maintained at this temperature for 3 h after which the components are to be impact tested while still cool from conditioning.

3.4.1.6.2 The component samples are to be impacted as shown in Figure 3.7 while mounted in their intended manner. A force of 4.1 Nm (3 ft-lb) is to be applied on any surface that can be exposed to a blow during intended use. This impact is to be produced either by dropping a steel sphere, 50.8 mm (2 inch) in diameter and weighing 0.54 kg (1.18 lb), from the height necessary to produce the desired impact force or the steel sphere is to be suspended by a cord and swung as a pendulum, dropping through the vertical distance necessary to produce the desired impact force.

Figure 3.7

Impact test



3.4.1.6.3 No opening shall result that:

a) Exceeds the size limitations for an open hole in an enclosure as specified in 2.4.1.1 and Table 2.6,

b) Allows access to current carrying parts by the accessibility probe specified in 2.4.1.6, and

c) Reduces spacings to less than those specified in 2.15.

3.4.1.7 Accessibility barrier test

3.4.1.7.1 An accessibility barrier shall not permanently or temporarily distort, break or crack exposing current-carrying parts required to be inaccessible to the probe in 2.4.1.6 or reduce spacings to metal parts less than required in 2.15 with the application of a force of 44.5 N (10 lb) over an area of 6.45 cm^2 (1 in^2) to the barrier.

3.4.1.8 Polymeric component mounting and support test

3.4.1.8.1 Three samples of a component provided with a mounting means that relies on a polymeric material to hold itself in place shall after conditioning and with a weight applied remain secured to the supporting surface.

3.4.1.8.2 The components are to be installed to the intended supporting surface in accordance with the manufacturer's installation instructions. The samples and supporting surface are to be conditioned for 7 h in a 70°C (21°F) air circulating oven. After oven conditioning, the assemblies are to be conditioned in a freezer at minus 35°C (minus 37°F) for a period of 4 h. After the conditioning period and while still cold, a weight as specified in Sections 4 and 5 for a specific component shall be suspended from the supporting member for a period of one minute.

3.4.1.9 Rain test

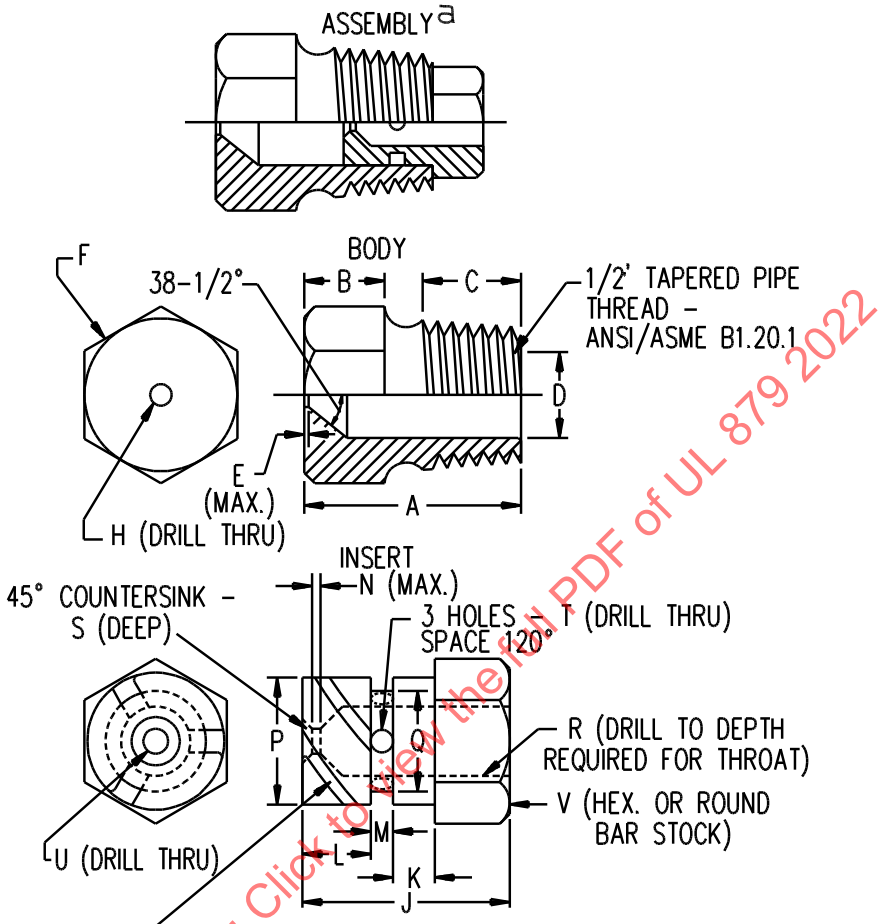
3.4.1.9.1 A component shall withstand a simulated rain produced in accordance with 3.4.1.9.2 – 3.4.1.9.5 without allowing the entrance of water onto live parts.

3.4.1.9.2 During the test, unless the construction and intended use of the sign component is such that only one orientation is likely regardless of any markings provided, each sample tested shall be oriented in a position most likely to result in the wetting of live parts.

3.4.1.9.3 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 3.9. Spray heads are to be constructed in accordance with the details shown in Figure 3.8. The assembly is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the component. The water pressure is to be maintained at 34.5 kPa (5 lb/in^2) at each spray head.

Figure 3.8

Spray head



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

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

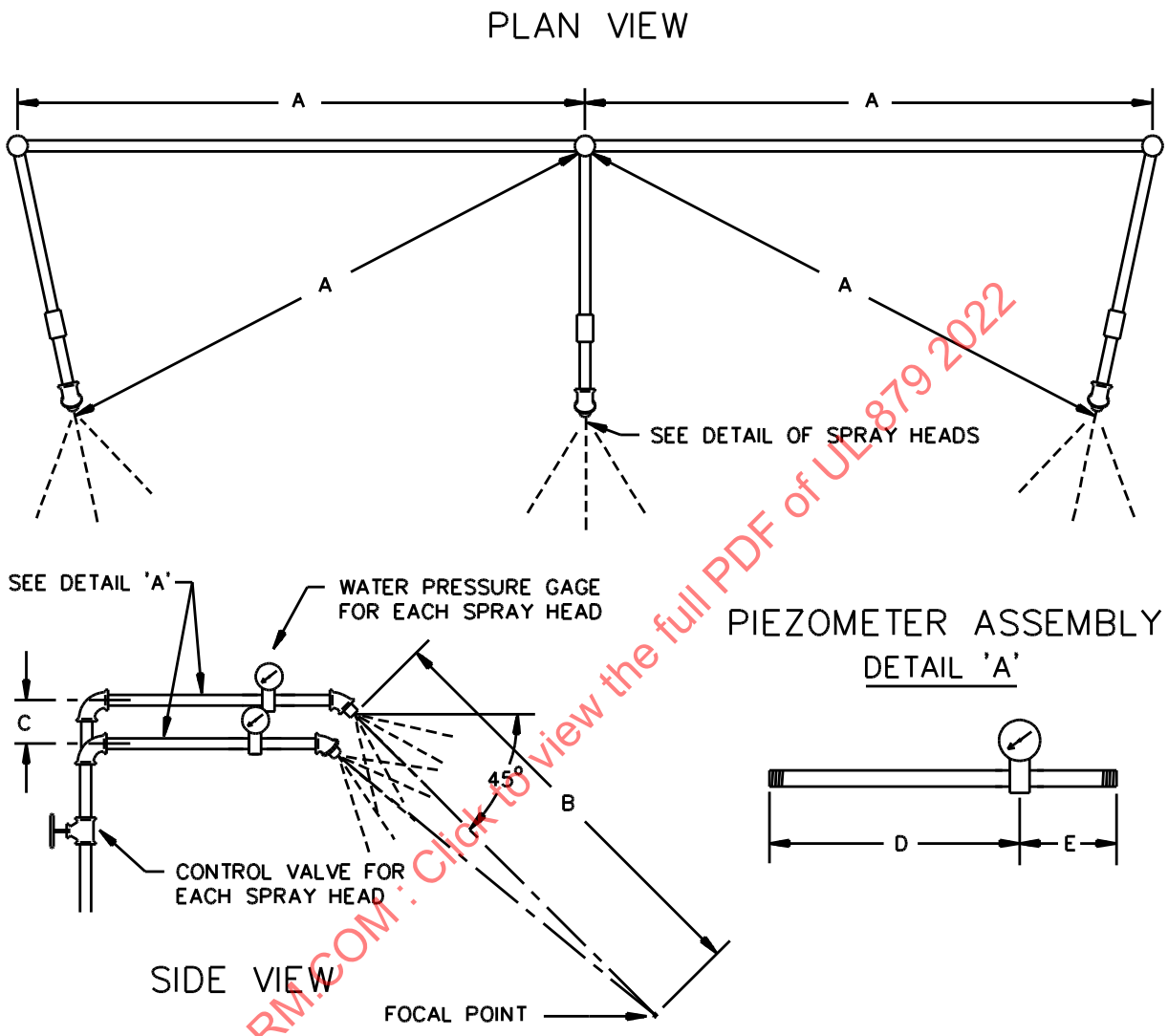
[b] ANSI B94.11M Drill Size

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

RT100F

Figure 3.9

Spray head piping



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

RT101F

3.4.1.9.4 The assembly is to be subject to the water spray for a total of 4 h. During the 4 h the assembly is to, when appropriate, be energized and unenergized in the following sequence:

a) Hour 1 – Unenergized;

b) Hour 2 – Energized, Normal Operation;

c) Hour 3 – Unenergized; and then

d) Hour 4 – Energized, Normal Operation.

3.4.1.9.5 After rain conditioning, no wetting of current carrying parts is an acceptable result.

3.4.1.10 Fastening securement test

3.4.1.10.1 Six samples of a component provided to be adjustable by physical fit and friction are to be adjusted as intended with 3 samples adjusted to the maximum adjustment and 3 samples to the minimum adjustment. After being adjusted to the minimum and maximum range of adjustment, any locking mechanism provided is to be locked into position. The components are to be conditioned for 7 h in a 70°C (21°F) air circulating oven. After oven conditioning, the same samples are to be conditioned in a freezer at minus 35°C (minus 37°F) for a period of 4 h. After the conditioning period and while still cooled, a weight of 2 lb (0.92 kg) is to be applied to the component in a direction that is most likely to test the ability of the adjustment to maintain its original position. The weight is to be applied in a direction that would disengage any locking mechanism, unless that locking mechanism can be disengaged merely by the applied force provided in the direction of the anticipated force that would be applied in a field application. The force is to be applied to each sample for a period of one minute and shall not disengage any locking mechanism and shall not cause the adjustment to change from its set position.

3.4.1.11 Retention test

3.4.1.11.1 Neon electrode enclosure to neon tube electrode

3.4.1.11.1.1 A neon electrode enclosure shall withstand a pulling force of 0.44 kg (1 lb) applied between the neon electrode enclosure and neon tube electrode without displacement when assembled as specified in 3.4.1.11.1.2 and subjected to the test in 3.4.1.11.2.3.

3.4.1.11.1.2 Three neon tubes of the appropriate size for the neon electrode enclosure are to be inserted into the neon electrode enclosure to a depth that is representative of the depth of installation had a splice connection to a GTO cable been made. The assemblies are to be tested without GTO cable in place and therefore, without a splice having been made between the neon tube electrode and GTO cable.

3.4.1.11.2 GTO sleeving, GTO cable with integral sleeving, conduit plug or GTO cable assembly to neon electrode enclosure

3.4.1.11.2.1 GTO sleeving, GTO cable with integral sleeving, a conduit plug assembly or GTO cable assembly shall withstand a pulling force of 0.44 kg (1 lb) applied between a neon electrode enclosure and GTO sleeving, GTO cable with integral sleeving, a conduit plug assembly or GTO cable of the intended diameters without being displaced when assembled as specified in 3.4.1.11.2.2 and subjected to the test in 3.4.1.11.2.3.

3.4.1.11.2.2 Each of three lengths of GTO sleeving with GTO cable within the lengths, three lengths of integrally sleeved GTO cable, three conduit plug assemblies with GTO cable within the conduit plug assembly or three cable assemblies are to be inserted into the designated opening of a neon electrode enclosure or over the top of the neon electrode enclosure fitting intended to accommodate the GTO sleeving, GTO cable with integral sleeving, conduit plug assembly or GTO cable assembly. A neon tube

electrode of the appropriate size is to be inserted into the neon electrode enclosure with no connection between the neon tube electrode leads and GTO cable within the GTO sleeving, GTO cable with integrally sleeving, GTO cable within the conduit plug assembly or cable assembly. The assembly is to be tested in accordance with 3.4.1.11.2.3.

3.4.1.11.2.3 Each assembly is to be conditioned in an air circulating oven set to 50°C (122°F) for a period of 7 h before applying the force. Each assembly is to be secured at each end in a manner that does not result in either part being deformed where they interface with each other. A pulling force of 0.44 kg (1 lb) is to be applied uniformly between the two ends of each assembly for one minute.

3.4.1.12 Flexing test

3.4.1.12.1 Three samples of a component enclosure intended to be flexed during normal use or servicing shall not be damaged, cracked or torn as a result of being flexed through 50 cycles of the maximum length of travel permitted by its construction. One cycle consists of moving from one extreme position to the opposite position and back to the starting position.

3.4.1.13 Material adhesion

3.4.1.13.1 General

3.4.1.13.1.1 The average bond strength between two materials bonded by adhesive shall decrease no more than 50% after conditioning when compared to the average bond strength before conditioning. Unless otherwise specified, all testing shall be conducted in a standard laboratory atmosphere of 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5% relative humidity.

3.4.1.13.1.2 The designated surfaces of the materials to be bonded are to be prepared and the adhesive applied in accordance with the manufacturer's specification. The adhesive is to be cured in accordance with the manufacturer's specifications.

3.4.1.13.1.3 The specimens are to be subjected to applicable tests to determine the value of the critical properties in the as-received condition. In the case of bond-strength evaluation, specimens that break at an obvious flaw remote from the adhesive line shall be discarded and a retest made. The average value of the property is to be computed. This value is to be used for comparison with values of the same property after the environmental conditioning described in 3.4.1.13.1.8 – 3.4.1.13.5.2.

3.4.1.13.1.4 Six test assemblies are to be prepared. Each assembly shall consist of 5 by 10 cm (2 by 4 in) strips of the material to be tested adhered to separate pieces of the designated surface materials. The surface material is to also be 5 by 10 cm (2 by 4 in). Before adhesion to the designated surface material, each strip shall be:

a) Cleaned for direct adhesion, or

b) Prepared by applying a designated coating.

3.4.1.13.1.5 For a material intended to be adhered in a frame, six additional test assemblies are to be prepared. Each assembly is to consist of a steel frame, aluminum frame, material and the adhesive to be tested. The material is to be of the generic material type designated for the adhesive. The steel frame is to consist of 2.54 by 2.54 cm (1 by 1 in) angle iron 0.64 by 0.64 cm (0.25 by 0.25 in) thick and when assembled shall have an inside dimension of 31.75 by 31.75 cm (12.5 by 12.5 in) to the upright sides of the angle iron frame. Two corners of each length of angle iron are to be outside-mitered and the four pieces assembled as a frame. The un-mitered side of each angle iron is to be welded to the other angle iron corners to form a frame. The aluminum frame is to consist of 90° aluminum angle pieces 2.54 by 2.54 cm (1 by 1 in) that are 0.64 by 0.64 cm (0.25 in by 0.25 in) thick constructed into a frame having an inside

dimension of 31.2 by 31.2 cm (12.25 by 12.25 in). The frame is to be mitered and assembled in the same manner as the steel frame, except the corners of the aluminum frame are to be secured together by angle brackets and screws. The aluminum frame is to then be secured into the steel frame by 8 screws; two on each side located 5.0 cm (4 in) from each corner. The material to be secured to the frame by adhesive shall measure 30.5 by 30.5 cm (12 by 12 in) or, if the manufacturer specifies the distance from the edge of the material to the edge of the frame the material shall be sized to provide that distance to the frame. The material shall be centered in the aluminum frame.

3.4.1.13.1.6 The inside surface of the aluminum frame is to be prepared in accordance with the manufacturer's specification for fabrication. The surface preparation is to consist of coating the surface with the material to which a sign face is to be adhered or removing all contaminating substances, oxide films, oil, and dust from metal surfaces and the like in accordance with the manufacturer's installation instructions. If the adhesive cannot be applied immediately, the freshly cleaned surfaces are to be protected by a primer. The adhesive is to be applied by spray, brush, knife, or film in accordance with the manufacturer's specifications. The temperature and pressure application during bonding shall be in accordance with the adhesive manufacturer's specifications.

3.4.1.13.1.7 The material is to be similarly prepared to adhere to the aluminum frame in accordance with the manufacturer's specifications. After the material has been secured to the aluminum frame in accordance with the manufacturer's specifications, the adhesive is to be cured in accordance with the manufacturer's specifications.

3.4.1.13.1.8 The test assemblies are to be conditioned for 40 h at 23.0 ±2.0°C (73.0 ±3.6°F) and a relative humidity of 50 ±5% prior to testing. Three of the test assemblies are to be subjected to the effect of temperature, effect of humidity, effect of cold and effect of cyclic conditions as specified in 3.4.1.13.2 – 3.4.1.13.5.

3.4.1.13.2 Effect of temperature

3.4.1.13.2.1 The three test assemblies are to be conditioned for 1000 h at the oven temperature taken from the respective thermal-endurance-profile line in Figure 3.10, where the temperature index T is the measured normal operating temperature of the adhesive, but not less than 60°C (140°F).

3.4.1.13.3 Effect of Humidity

3.4.1.13.3.1 The same three test assemblies are to be conditioned for 7 days at 95 – 100% relative humidity at 60.0 ±1.0°C (140.0 ±1.8°F).

3.4.1.13.4 Effect of cold

3.4.1.13.4.1 The same three test assemblies are to be conditioned for 24 h at minus 33.0 ±1.0°C (minus 31 ±1.8°F) for damp or dry location applications and at 0.0 ±1.0°C (32.0 ±1.8°F) for dry location applications.

3.4.1.13.5 Effect of cold

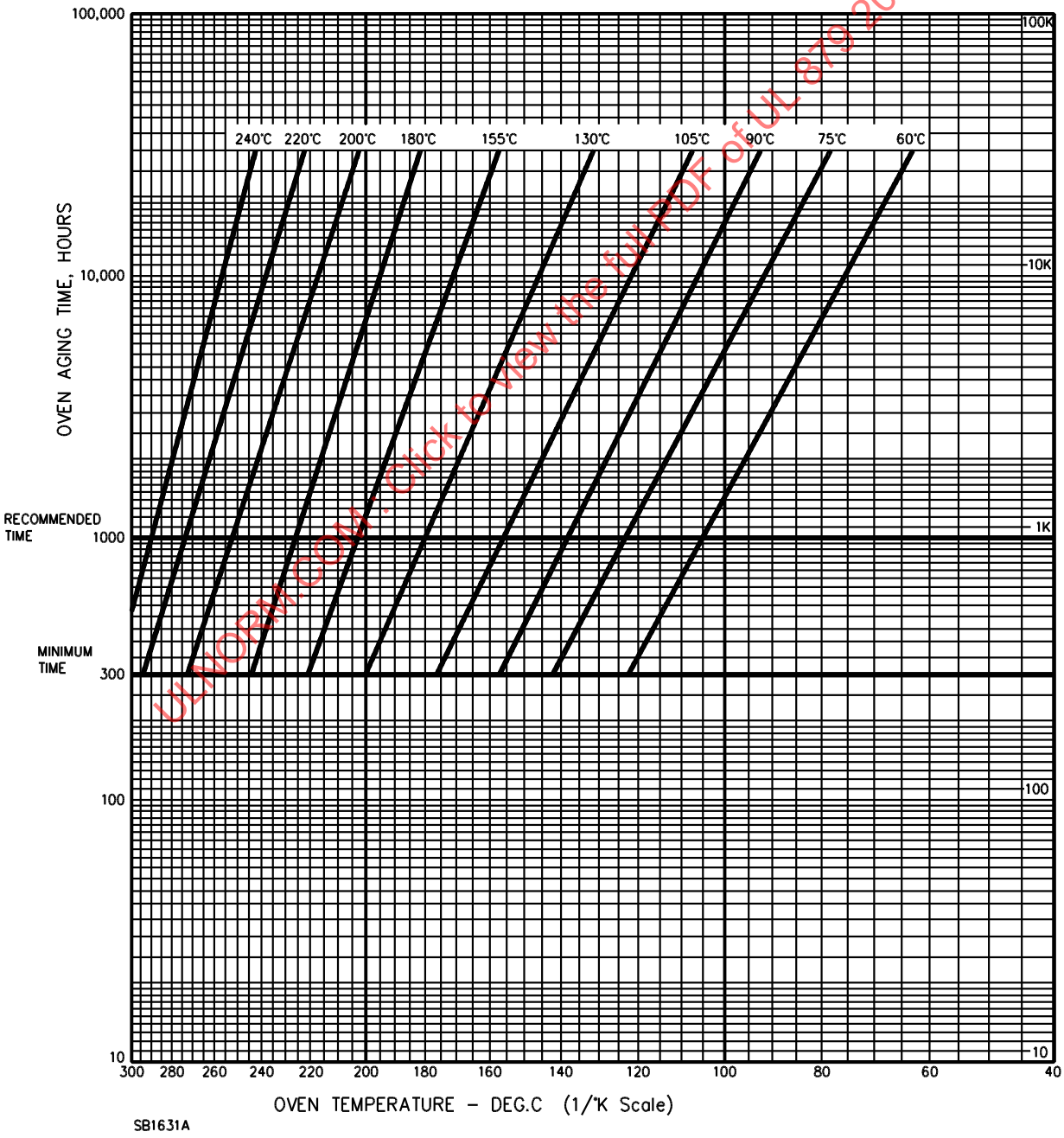
3.4.1.13.5.1 The same three test assemblies are to be subjected to three complete cycles of the conditioning indicated in Table 3.7.

3.4.1.13.5.2 After the conditioning, the test assemblies shall be brought to and tested at room temperature to determine the critical property values.

Table 3.7
Cycling conditions

For dry location applications	For damp and wet location applications
24 h at T followed immediately by at least 96 h at 35 ±2°C (95 ±3.6°F), 90% relative humidity, followed by 8 h at 0 ±2°C (32 ±3.6°F)	A minimum of 24 h immersed in 25 ±2°C (77 ±3.6°F) water; followed immediately by 24 h at T followed immediately by at least 96 h at 35 ±2°C (95 ±3.6°F), 90% relative humidity; followed by 8 h at minus 35 ±2°C (minus 31 ±3.6°F).
Note: T is the rated temperature, but not less than 60°C (140°F)	

Figure 3.10
Conditioning time versus oven temperature for temperature index of adhesives



3.4.1.14 Conformal coating

3.4.1.14.1 Three samples of a printed-wiring board without electrical components installed, and coated with a conformal coating, shall be subjected to 2500-V AC dielectric voltage-withstand potential applied between the conductors, followed in turn by (a) – (d). 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.

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 V AC.

3.4.1.14.2 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.

3.4.1.15 Durability of stamped ink marking test

3.4.1.15.1 Stamped ink markings shall be dried at room temperature for at least five days, after which they shall be given one wipe with a cloth dampened with water, and then a second wipe with a cloth dampened with mineral spirits, without becoming illegible.

3.4.1.16 Marking adhesion test

3.4.1.16.1 Test strips approximately 12.7-mm (1/2-in) wide are to be prepared by making two parallel cuts through the sample to the test surface, using a sharp instrument such as a razor blade. Strips are to be cut parallel to the length and width of the sample if the size and configuration of samples allows. One end of each strip shall be separated from the surface for attachment to the apparatus for test. The remainder of each strip, at least 25.4 mm (1.0 in) is then to be pulled from the surface at a 90° angle and at a rate of 50.8 mm (2 in) per minute, using a tension machine equipped with an automatic recorder. The average force required to remove the strip is to be calculated in N/mm (lb/in) width. The value obtained for two or more samples is to be averaged and taken as the quantitative adhesion value.

3.4.1.17 Spring contact elongation and compression test

3.4.1.17.1 A spring contact shall be extended 50% greater that its at rest position dimension and released. The spring contact shall return to its original dimension.

3.4.1.17.2 A spring contact shall be collapsed by compression to its minimum dimension and released. The spring contact shall return to its original dimension.

3.4.2 Electrical tests

3.4.2.1 General

3.4.2.1.1 Unless otherwise specified, all tests are to be conducted with the sign component connected to a rated frequency source of supply of 60 Hz when rating is AC. The test voltage of the source of supply is to be adjusted to within 5% of the voltage and with the overcurrent protection rating specified in Table 3.8.

Table 3.8
Normal test voltages

Marked voltage rating	Test voltage	Overcurrent protection rating
11 – 12 Vac	12 Vac	Maximum current from source
11 – 15 Vdc	14 Vdc	20 A
110 – 130 V	120 Vdc	20 A
220 – 250 V	240 Vac	20 A
267 – 288 V	277 Vac	20 A
Other marked voltage	Marked rating	20 A

3.4.2.2 Input test

3.4.2.2.1 The current input shall not exceed 110% of the components rated value when connected to the test voltage specified in Table 3.8 and where applicable, rated load.

3.4.2.2.2 Rated load where applicable for a component, shall be a range of loads from maximum to minimum. The load shall incorporate the intended type of load where an impedance type of load is involved, unless it can be determined that a resistive load will not influence the output characteristics of the component.

3.4.2.2.3 For an intermittent output type component or a component with multiple outputs the maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. The maximum duty cycle for each output is to be caused to occur within the limitations of an integral controller or the controller identified for use with the component.

3.4.2.2.4 A product that contains a motor other than a stepper motor, shall be tested in both a normal operating and a stalled-rotor condition. The input current under either condition shall not exceed 110% of rated.

3.4.2.3 Normal temperature test

3.4.2.3.1 A product when mounted and operated as intended in service shall not exceed the temperature rise limits specified in Table 3.9.

Table 3.9
Maximum temperature rises

Materials and components	°C (°F)
1. On the outside of an enclosure intended to be secured or in contact with a building structure or a part of a sign in contact with a building structure	65 (149)
2. Field-wiring conductors or any surface that is contacted by field-wiring	35 (95)
3. Field-wiring terminals	50 (122)
4. Coil insulation systems of a relay, a solenoid, or similar part not identified as having an insulation Class:	
Thermocouple method	70 (158)
Resistance method	80 (176)
5. Transformer insulation systems not identified as having an insulation Class:	
Thermocouple method	65 (149)
Resistance method	75 (167)
6. Class 130 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	85 (185)
Resistance method	95 (203)
7. Class 155 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	110 (230)
Resistance method	150 (302)
8. Class 180 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	125 (257)
Resistance method	135 (275)
9. Class 200 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	145 (293)
Resistance method	160 (320)
10. Class 220 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	160 (320)
Resistance method	175 (347)
11. Class 250 coil insulation systems of a relay, a solenoid, transformer or similar part:	
Thermocouple method	190 (374)
Resistance method	205 (401)
12. Capacitor (unless rated, or marked otherwise)	65 (149)
13. Varnished-cloth insulation	60 (140)
14. Fiber used as electrical insulation	65 (149)
15. Thermoset electrical insulation (phenolic, urea, and the like)	125 (257)
16. Wood or other combustible material	65 (149)
17. Fuse	65 (149)
18. Sealing or potting compound	Rated
19. Power switching semiconductor case without manufacturer's de-rating curve	80 (176)
20. Power switching semiconductor case with manufacturer's de-rating curve	Rated
21. Polymeric material, generic	See 2.1.4.3
22. Neon electrode enclosure	See 4.6
23. GTO cable insulation and sleeving	80 (176)

3.4.2.3.2 The values for temperature rise in Table 3.9 are based on an assumed ambient of 25°C (77°F), and tests are to be conducted at an ambient temperature of 25 ±15°C (77 ±27°F).

3.4.2.3.3 Temperatures are to be obtained by thermocouples located on exposed surfaces unless the resistance method must be used due to the coil being inaccessible for mounting thermocouples. Types of such inaccessible coils include:

a) Coils immersed in sealing compound,

b) Coils wrapped in thermal insulation, and

c) Coils wrapped with more than two layers of insulating material more than 0.8-mm (0.03-in) thick.

3.4.2.3.4 Temperatures of a motor winding may be measured by placing a thermocouple on the integrally-applied insulation of the winding coil wire or if the coil winding wire is inaccessible, a thermocouple may be placed on the motor case.

3.4.2.3.5 Temperatures shall be measured after they have stabilized, when:

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

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

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

3.4.2.3.6 The temperature rise of a winding is determined by the resistance method according to the formula shown in the following equation.

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

in which:

Δt is the temperature rise of the winding °C

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

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

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.

3.4.2.3.7 Thermocouples shall have conductors no larger than 24 AWG (0.25 mm^2) and no smaller than 30 AWG (0.05 mm^2). Thermocouples shall comply with the requirements specified in the Standard Test Method for Comparing EMF Stability of Single-Element Base-Metal Thermocouple Materials in Air, ASTM STP 470B and thermocouples as listed in the table of the limits of error specified in the Thermocouple Database, NIST ITS 90, or 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. Thermocouple conductors smaller than 30 AWG (0.05 mm^2) may be used for miniature circuitry and components. The thermocouple junction shall be fused.

3.4.2.3.8 If referee temperature measurements are required, 30 AWG (0.05 mm^2) iron and constantan thermocouples and a potentiometer-type instrument shall be used.

3.4.2.3.9 A thermocouple junction and the adjacent thermocouple conductor shall be held in good thermal contact with the surface of the material where a temperature is being measured. Tape alone shall not be relied upon as a means to provide good thermal contact of the thermocouple junction. Acceptable means of securing a thermocouple include water glass, cyanoacrylate, melting the tip into plastic, soldering, or wedging between two surfaces.

3.4.2.4 Leakage current test

3.4.2.4.1 The leakage current of a cord-connected component shall not exceed 0.5 mA when tested as described in 3.4.2.4.2 – 3.4.2.4.6.

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

3.4.2.4.3 The leakage current from all exposed dead metal surfaces is to be measured to the grounded supply conductor.

3.4.2.4.4 The circuit for the leakage current measurement is to be as illustrated in Figure 3.11. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all 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 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 to 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 mA, the measurement is not to have an error of more than 5%t at 60 Hz.

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

3.4.2.4.6 A sample of the product is to be tested for leakage current starting with the as-received condition – the as-received condition is without prior energization except as may occur as part of the production-line testing but with the grounding conductor, if any, open at the attachment plug. The supply voltage is to be adjusted to the product's maximum rated voltage. The test sequence, with reference to the measuring circuit, Figure 3.11, is to be as follows:

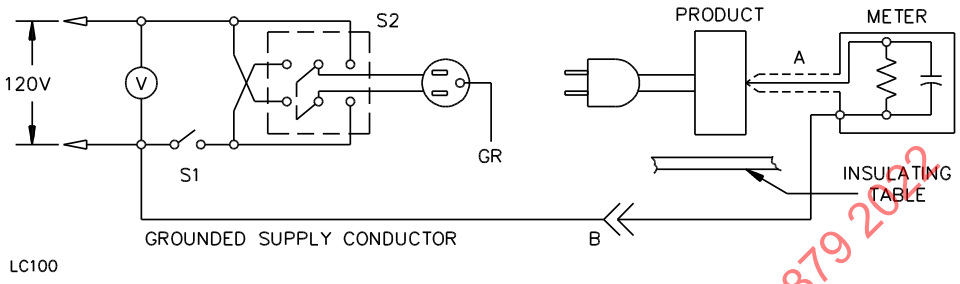
a) With switch S1 open, the product is to be without load and connected to the measuring circuit. The leakage current is to be measured using both positions of switch S2 and with the product switching devices in all their operating positions.

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

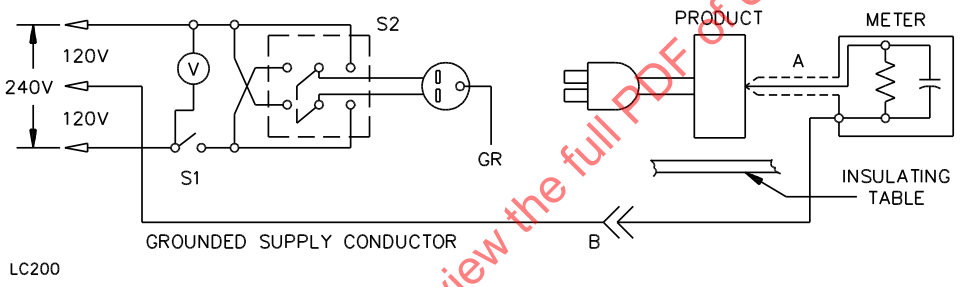
c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in making this measurement. Thermal stabilization is obtained when maximum temperatures by operation as in the normal temperature test are reached.

Figure 3.11

Leakage current measurement circuit



Component intended for connection to a 120-V power supply



Component intended for connection to a 3-wire, grounded neutral power supply

A – Probe with shielded lead

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

3.4.2.5 Dielectric voltage withstand test

3.4.2.5.1 General

3.4.2.5.1.1 A component shall withstand, without dielectric breakdown, a dielectric voltage applied between live parts of opposite polarity and between live parts and dead metal parts. The application of the dielectric withstand voltage is to be in accordance with 3.4.2.5.1.2 and 3.4.2.5.1.3. Components with voltages of 1000 V and less are subject to the procedure in 3.4.2.5.2. Components with voltages greater than 1000 V are subject to the procedure in 3.4.2.5.3.

3.4.2.5.1.2 The dielectric voltage-withstand test is to be conducted using a 500 VA or larger capacity testing transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased 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 product unless otherwise noted.

3.4.2.5.1.3 The dielectric voltage between current-carrying parts and an insulating type material (polymeric enclosure, barrier, or the like) shall be applied between metal foil covering the outside of the material and current carrying parts.

3.4.2.5.2 Dielectric voltage withstand (for products with no operating voltages greater than 1000 V)

3.4.2.5.2.1 A component is to be operated until in a heated condition and then in a heated condition, withstand without breakdown the application of a 60-Hz essentially sinusoidal potential of:

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

b) 1000 V plus twice the maximum rated input voltage applied between the primary circuit and the secondary circuits of isolating transformers; and

c) 1000 V between live and dead metal parts of a motor.

3.4.2.5.3 Dielectric voltage withstand (for products rated greater than 1000 V)

3.4.2.5.3.1 A sample is to be subjected to the application of a 60 Hz essentially sinusoidal potential of the voltage specified in Table 3.10 for a period of 1 min. The potential shall be applied between current carrying parts and the exterior surface of a component. For components such as neon electrode enclosures, the current carrying parts are to be located when installed in accordance with the manufacturer's installation instructions and metal placed either on the other side of the material or on the exterior of the component. The potential is to be increased at a uniform rate and as rapid as is consistent from zero until the required voltage is reached or until breakdown occurs.

Table 3.10
Dielectric withstand potential

Rating in kV ac rms to ground	Test potential in kV
2	6
3	8
5	12
6	14
7.5	17

3.4.2.6 Ground continuity test

3.4.2.6.1 The resistance from any dead-metal part that is likely to become energized to the grounding equipment means shall not exceed the resistance specified in Table 3.11 when tested in accordance with 3.4.2.6.2 and 3.4.2.6.3.

3.4.2.6.2 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. The voltage drop and current between the two points shall be measured.

3.4.2.6.3 The resistance in ohms is to be calculated by dividing the drop in potential (in volts) by the current (in amperes).

Table 3.11
Resistance to equipment grounding means

Point of equipment means to grounding supply	Maximum resistance in Ω
Equipment grounding lead or terminal	0.1
Grounding pin of a 6-ft or less power supply cord	0.1
Grounding pin greater than 6-ft power supply cord	0.15

3.4.2.7 Abnormal tests

3.4.2.7.1 General

3.4.2.7.1.1 Abnormal operation tests shall be conducted as described in 3.4.2.7.1.2 – 3.4.2.7.1.8, followed by a dielectric voltage-withstand test as described in 3.4.2.5.

3.4.2.7.1.2 During each abnormal test, the grounding means of the product is to be connected directly to ground through a 3-A non-time-delay fuse, the product 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 component. The cheesecloth is to be untreated cotton cloth running 26 – 28 m^2/kg (14 – 15 yd^2/lb) and for any 6.5 cm^2 (1 in^2), a count of 32 threads in one direction and 28 in the other direction.

3.4.2.7.1.3 The supply circuit for components is to be connected to a supply source as specified in 3.4.2.1.1 except the supply voltage for a dc rated input shall be as follows:

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

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

3.4.2.7.1.4 The supply circuit shall be rated at 125% of the rated input current of the product, but no less than 20 A for branch circuit connected incandescent and fluorescent sign components and 30 A for neon sign components.

3.4.2.7.1.5 A fuse provided as part of a sign component that is user accessible is to be shorted out of the circuit.

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

3.4.2.7.1.7 Each abnormal test is to be continued until one of the following conditions is obtained:

a) The test continues for at least 4 h and there is no change in temperature or condition of the test sample within a ½-h time period;

b) An automatically reset protector functions during test and the test has continued for 7 h;

c) A manual reset protector which has been reset 10 times using the minimum resetting time, but not more frequently than 10 cycles of operation in a minute, continues to be operational at the completion of the test; or

d) The test has continued for 7½ h with little significant change in the operating temperature of the product.

3.4.2.7.1.8 A risk of fire or electric shock is considered to exist if any of the following occur:

a) Flame or molten metal is emitted from the enclosure of the component 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; or

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

3.4.2.7.1.9 Following each abnormal test, the Dielectric Voltage-Withstand Test specified in 3.4.2.5, shall be conducted on the component.

3.4.2.7.2 Abnormal operation test

3.4.2.7.2.1 A component shall not result in a risk of fire or electric shock as a result of being subjected to potential misuses that are likely to exist during normal use. Examples of abnormal operation are as follows:

a) Stalling of the rotor of a fan and blower,

b) The shorting of output terminals, and

c) Leaving output terminals unconnected to a load while energized.

3.4.2.7.3 Abnormal component breakdown test

3.4.2.7.3.1 A component as specified in 3.4.2.7.3.2 that is likely to fail by experiencing an open circuit or a short circuit in a circuit shall not result in risk of fire or electric shock as a result of being subjected to the test specified in 3.4.2.7.3.3 with the component open circuited and short circuited.

3.4.2.7.3.2 The component mentioned in 3.4.2.7.3.1 includes an electrolytic capacitor, a diode, a solid state device, or any other component not previously investigated and determined to be suitable for the application. An electromagnetic and radio frequency interference capacitor, a resistor, a transformer, an inductor, or an optical isolator is not required to comply.

3.4.2.7.3.3 Three tests of each component under the open- and short-circuit conditions, using untested components for each test, are to be conducted using the guidelines specified in (a) – (f) below. A component located in a feedback circuit providing voltage, current or temperature limiting, is to be subjected to open- and short-circuit conditions. Each component fault is to be applied one fault at a time.

a) Capacitors – open-circuited;

b) Discrete semiconductor devices (triacs, transistors, diodes, and the like) – open-circuit and short-circuited;

c) Integrated circuits – critical pins shorted to ground;

d) Resistors – open-circuited;

e) Inductors – open-circuited; and

f) Other components – open-circuit and short-circuited.

3.4.2.8 Humidity exposure test

3.4.2.8.1 A sign component enclosing or insulating a live part is to comply with the Dielectric Voltage Withstand Test after being subjected to humidity conditioning. Humidity conditioning is to be on a component after being assembled in accordance with the manufacturer's installation instructions. The assemblies are to be arranged in a chamber in the position that is most likely to result in moisture accumulation and is a likely field orientation.

3.4.2.8.2 Three samples shall be exposed for 168 h to moist air having a relative humidity of 88 ±2% at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F).

3.4.2.8.3 Within 10 min of being removed from humidity conditioning, the assemblies shall comply with the Dielectric Voltage Withstand Test requirements in 3.4.2.5 for the maximum voltage rating of the component.

3.4.2.9 Condensation test

3.4.2.9.1 A sign component enclosing or insulating a live part in a damp or wet location is to comply with the Dielectric Voltage Withstand Test after being subjected to condensation conditioning. Condensation conditioning is to be on a component after being assembled in accordance with the manufacturer's installation instructions. The assemblies are to be arranged in a chamber in the position that is most likely to result in moisture accumulation and is a likely field orientation.

3.4.2.9.2 A component is to be conditioned for 24 ±1/2 h in a minus 40 ±2°C (minus 40 ±3.6°F). After 24 h, the samples are to be removed from the 40 ±2°C (minus 40 ±3.6°F) ambient and placed within 2 min into a humidity chamber maintained at 88 ±2% at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F) for 48 h.

3.4.2.9.3 At the conclusion of the 48 h in the chamber, the assemblies shall comply with the Dielectric Voltage Withstand Test requirements in 3.4.2.5 for the maximum voltage rating of the component.

3.4.2.10 Motor tests

3.4.2.10.1 Starting current test

3.4.2.10.1.1 A motor operated sign component shall start and operate normally on a circuit protected by an ordinary – not time delay – fuse having a current rating corresponding to that of the branch circuit to which the appliance should be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the sign component trips.

3.4.2.10.1.2 The sign component is to be started three times at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle. The component is to be allowed to come to rest between successive starts.

3.4.2.10.2 Locked rotor test

3.4.2.10.2.1 A motor sample is to be placed on a soft wood surface covered with two layers of tissue paper. The motor is to be covered with two layers of cheesecloth. The test is to be conducted at room ambient. The motor is to be energized at rated potential with the rotor locked. The locked rotor condition is to be maintained for 7½ h. The motor enclosure is to be connected to ground through a 3-A non-time delay cartridge fuse with voltage rating based on the rating of the motor.

3.4.2.10.2.2 As a result of the locked rotor condition:

a) There shall be no indication that the cheesecloth or tissue paper glowed or flamed;

b) When subjected to the Dielectric Voltage Withstand Test specified in 3.4.2.5; there shall be no indication of dielectric breakdown;

c) There shall be no indication of softening, cracking, warping or other deformation to result in a reduction in spacings; and

d) During and at the conclusion of the test the fuse shall not have opened.

3.4.2.11 Circuit interrupting devices tests

3.4.2.11.1 Overload test

3.4.2.11.1.1 A device that interrupts an inductive (ballasts or transformers) or tungsten (incandescent lamps) load circuit shall be subjected to the overload test in 3.4.2.11.1.2 – 3.4.2.11.1.5 and the endurance test in 3.4.2.11.2.

3.4.2.11.1.2 During the test, there shall be no electrical or mechanical breakdown of the equipment, no undue burning or pitting of contacts and no welding of contacts.

3.4.2.11.1.3 With the product containing the circuit interrupting device connected to a test voltage within 5% of rated voltage, the device contacts shall be connected in the manner representative of intended use to a load that causes 1.5 times the current during intended use. If the intended load is inductive, the load shall be inductive with a power factor of 0.40 – 0.50.

3.4.2.11.1.4 The test shall consist of 100 cycles of operation being cycled at a rate of 6 – 10 cycles per minute with the on time for each cycle to be not more than 1 s.

3.4.2.11.1.5 At the conclusion of the test, the circuit-interrupting device shall be capable of performing its intended function.

3.4.2.11.2 Endurance

3.4.2.11.2.1 After being subjected to the overload test, a circuit interrupting device shall be subjected to 10,000 cycles of operation interrupting the intended load while connected to a voltage source that is within 5% of rated voltage.

3.4.2.11.2.2 At the conclusion of the endurance test a circuit interrupting device shall:

a) Be capable of performing its intended function,

b) Show no wear,

c) Show no loosening of parts, and

d) Show no indication of other damage or defect that is capable of diminishing the usefulness and reliability of the device.

3.4.2.11.2.3 Following the endurance test the device is to be subjected to the Dielectric Voltage Withstand Test, 3.4.2.5, with the voltage potential applied between current carrying parts and:

a) Exterior dead metal parts, or

b) In cases where there is no dead metal on the exterior, metal foil wrapped around the device.

3.4.2.11.2.4 During the test, the load is to be rated load. If the intended load is inductive, the load shall have a power factor of 0.40 – 0.50.

3.4.2.11.2.5 The test is to consist of 10,000 cycles of operation, at a rate of 18 – 24 cycles per minute for an inductive load and 6 – 10 cycles per minute for a tungsten (incandescent) load.

3.4.2.12 Printed-wiring board tests

3.4.2.12.1 Abnormal reduced spacing trace-to-trace short-circuit

3.4.2.12.1.1 A printed-wiring board shall be tested as described in 3.4.2.12.1.2 – 3.4.2.12.1.5.

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

3.4.2.12.1.3 A sample of the sign component 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 2.17 or Table 2.18 or Table 2.19, one at a time.

3.4.2.12.1.4 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 3.4.2.7.3, the test is to be repeated two more times using untested components as required.

3.4.2.12.1.5 The test is to be continued for 1 h or until one of the conditions described in 3.4.2.7.1.8 occurs. However, when at the end of 1 h no condition described in 3.4.2.7.1.8 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.

3.4.2.13 Class 2 and Class 3 tests

3.4.2.13.1 Maximum output voltage test

3.4.2.13.1.1 The maximum output voltage of a Class 2 and Class 3 supply source, when tested under the conditions specified in 3.4.2.13.1.2 shall not exceed the voltages specified in Table 2.11 and Table 2.12.

3.4.2.13.1.2 To determine compliance with 3.4.2.13.1.1 a Class 2 or Class 3 supply source is to be connected to the rated input. When a supply source is required to be grounded, the branch-circuit ground is to be connected to the grounding means on the supply source. The output is not to be connected to a load (open circuit). The output from lead to lead or terminal to terminal of each circuit is to be measured. A supply source that does not provide the full output voltage under open-circuit conditions shall have the circuitry responsible for limiting or interrupting the output voltage under open circuit conditions defeated.

3.4.2.13.2 Maximum output current and power test

3.4.2.13.2.1 The maximum output current and output volt-amperes specified in Table 2.11 and Table 2.12 are to be determined using a current meter and a wattmeter. A resistive load is to be adjusted to result in maximum reading of the meters. With no further adjustment of the load, the sample is to be de-energized and cooled to room temperature. The sample is then to be energized and maximum current and wattage measurements are to be taken as specified in 3.4.2.13.2.2 for an inherently limited supply source and 3.4.2.13.2.4 for a not inherently limited supply.

3.4.2.13.2.2 To determine compliance with 3.4.2.13.2.1, an inherently limited Class 2 or Class 3 supply source is to be connected to the rated input. A supply source required to be grounded is to be connected to branch-circuit ground. The output from lead to lead or terminal to terminal of each circuit is to be measured under the following conditions, as applicable:

a) For a supply source employing a transformer with no form of protection, the measurement is to be made 60 s after the unit is connected to the source of supply.

b) For a supply source employing a transformer and energy limiting impedance or energy limiting circuit (a resistor, a PTC device or similar circuitry) required for the purpose, the measurement is to be made five seconds after the unit is connected to the source or supply.

c) For a supply source which employs a transformer and either a thermal cutoff, a fuse, or both, all protection is to be defeated during the test and the measurement made 60 s after the unit is connected to the supply source.

d) For a supply source that employs a transformer and a combination of a limiting impedance or circuit required for the purpose, and a protective device (such as a thermal cutoff, a fuse, or both), all protective devices are to be defeated and the measurement is to be made five seconds after the unit is connected to the supply source.

e) For a supply source that employs a dc input and a combination of a limiting impedance or circuit required for the purpose, and a protective device (i.e. thermal cutoff, fuse, or both), the protective device is to be defeated and the measurement is to be made five seconds after the unit is connected to the supply source.

3.4.2.13.2.3 During the maximum output current and power measurements specified in 3.4.2.13.2.2, the output of the supply source shall not shutoff.

3.4.2.13.2.4 To determine compliance with 3.4.2.13.2.1, a not inherently limited Class 2 or Class 3 supply source is to be connected to the rated input. A supply source required to be grounded is to be connected to branch-circuit ground. The output from lead to lead or terminal to terminal of each circuit is to be measured in accordance with 3.4.2.13.2.2 with protective devices shorted out during the test.

3.4.2.13.2.5 A protective device provided as a part of a not inherently limited unit shall operate in not more than the time indicated in Table 3.12 when the unit is delivering the specified secondary current.

Table 3.12
Maximum Acceptable Time for Protection Device Operation

Open circuit secondary potential	Secondary test current	Maximum time for overcurrent-protective device to open
V	A	min
Class 2		
20 or less	10	2
20 or less	6.75	60
Over 20 – 30	$200/V_{max}$	2
Over 20 – 30	$135/V_{max}$	60
Class 3		
Over 30 – 100	$200/V_{max}$	2
Over 30 – 100	$135/V_{max}$	60
Over 100 – 150	2	2
Over 100 – 150	1.35	60

Notes:

1) For secondary test currents of 10 and $200/V_{max}$, the load is to be adjusted continuously to maintain the test current value shown.

2) For secondary test currents of 6.75 and $135/V_{max}$, after 15 min of operation, the load is to be readjusted to return the output current to the value shown.

3) For secondary test currents of $135/V_{max}$ and $200/V_{max}$, V_{max} is the maximum output voltage regardless of load with rated input.

3.4.3 Installation and assembly test

3.4.3.1 A sign component involving any degree of assembly or installation is to be installed and assembled in a method typical of factory and field conditions in accordance with the installation instructions. An assembled and installed component shall comply with the requirements in the end product standard. Assembly and installation is to include and identify possible misuse and abnormal assembly and installation that can result in the need for either construction revisions, or, where construction revisions are not feasible, warning instructions to minimize the potential for misuse and abnormal condition.

4 Specific Components Only for Use in an End Product

4.1 General

4.1.1 This section of the Standard includes the specific requirements for sign components that have been identified as components for use only in an end product, such as a sign, outline lighting, and cold cathode lighting. This section of the Standard also includes the specific requirements for components used in field assembled skeletal neon installations as part of a system specified in Section 5 of this Standard.

4.1.2 Components covered by this part of the standard are identified in Table 4.1.

Table 4.1
Sign components suitable for factory assembled signs and outline lighting

Section No.	Sign components suitable only for factory assembled signs and outline lighting
4.2	Electrode receptacle, other than through wall housing type
4.3	Feed type cold cathode and over 1000 V lampholders

Table 4.1 Continued on Next Page

Table 4.1 Continued

Section No.	Sign components suitable only for factory assembled signs and outline lighting
4.4	Interconnecting cold cathode and over 1000 V lampholders
4.5	Electrode receptacle enclosure
4.6	Polymeric neon electrode enclosure
4.7	Glass cup receptacles
4.8	Glass tubing conduit assembly
4.9	GTO cable sleeving
4.10	GTO cable splice enclosure
4.11	Sign body, awning and sign face material - not enclosure rated
4.12	Enclosure sign face materials
4.13	Sign face tensioning systems
4.14	Structural materials
4.15	Electrode receptacle insulator
4.16	Trim cap
4.17	Dimmers, flashers, controllers and animators
4.18	LED components
4.19	Electroluminescent displays
4.20	Switch enclosures
4.21	Sign rotating equipment
4.22	Clock mechanisms

4.1.3 The requirements covering sign components in this section are supplementary to the general requirements in Sections 1 – 3 and where applicable modify a general requirement for a particular component.

4.1.4 A sign component shall be provided with installation instructions. The installation instructions are to be verbatim as specified in Table 4.2. The applicable installation instructions for each component are specified under the section for a specific component. Additional installation instructions are permitted based on the intended use of the component.

Table 4.2
Installation instructions

Installation instruction
Must be enclosed in end product.
Limited to use only in dry locations.
Limited to use in dry and damp locations.
Acceptable for use in wet locations.
Acceptable for use in dry, damp and wet locations.
Limited to only decorative applications.
Limited to only decorative and sign body applications.
Acceptable for enclosure, sigh body and decorative applications. Enclosure applications include exposed live parts.
Suitable for enclosure, sign body and decorative applications. Enclosure applications limited to insulated live parts.

Table 4.2 Continued on Next Page

Table 4.2 Continued

Installation instruction
Suitable for use in component support applications.
Limited to only portable sign use.
Water exclusion must be determined in the end product.
Minimum 5 cm (2 in) spacing from heat producing components required.
Minimum 8 cm (3 in) spacing from heat producing components required.
Minimum 2 to side and 1/2 in spacing in compartment surrounding component required.
Minimum 4 to side and 1 in spacing in compartment surrounding component required.
Marking required on end product stating, "Replace only with (manufacturer's name of component), type (type designation of sign face) sign face material."
Channel letters must be provided with sign face material.
Suitable for use in terminating conduit.
Suitable for use only when connected to a ____volts, Class 2 transformer or power supply.
Rated for maximum 5 kV, 2.5kV to ground.
Rated for a maximum 10 kV, 5kV to ground.
Rated for maximum 15 kV, 7.5kV to ground.
Tests required in end product.

4.1.5 Specific use components utilizing polymeric material in its construction shall comply with the polymeric material requirements in 2.1.4 and as amended in Section 4. Table 4.3 part 1 summarizes the polymeric enclosure requirements in Section 4.

Table 4.3 part 1
Polymeric Material Requirements, Components

Component	Install type		Illumination type					Table 4.3 part 2 reference
	Stationary & permanent	Portable	Incandescent	Fluorescent	Neon/ Cold Cathode	HID	LED	
Neon Electrode Enclosure	X	X			X			A
GTO Sleeving	X				X			B
GTO Sleeving		X			X			C
Integral Sleeved GTO Cable	X				X			D
Integral Sleeved GTO Cable		X			X			E
Enclosure sign face material	X		X					F
Enclosure sign face material	X			X	X			G
Enclosure sign face material	X					X		H
Enclosure sign face material	X						X	I
Enclosure sign face material		X	X					J
Enclosure sign face material		X		X	X			K
Enclosure sign face material		X				X		L
Enclosure sign face material		X					X	M
GTO cable splice enclosure	X	X			X			N
Sign body, not enclosure rated	X	X						O
Tube supports	X				X			P
Cable Supports	X	X			X			Q
Flexible sign face, not enclosure rated	X			X	X	X		R
Flexible sign face, not enclosure rated	X		X					S
Flexible sign face, not enclosure rated		X		X	X			T
Flexible sign face, not enclosure rated		X	X			X		U
Flexible sign face, not enclosure rated		X	X				X	V
Rigid non-enclosure sign face	X		X	X	X	X	X	W

Table 4.3 part 1 Continued on Next Page

Table 4.3 part 1 Continued

Component	Install type		Illumination type					Table 4.3 part 2 reference
	Stationary & permanent	Portable	Incandescent	Fluorescent	Neon/ Cold Cathode	HID	LED	
Rigid non-enclosure sign face		X	X				X	**X**
Rigid non-enclosure sign face		X		X	X			**Y**
Rigid non-enclosure sign face		X				X		**Z**
Frame	X	X	X	X	X	X	X	**AA**
Structural panel	X	X	X	X	X	X	X	**BB**
Sign face trim	X	X	X	X	X	X	X	**CC**
Switch enclosure	X	X	X	X	X	X	X	**DD**
Polymeric channel letter, non-enclosure rated	X	X	X					**EE**
Polymeric channel letter, non-enclosure rated	X	X		X	X			**FF**
Polymeric channel letter, non-enclosure rated	X	X				X		**GG**
Polymeric channel letter, non-enclosure rated	X	X					X	**HH**
Polymeric channel enclosure	X	X	X					**II**
Polymeric channel enclosure	X	X		X	X			**JJ**
Polymeric channel enclosure	X	X				X		**KK**
Polymeric channel enclosure	X	X					X	**LL**

Notes:

1. An "X" provided in a column under installation and illumination type, in the row of a component, identifies the use for the component.

2. See Notes 2 through 9 of Table 4.3 part 2 for additional notes that are applicable to both parts.

Table 4.3 part 2
Polymeric Material Requirements, Components

Component reference letter from part 1	Wet locations											
	Damp locations											
	Dry locations											
	Min. temp °C (°F)	Min. Flame	Humidity	CTI, PLC	UV	Ozone	Mold stress	Min. temp °C (°F)	UV & ozone	Cold impact	Condensation test	Rain test
A	120 (248)	5VA	Y	1	Y	Y	Y	135 (275)	Y	Y	Y	Y
B	120 (248)	5VA	Y	1	Y	Y	N	120 (248)	Y	N	N	Y
C	105 (221)	V-2	Y	1	Y	Y	N	120 (248)	Y	N	N	Y
D	120 (248)	5VA	Y	1	Y	Y	N	120 (248)	Y	N	N	Y
E	105 (221)	V-2	Y	1	Y	Y	N	120 (248)	Y	N	N	Y
F	75 (167)	5VA	N	N	N	N	Y	75 (167)	Y	Y	Y	N
G	75 (167)	5VA	N	N	Y	Y	Y	75 (167)	Y	Y	Y	N
H	75 (167)	V-2	N	N	Y	N	Y	75 (167)	Y	Y	Y	N
I	75 (167)	5VA	N	N	N	N	Y	75 (167)	Y	Y	Y	N
J	75 (167)	V-2	N	N	N	N	Y	75 (167)	Y	Y	N	N
K	75 (167)	V-2	N	N	Y	Y	Y	75 (167)	Y	Y	N	N
L	75 (167)	V-2	N	N	Y	N	Y	75 (167)	Y	Y	N	N
M	75 (167)	V-2	N	N	N	N	Y	75 (167)	Y	Y	N	N
N	105 (221)	5VA	Y	1	Y	Y	Y	105 (221)	Y	Y	Y	Y
O	50 (122)	HB	N	N	N	N	Y	50 (122)	UV	N	N	N
P	60 (140)	HB	Y	1	Y	Y	Y	75 (167)	UV	Y	Y	Y
Q	60 (140)	V-2	N	1	N	N	Y	75 (167)	UV	Y	Y	N
R	50 (122)	HB	N	N	N	N	N	50 (122)	UV	N	N	N
S	50 (122)	HB	N	N	N	N	N	50 (122)	UV	N	N	N
T	50 (122)	HB	N	N	N	N	N	50 (122)	UV	N	N	N
U	50 (122)	HB	N	N	N	N	N	50 (122)	UV	N	N	N
V	50 (122)	HB	N	N	N	N	N	50 (122)	UV	N	N	N
W	50 (122)	HB	N	N	N	N	–	50 (122)	UV	N	N	N
X	50 (122)	HB	–	N	N	N	–	50 (122)	UV	N	N	N

Table 4.3 part 2 Continued on Next Page

Table 4.3 part 2 Continued

Component reference letter from part 1	Wet locations											
	Damp locations											
	Dry locations											
	Min. temp °C (°F)	Min. Flame	Humidity	CTI, PLC	UV	Ozone	Mold stress	Min. temp °C (°F)	UV & ozone	Cold impact	Condensation test	Rain test
Y	50 (122)	HB	–	N	N	N	–	50 (122)	UV	N	N	N
Z	50 (122)	HB	–	N	N	N	–	50 (122)	UV	N	N	N
AA	90 (194)	5VA	Y	N	Y	N	Y	105 (221)	Y	Y	N	N
BB	50 (122)	HB	N	N	N	N	N	50 (122)	N	N	N	N
CC	50 (122)	N/A	Y	–	N	N	N	50 (122)	UV	Y	N	N
DD	50 (122)	N/A	Y	–	Y	N	Y	65 (149)	Y	Y	Y	Y
EE	105 (221)	HB	Y	1	N	N	Y	120 (248)	N	Y	N	Y
FF	80 (176)	HB	Y	N	Y	Y	Y	80 (176)	Y	Y	N	Y
GG	105 (221)	HB	Y	1	Y	Y	Y	120 (248)	Y	Y	N	Y
HH	80 (176)	HB	Y	N	N	N	Y	80 (176)	N	Y	N	Y
II	105 (221)	5VA	Y	1	N	N	Y	120 (248)	N	Y	N	Y
JJ	105 (221)	5VA	Y	1	Y	Y	Y	120 (248)	Y	Y	N	Y
KK	105 (221)	5VA	Y	1	Y	Y	Y	120 (248)	Y	Y	N	Y
LL	105 (221)	5VA	Y	1	N	N	Y	120 (248)	N	Y	N	Y

Notes for Table 4.3 part 1 and 2:

1. A "Y" provided in a column under a test, in the row of a component, indicates that the test is required. An "N" provided in a column under a test, in the row of a component, indicates that the test is not required.

2. A component not identified for use only in a portable sign or by its nature restricted for use only in permanently installed signs is to comply with the requirements for permanently installed signs.

3. A component that is not identified for use only in a sign of a particular type of illumination shall comply with the most stringent requirements for all types of illumination.

4. Where a rain test is specified for a neon electrode enclosure, GTO Sleeving, and integrally sleeved GTO cable, the test is to be performed on every combination of electrode enclosure and GTO sleeving and integrally sleeved GTO cable for which each is designated.

5. In a portable sign in other than a dry location, a GTO cable sleeving or integrally sleeved GTO cable that inserts into the electrode enclosure and is within 1.25 cm (1/2 in) of the electrode shell of a neon tube electrode shall be rated at least 120°C (248°F).

6. A wet location designation that includes a Rain Test shall only exist when both the neon electrode enclosure and GTO sleeving or integrally sleeved GTO cable are designated as a system.

Table 4.3 part 2 Continued on Next Page

Table 4.3 part 2 Continued

Component reference letter from part 1	Wet locations											
	Damp locations											
	Dry locations							Min. temp °C (°F)	UV & ozone	Cold impact	Condensation test	Rain test
	Min. temp °C (°F)	Min. Flame	Humidity	CTI, PLC	UV	Ozone	Mold stress					
7. For other than neon electrode enclosures, GTO sleeving and integrally sleeved GTO cable, a lower temperature rating is permitted for a component identified for limited applications.												
8. The minimum temperature rating of a material is the Relative Thermal Index (RTI). For neon electrode enclosure, GTO sleeving and integrally sleeved GTO cable only, the minimum temperature rating of a material is determined by the Relative Thermal Index (RTI) or the Wire and Cable Accelerated Aging Test specified in 3.2.2.1 are acceptable.												
9. N does not apply to gaskets used with metallic enclosures.												

4.2 Electrode receptacles, other than the through wall housing type

4.2.1 General

4.2.1.1 These requirements apply to electrode receptacles that are not provided with an enclosure, intended for installation through an enclosure or raceway wall and are not provided with a means to be connected to a permanent wiring system. Several types of electrode receptacles are shown in Figure 4.1 and Figure 4.2.

Figure 4.1

Closed end type electrode receptacles

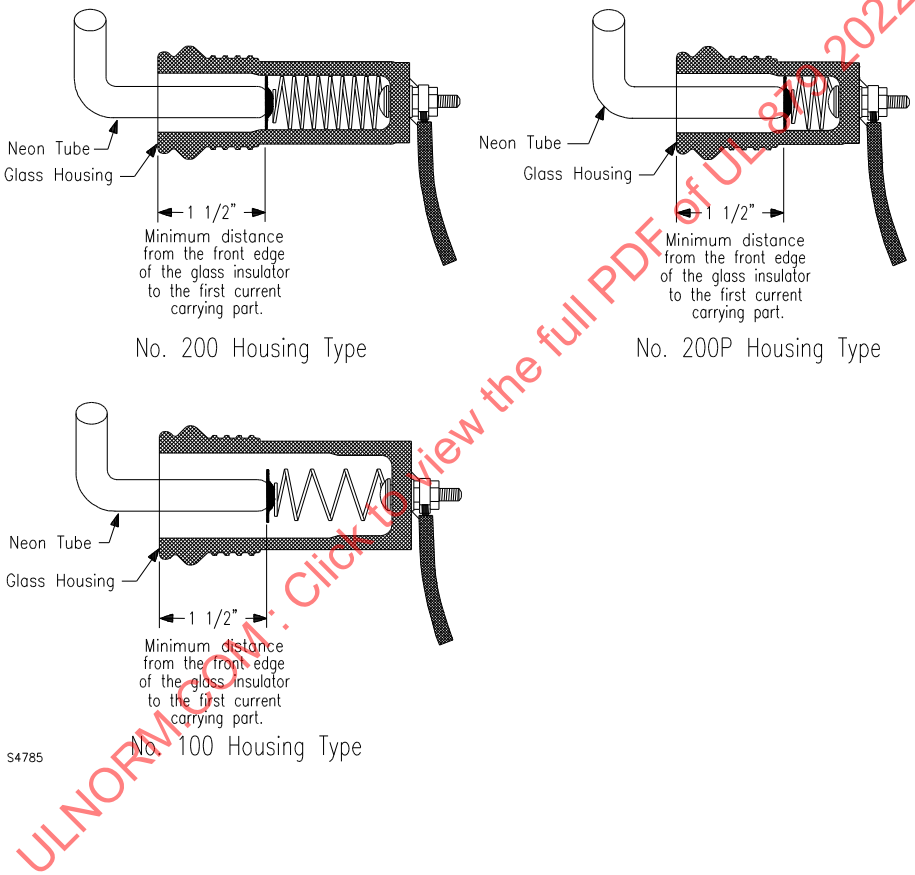
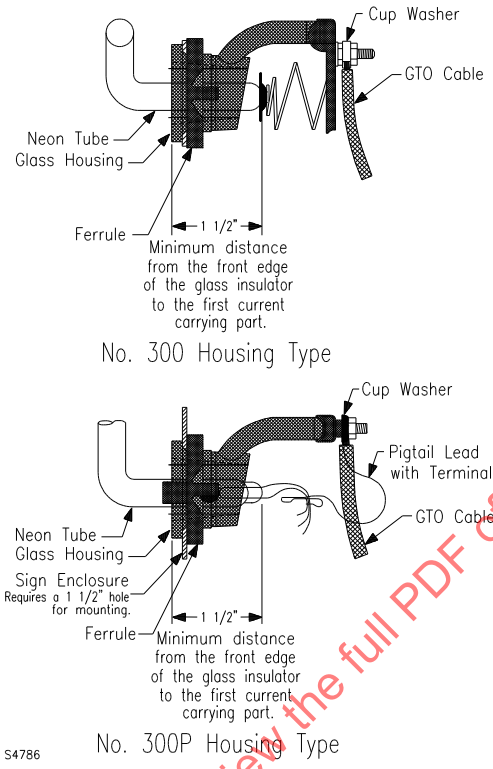


Figure 4.2

Closed end type electrode receptacles



4.2.2 Construction requirements

4.2.2.1 The insulating material of an electrode receptacle shall be porcelain, glass, or other insulating material that has been evaluated to comply with environmental and insulating characteristics for the intended use. A porcelain or ceramic material shall be glazed or provided with a non-absorptive coating on all surfaces.

4.2.2.2 An electrode receptacle shall be of a length that when the mounting means is adjusted to accommodate the thickest mounting surface possible, the minimum through air and across surface spacings required in section 2.15 for the voltage involved are maintained between live parts and dead metal parts.

4.2.2.3 The diameter of an electrode receptacle shall have an inside diameter that is at least 6.35 mm (0.25 in) larger than the maximum diameter of neon tubing for which the electrode receptacle is rated.

4.2.2.4 A closed end electrode receptacle identified for use in a damp location or in a wet location shall:

a) Have an inside diameter at the mouth at least 6.4 mm (0.25 in) greater than the interior diameter at the terminal end, and be provided with a sloping interior wall which extends for it entire length; or

b) Be provided with drain holes as specified in 4.2.2.5.

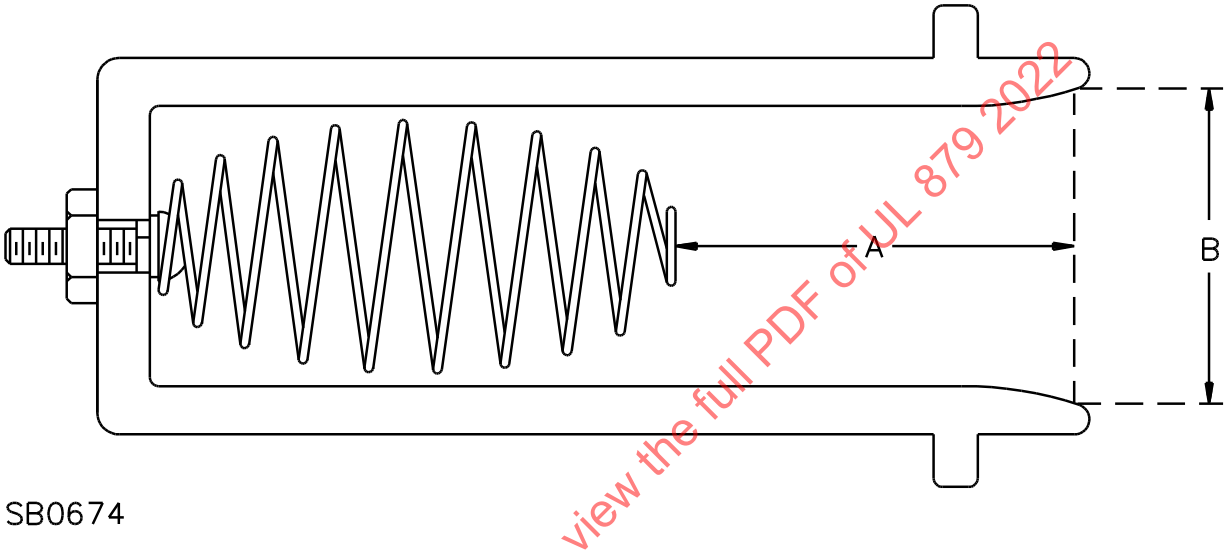
4.2.2.5 The drain holes required in 4.3.2.4 shall be located in the closed end of the receptacle. There shall be four drain holes each at least 3.175-mm (0.125-in) diameter and no greater than 7.9 mm (5/16 in). Each drain hole shall be positioned equal distance in each quadrant of the end of the receptacle.

4.2.2.6 A closed end electrode receptacle shall have supply connections centered at the back of the receptacle shall have the terminal located at the center of the closed end of the receptacle.

4.2.2.7 An open ended electrode receptacle shall have a supply connection terminal support located offset from the center axis of the receptacle on an arm that can be positioned above the back of the receptacle. See Figure 4.3.

Figure 4.3

Coiled-spring electrode receptacle



4.2.2.8 A coiled-spring within a receptacle in an un-depressed position shall not have a distance between the contact and the plane of the mouth of the receptacle no less than the spacings required in 2.15. See Figure 4.3.

4.2.2.9 A spring contact shall have a spring that can be compressed and extended at least 38 mm (1.5 inch) in both directions from its original relaxed position without resulting in the overall dimension of the spring being changed from its original relaxed length.

4.2.3 Supply connection means

4.2.3.1 An electrode receptacle shall be provided with a terminal capable of securing an 18 to 14 AWG (0.82 to 2.1 mm^2) conductor or be provided with an 18 to 14 AWG (0.82 to 2.1 mm^2) stranded conductor.

4.2.4 Mounting means

4.2.4.1 A receptacle shall be provided with a mounting means.

4.2.5 Tests

4.2.5.1 An electrode receptacle shall comply with the Dielectric Voltage Withstand Test in 3.4.2.5 for the maximum open circuit rating marked on the receptacle.

4.2.5.2 An electrode receptacle with a polymeric insulating body shall be subject to a Normal Temperature Test in 3.4.2.3 with the highest current rated electrode having the maximum diameter neon tube electrode. The tubing shall be filled with a mercury cold weather gas mixture. The tubing load shall be the length required to draw 80 % of the maximum current rating.

4.2.5.3 An electrode receptacle designated for use in a dry and damp or dry, damp and wet location shall comply with Condensation Test in 3.4.2.9 and the material tests for inorganic, non-metallic materials specified in 3.3 or comply with the material tests for polymeric materials in 3.2 including requirements for ultraviolet radiation, ozone, and other tests as required for Neon Electrode Enclosures in 4.6.

4.2.5.4 An electrode receptacle designated for use in a wet location shall comply with the Rain Test in 3.4.1.9 and then comply with the Dielectric Voltage Withstand Test in 3.4.2.5. During the test water shall not collect along the length of the receptacle and shall drain out the drain holes or mouth of the enclosure. Water can contact live parts as long as a continuous path along the length of the receptacle is not established as determined by the Dielectric Voltage Withstand Test.

4.2.6 Ratings

4.2.6.1 An electrode receptacle shall have a maximum open circuit voltage rating to ground, the maximum diameter of neon tube electrode that the receptacle is intended to accommodate and the maximum current rating.

4.2.7 Markings and installation instructions

4.2.7.1 General installation instructions

4.2.7.1.1 The installation instructions for an electrode receptacle shall include at least the following:

a) The maximum voltage and current rating of the electrode receptacle.

b) A location designation relating to the type of environmental the electrode receptacle has been evaluated for use in – Dry Only, Dry and Damp Only or Dry, Damp and Wet Locations.

4.2.7.1.2 Electrode Receptacle specific installation instructions:

a) An electrode receptacle shall specify that it is "Suitable for use with maximum ___ mm diameter neon tubing." The blank is to be filled in with the maximum diameter of neon tubing that complies with the requirements in 4.2.2.3.

b) An electrode receptacle with a closed end, commonly referred to as #200, #200 P and #100 housing, shall be provided with a condition of use indicating in a damp or wet location – the opening of the receptacle must be installed horizontal to ground or with the end accepting the neon tube lower than the closed end of the receptacle.

c) An electrode receptacle shall be provided with a condition of use that specifies "Neon tubing shall be centered inside the receptacle such that contact with the receptacle walls is avoided."

d) An electrode receptacle provided with a metal mounting means shall be identified by the instruction "This electrode receptacle is intended for installation only in the surface of a metal enclosure or raceway."

e) An electrode receptacle with an open end, commonly referred to as #300 and #300 P housing, shall be provided with a condition of use indicating "In a damp or wet location – the electrode receptacle must be located where no live parts are located below the receptacle and the with supply terminal be positioned above the rest of the receptacle."

4.2.7.1.3 Installation Instructions shall be provided inside each smallest unit container or at least twenty instruction sheets provided per carton of 100 receptacles.

4.3 Feed type over 1000 V lampholders

4.3.1 General

4.3.1.1 These requirements apply to lampholders and electrode housings as shown in Figure 4.4 intended for:

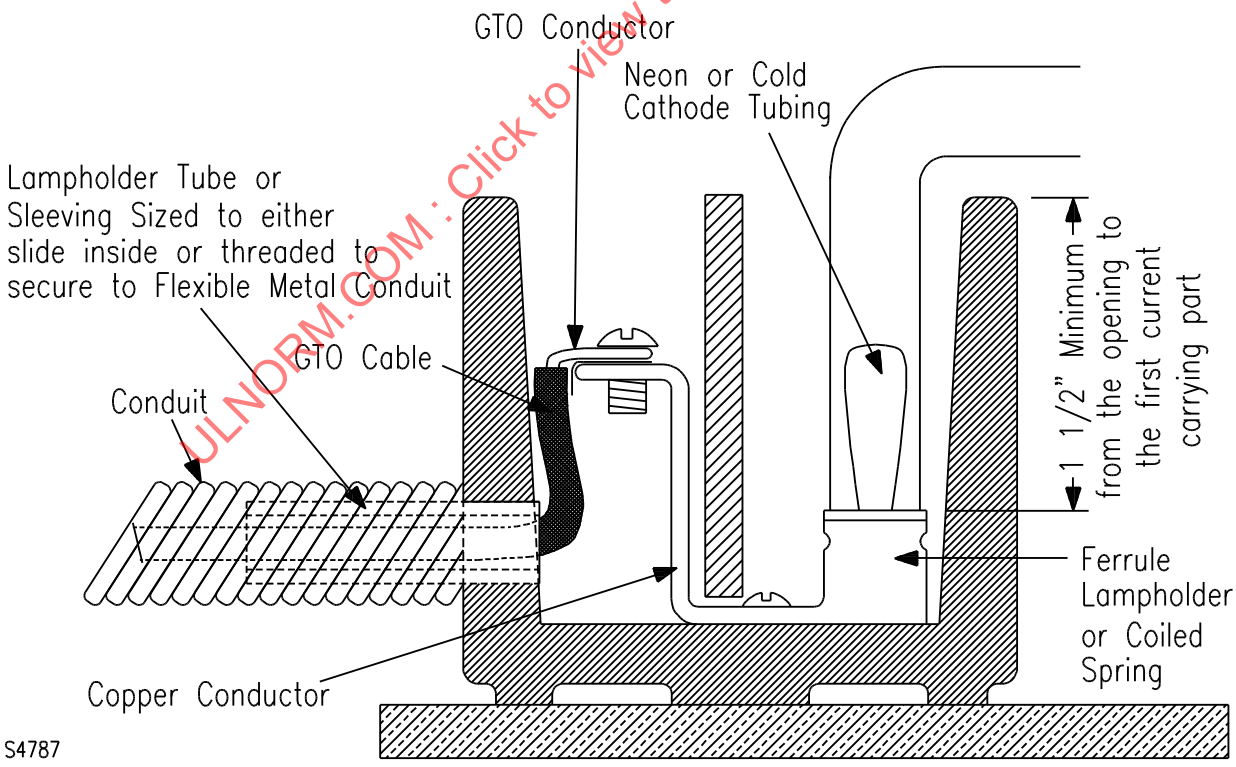
a) Use in secondary circuits having voltages in the range of 1000 to 15,000 V,

b) Are intended for connection to a permanent wiring system in accordance with the National Electrical Code, and

c) Cold cathode lampholders having voltages 900 V and higher.

Figure 4.4

Feed type over 1000 V lampholder



4.3.2 Construction requirements

4.3.2.1 The insulating material of an electrode receptacle shall be porcelain, glass, or other insulating material that has been evaluated to comply with environmental and insulating characteristics for the

intended use. A porcelain or ceramic material shall be glazed or provided with a non-absorptive coating on all surfaces.

4.3.2.2 Other than areas inside compartments that, due to their location, cannot be glazed readily, a porcelain material used in a lampholder suitable for use in damp or dry locations shall be glazed or provided with a non-absorptive coating on all surfaces.

4.3.2.3 A lampholder and electrode housing suitable for use in damp locations shall be intended for installation with an orientation that will not result in the collection of moisture such as from condensation. Where a lampholder or electrode housing is in a horizontal position it shall be provided with a sloping interior wall that extends its entire length. The gradual slope shall be continuous with no portion raised or lowered that could result in the collection of moisture. The slope shall be such that the inside diameter of the open end of the lampholder is at least 6.4 mm (0.25 in) greater than the inside diameter at the bottom.

4.3.2.4 A lampholder and electrode housing suitable for use in wet locations must be provided with a ridge or other mechanical means to secure a cap over its mouth that prevents the entrance of water into the lampholder. The cap shall be provided with the lampholder and comply with receptacle cap requirements in 5.5.

4.3.2.5 Spacings between live parts and dead-metal parts shall also be judged with a metallic wiring system connected to the lampholder in accordance with the manufacturer's installation instructions.

4.3.2.6 The mounting surface to which a lampholder and electrode housing is mounted as intended shall be considered a dead metal part when applying the spacing requirements.

4.3.2.7 A lampholder cover shall not be relied upon to comply with the spacing requirements.

4.3.2.8 A polymeric material shall be ozone and ultraviolet radiation resistant material.

4.3.2.9 A spring contact shall on at least a quarterly basis take samples of a spring contact and compress the spring and extended the spring at least 38 mm (1.5 in) form its original relaxed position. There shall be no change in the overall dimension of the spring when returned to its relaxed state.

4.3.3 Supply connection means

4.3.3.1 A feed type lampholder and electrode housing shall be provided with a terminal or lead for terminating a GTO cable conductor.

4.3.4 Mounting means

4.3.4.1 A lampholder shall be provided with means to be mechanically secured.

4.3.5 Tests

4.3.5.1 A lampholder and electrode housing shall comply with the Dielectric Withstand Test in 3.4.2.5. The lampholder is to be mounted in accordance with the manufacturer's installation instructions onto a sheet metal surface having dimensions at least 50.8 mm (2 in) larger than the mounting surface of the lampholder. The metal mounting surface is to be conductive connected to any dead metal provided on the lampholder. The test potential is to be applied between a length of GTO cable conductor connected to the supply lead or terminal and any dead-metal on the lampholder or sheet metal mounting surface.

4.3.5.2 An electrode receptacle with a polymeric insulating body shall be subject to a Normal Temperature Test in 3.4.2.3 with the highest current rated electrode having the maximum diameter neon

tube electrode. The tubing shall be filled with a mercury cold weather gas mixture. The tubing load shall be the length required to draw 80 % of the maximum current rating.

4.3.5.3 A lampholder designated for use in a dry and damp or dry, damp and wet location shall comply with Condensation Test in 3.4.2.9 and where the insulating materials are porcelain, ceramic or glass, the material tests for inorganic, non-metallic materials specified in 3.3.

4.3.5.4 A lampholder designated for use in a wet location shall comply with the Rain Test in 3.4.1.9 without the entrance of water into the receptacle.

4.3.6 Ratings

4.3.6.1 A cold cathode lampholder shall have a maximum open circuit voltage rating to ground, the maximum diameter of neon tube that the receptacle is intended to accommodate and the maximum current rating available for the diameter of neon tube electrode.

4.3.7 Markings and installation instructions

4.3.7.1 A lampholder shall be plainly marked with the voltage and current rating and the minimum and maximum neon tube electrode for some applications.

4.3.7.2 A lampholder requiring special mounting or orientation to comply with drainage requirements shall be marked "Top" or in other equally descriptive terms.

4.3.7.3 Required markings shall appear on the body of a lampholder and not on a lampholder cover or other removable part unless the cover or part is electrically essential to the operation of the device.

4.3.7.4 Installation instructions shall be provided with each lampholder.

4.3.7.5 The installation instructions for a cold cathode lampholder shall include at least the following:

a) The neon tube electrode must be inserted into the lampholder to a depth that provides for minimum 1½ in spacing between the end of the neon tube and the mouth of the mouth of the lampholder.

b) The maximum voltage and current rating of the cold cathode lampholder.

c) A location designation relating to the type of environmental the electrode receptacle has been evaluated for use in – Dry Only or Dry and Damp locations.

d) A lampholder designated as suitable for use in dry and damp locations shall be accompanied by a condition of use indicating that in a damp location the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

e) A lampholder designated as suitable for use in dry, damp and wet locations shall be accompanied by a condition of use indicating that it is only suitable for use in a wet location when provided with the required cap over the mouth of the lampholder and in a damp location, the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

f) Not suitable for use in dwellings unless connected to a neon supply designated for use with cold cathode lighting having an output voltage of less than 1000 V and used with a lampholder having a circuit interrupting feature on the other end of the cold cathode tubing.

The installation instructions shall also include:

a) Details on the installation of the lampholder and proper means of connecting GTO cable to a terminal;

b) The maximum open circuit voltage rating to ground, the maximum diameter of neon tube that the receptacle is intended to accommodate and the maximum current rating available for the diameter of neon tube;

c) To install the lampholder in a horizontal position or with the mouth of the lampholder below horizontal when installed in a damp location, or

d) To install the lampholder cover to prevent the entrance of water into the lampholder when installed in a wet location.

4.4 Interconnecting over 1000 V lampholders

4.4.1 General

4.4.1.1 These requirements apply to lampholders over 1000 V as shown in Figure 4.5 that are provided with:

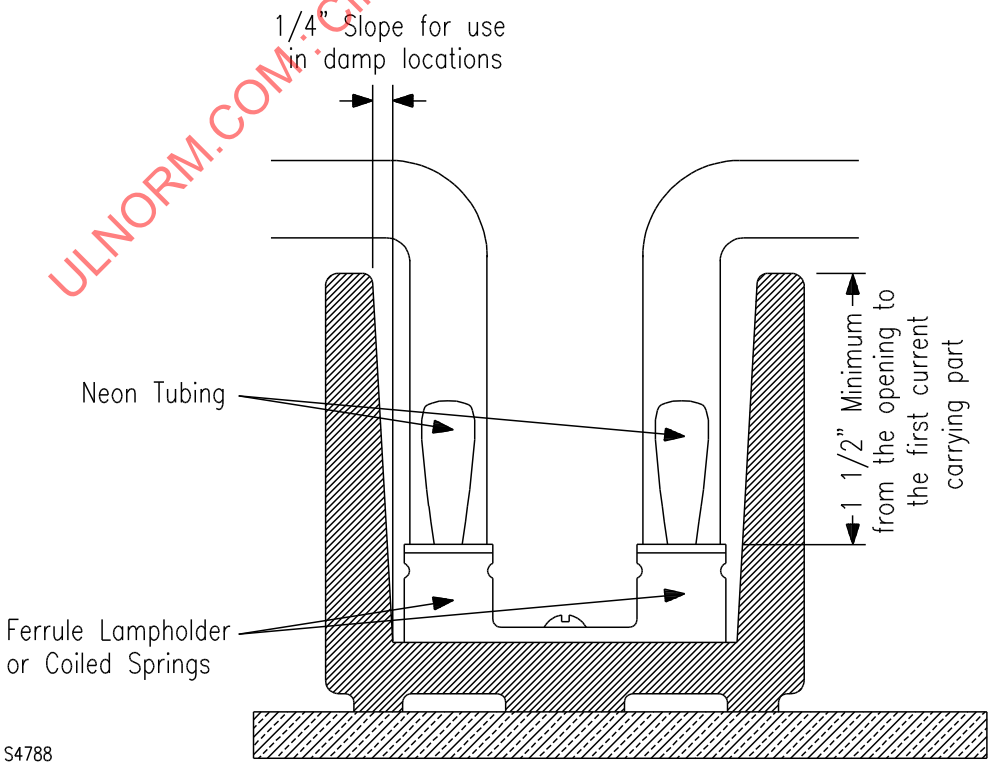
a) Receptacles for two neon tube electrodes,

b) Be evaluated for use on secondary circuits having voltages in the range of 900 to 15,000 V,

c) Have no means of supply connection other than through cold cathode and neon tubing.

Figure 4.5

Interconnecting over 1000 V lampholder



4.4.2 Construction requirements

4.4.2.1 The insulating material of a lampholder shall be porcelain, glass, or other non-absorptive insulating material. An other non-absorptive insulating material such as a polymeric insulating material shall be evaluated for ultraviolet radiation resistance, high voltage arc tracking, water absorption and be rated for the maximum temperature experienced when tested with the highest rated neon tube electrode that can physically fit into the lampholder.

4.4.2.2 Other than areas inside compartments that due to their location can not be glazed readily, a ceramic material used in a lampholder suitable for use in damp or dry locations shall be glazed or provided with a non-absorptive coating on all surfaces.

4.4.2.3 A lampholder suitable for use in damp locations shall be provided with a sloping interior wall that extends its entire length. The gradual slope shall be continuous with no portion raised or lower than the gradual slope that could result in the collection of moisture. The slope shall be such that the inside diameter of the open end of the lampholder is at least 6.4 mm (0.25 in) greater than the inside diameter at the bottom.

4.4.2.4 A lampholder suitable for use in wet locations must be provided with a cap over its mouth that prevents the entrance of water into the lampholder around neon tubing.

4.4.2.5 A wet location lampholder shall be provided with a drain hole other than the mouth of the lampholder.

4.4.2.6 A lampholder shall have no openings into the interior of its insulating shell other than openings for neon tubing.

4.4.2.7 The mounting surface to which a lampholder is mounted as intended shall be considered a dead metal part when applying the spacing requirements.

4.4.2.8 A lampholder cover shall not be relied upon to comply with the spacing requirements.

4.4.2.9 A polymeric material, including polymeric hardware, within direct line of sight of neon tubing shall be ultraviolet radiation resistant material.

4.4.3 Supply connection means

4.4.3.1 Supply connection is by neon tubing only.

4.4.4 Mounting means

4.4.4.1 A lampholder shall be provided with means to be mechanically secured by at least two points to a mounting surface.

4.4.5 Mounting means

4.4.5.1 A lampholder shall comply with the Dielectric Withstand Test in 3.4.2.5. The lampholder is to be mounted in accordance with the manufacturer's installation instructions onto a sheet metal surface having dimensions at least 2 in larger than the mounting surface of the lampholder. The metal mounting surface is to be conductive connected to any dead metal provided on the lampholder. The test potential is to be applied between a length of GTO cable conductor connected to the supply lead or terminal and any dead-metal on the lampholder or sheet metal mounting surface.

4.4.5.2 A lampholder designated for use in a dry and damp or dry, damp and wet location shall comply with Condensation Test in 3.4.2.9 and where the insulating materials are porcelain, ceramic or glass, the material tests for inorganic, non-metallic materials specified in 3.2.

4.4.5.3 A lampholder designated for use in a wet location shall comply with the Rain Test in 3.4.1.9 without water contacting current carrying parts of the receptacle.

4.4.6 Mounting means

4.4.6.1 A cold cathode lampholder shall have a maximum open circuit voltage rating to ground, the maximum diameter of neon tube that the receptacle is intended to accommodate and the maximum current rating available for the diameter of neon tube.

4.4.7 Markings and installation instructions

4.4.7.1 A lampholder shall be plainly marked with the voltage rating and maximum diameter of neon tubing if less than 25 mm (1 in).

4.4.7.2 A lampholder requiring special mounting or orientation to comply with drainage requirements in damp locations shall be marked in a location that is readily visible after installation with "Top" or other equally descriptive terms.

4.4.7.3 Required markings shall appear on the body of a lampholder and not on a lampholder cover or other removable part unless the cover or part is electrically essential to the operation of the device.

4.4.7.4 Installation instructions shall be provided with each lampholder.

4.4.7.5 Interconnecting lampholders shall have the following installation instructions:

a) The neon tube electrodes must be inserted into the lampholder to a depth that provides for minimum 1½ in spacing between the end of the neon tube and the mouth of the mouth of the lampholder.

b) The maximum open circuit voltage rating to ground, the maximum diameter of neon tube that the receptacle is intended to accommodate and the maximum current rating available for the diameter of neon tube

c) A location designation relating to the type of environment the electrode receptacle has been evaluated for use in – Dry Only or Dry and Damp locations.

d) A lampholder designated as suitable for use in dry and damp locations shall be accompanied by a condition of use indicating that in a damp location the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

e) A lampholder designated as suitable for use in dry, damp and wet locations shall be accompanied by a condition of use indicating that it is only suitable for use in a wet location when provided with the required cap over the mouth of the lampholder and in a damp location, the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

f) Details on the installation of the lampholder:

g) To install the lampholder in a horizontal position or with the mouth of the lampholder below horizontal when installed in a damp location, or

h) To install the lampholder cover to prevent the entrance of water into the lampholder when installed in a wet location.

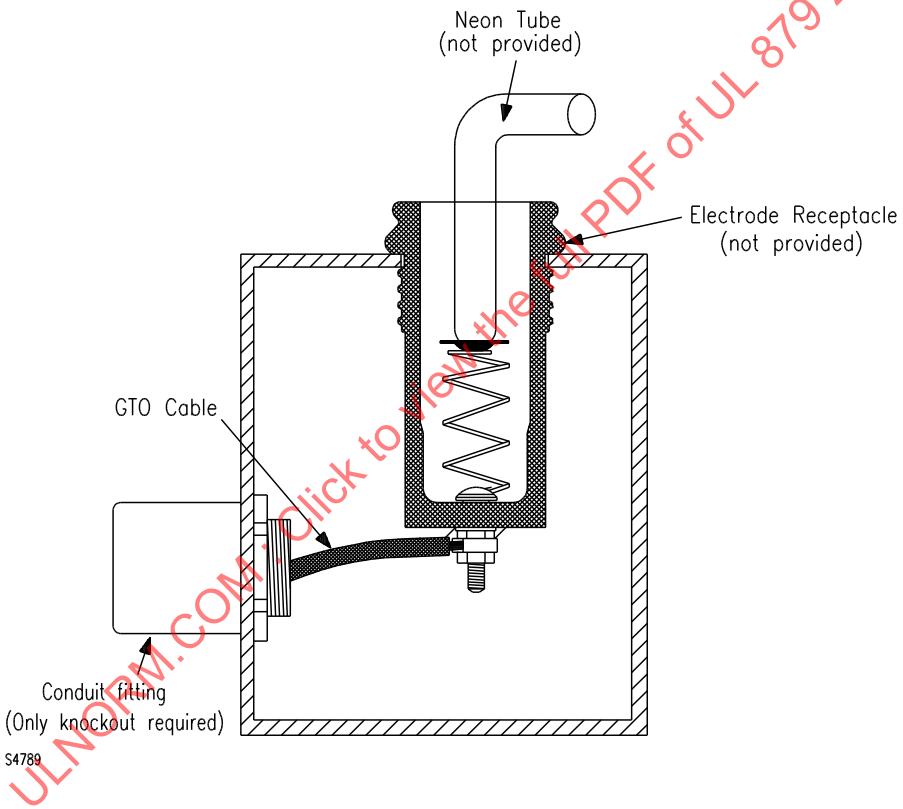
4.5 Electrode receptacle enclosure

4.5.1 General

4.5.1.1 These requirements apply to enclosures constructed to accommodate, but not provided with the one or more electrode receptacles, cold cathode lampholders or lampholders over 1000 V intended to be enclosed. A representative electrode receptacle is shown in Figure 4.6.

Figure 4.6

Electrode receptacle enclosure



4.5.2 Construction requirements

4.5.2.1 An electrode receptacle enclosure shall be provided with one or more openings of the proper size to accommodate the intended size of electrode receptacle and provide sufficient area around the electrode receptacle opening to permit the electrode receptacle securement means to seat properly.

4.5.2.2 An enclosure shall be of sufficient length to provide the minimum spacings for the maximum voltage rating of the maximum rated electrode receptacle for which the enclosure is rated. A metallic enclosure that relies on the placement of an insulator on an electrode receptacle such as an insulating cap must be provided with the insulator and be provided with a means to be reliably secured in place on the receptacle.

4.5.2.3 An enclosure provided with openings for more than one electrode receptacle and more than one supply connection means shall be provided with an internal metallic compartment wall that provides a barrier between live parts including insulating wiring between each receptacle.

4.5.3 Supply connection means

4.5.3.1 An enclosure provided with a supply connection means, the means should be suitable for connection to a permanent wiring system in accordance with the National Electrical Code.

4.5.4 Mounting means

4.5.4.1 A lampholder shall be provided with means to be mechanically secured by at least two points to a mounting surface.

4.5.5 Tests

4.5.5.1 An electrode receptacle enclosure shall comply with the Dielectric Withstand Test in 3.4.2.5 with the maximum size of electrode receptacle installed in each opening provided for receptacles. The test is to be conducted with the maximum diameter of tubing electrode inserted to its proper depth and centered in the lampholder. The test potential is to be applied between a length of GTO cable conductor connected to the shell of neon tube electrode and the metal enclosure.

4.5.5.2 An electrode receptacle enclosure designated for use in a damp location shall be prepared as in 4.5.5.2 and be subjected to the Condensation Test in 3.4.2.9 followed by the Dielectric Withstand Test in 3.4.2.5.

4.5.6 Ratings

4.5.6.1 An electrode receptacle enclosure shall be rated for:

a) The location of its intended use – dry, dry and damp, or dry, damp and wet locations,

b) The electrode receptacle diameter, and

c) The open circuit voltage rating and maximum short circuit current of the receptacle.

4.5.7 Markings and installation instructions

4.5.7.1 An electrode receptacle enclosure shall be plainly marked with the following:

a) The receptacle type or model number, electrical ratings, and

b) The maximum diameter of neon tubing, if less than 25 mm (1 in).

4.5.7.2 An electrode receptacle enclosure requiring special mounting or orientation to comply with drainage requirements in damp locations shall be marked in a location that is readily visible after installation with "Top" or other equally descriptive terms.

4.5.7.3 Required markings shall appear on the body of the enclosure and not on a cover or other removable part unless the cover or part is electrically essential to the operation of the device.

4.5.7.4 Installation Instructions shall be provided inside each smallest unit container.

4.5.7.5 The installation instructions are to include the following:

a) The nominal diameter, maximum length, open circuit voltage and short-circuit current rating of the electrode receptacle intended for use with the electrode receptacle enclosure, and

b) A location designation relating to the type of environment the electrode receptacle enclosure has been evaluated for use in – Dry Only or Dry and Damp locations or Dry, Damp and Wet locations.

c) An electrode receptacle enclosure designated as suitable for use in dry and damp locations shall be accompanied by a condition of use indicating that when installed in a damp location the enclosure must be mounted in a horizontal position with the mouth of the receptacles at the same height above ground or lower than the closed end of the lampholder.

d) An electrode receptacle enclosure designated as suitable for use in dry, damp and wet locations shall be accompanied by a condition of use indicating that it is only suitable for use in a wet location when the receptacles installed in the enclosure are provided with the required cap over the mouth of the lampholder and in a damp location, the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

e) The proper installation of electrode receptacle into the enclosure, and

f) Do not install the enclosure in a position that results in an electrode receptacle to collect moisture when installed in a damp location.

4.6 Polymeric neon electrode enclosures

4.6.1 General

4.6.1.1 These requirements apply to polymeric neon electrode enclosures intended to enclose the splice between a GTO cable conductor and neon tube electrode leads in secondary circuits having voltages over 1000 V. Examples of a straight electrode enclosure is shown in Figure 4.7 and a double back electrode enclosure in Figure 4.8.

Figure 4.7

Straight polymeric neon electrode enclosure

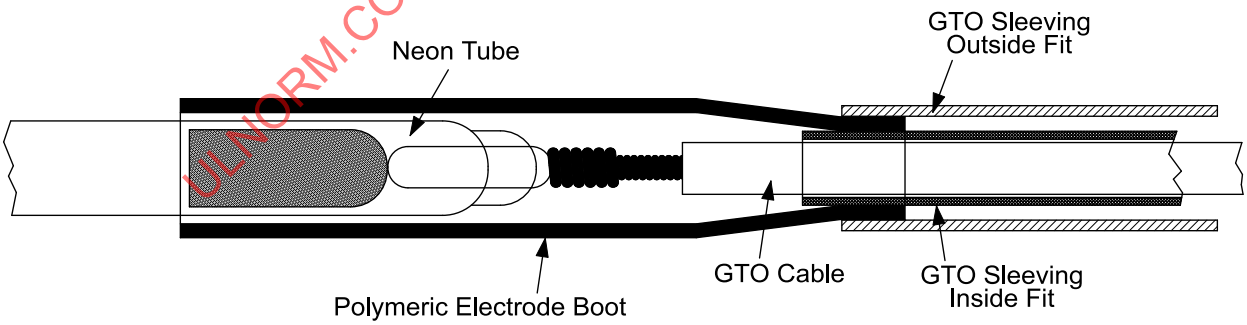


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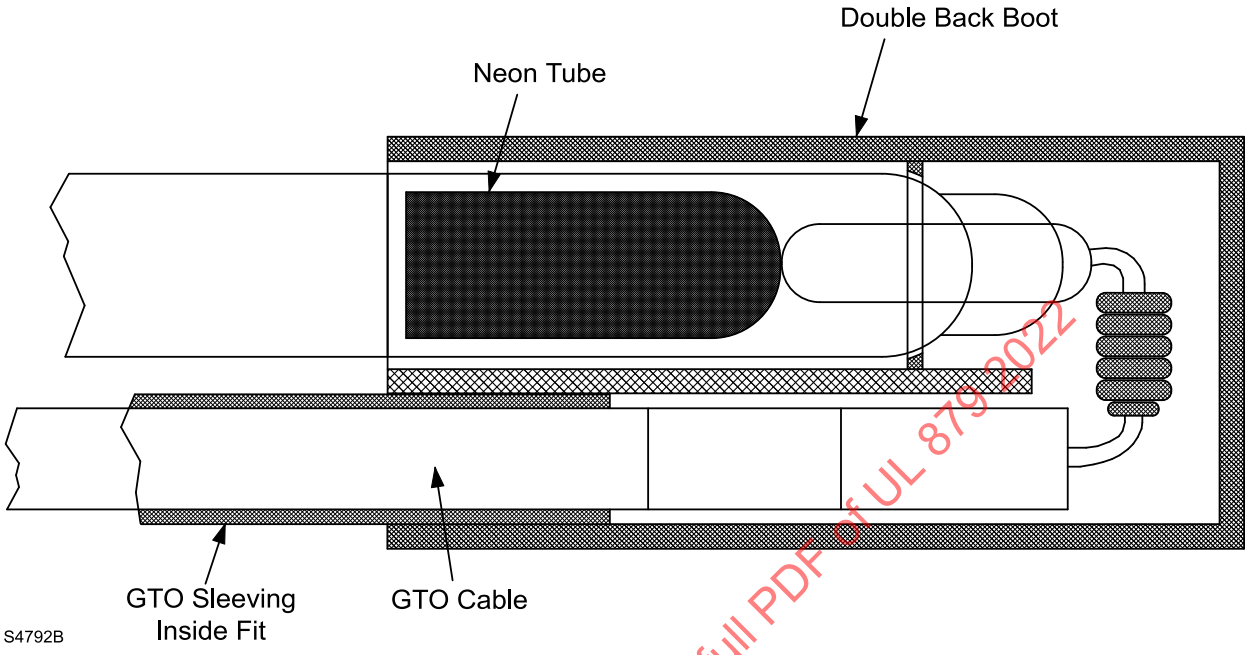
Figure 4.8

Double back polymeric neon electrode enclosure



4.6.2 Construction requirements

4.6.2.1 The material of a polymeric neon electrode enclosure shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.6.5.

4.6.2.2 The thickness of a polymeric material shall be no less than 0.7 mm (0.028 in).

4.6.2.3 A polymeric neon electrode enclosure shall have a minimum cavity depth to accept neon tubing that is 38 mm (1.5 in) for 8-mm (0.31-in) diameter tubing and 51 mm (2.0 in) for all other diameter tubing. The minimum length is to provide minimum over-surface spacing between the end of the neon tube where the splice is to be made when installed in accordance with the manufacturer's installation instructions and to extend over the neon tube electrode.

4.6.3 Supply connection means

4.6.3.1 A polymeric neon electrode enclosure shall be constructed to accept one or more of the following means of secondary supply: GTO cable with GTO cable sleeving, GTO cable with integral sleeving, GTO cable assembly or GTO cable and glass tubing.

4.6.4 Mounting means

4.6.4.1 A polymeric neon electrode enclosure shall have a cavity diameter that provides a snug fit when installed onto the neon tubing designated for the electrode enclosure in accordance with the manufacturer's installation instructions. The fit of the electrode enclosure on the neon tube is snug when the electrode enclosure complies with the Retention Test in 3.4.1.11.

4.6.5 Tests

4.6.5.1 Three samples of a dry location polymeric neon electrode enclosure shall be subjected to the following conditioning; accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, and humidity conditioning in 3.2.1.6. Where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3. Where the same 3 samples have been subjected to the conditions specified, the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3 shall be conducted only after all conditioning has been completed.

4.6.5.2 Three samples of a damp location polymeric neon electrode enclosure shall be subjected to the following conditioning; accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, humidity conditioning in 3.2.1.6, and cold conditioning specified in 3.2.1.7. At the conclusion of the conditioning, where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3. Where the same 3 samples have been subjected to the conditions specified, the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3 shall be conducted only after all conditioning has been completed.

4.6.5.3 To determine compliance with the mounting means requirements in 4.6.4.1 for snug fitting, a neon electrode enclosure shall be subject to the Retention Test in 3.4.1.11.

4.6.5.4 A polymeric neon electrode enclosure with a neon tube electrode diameter designation of 18 mm (0.7 in) and rated for greater than 60 mA shall be subjected to a temperature test with neon tubing having the higher rated current rating with the smallest electrode shell available. The temperature test is to be conducted with the electrode enclosure installed on the diameter of mercury/argon tubing for which it is rated. The neon tubing shall have the highest gas pressure recommended for the current rating. The total length of the tubing shall be the maximum and then the minimum for the maximum voltage of transformer available for the higher current rating. Each assembly is to be operated at rated current during the temperature tests. GTO sleeving shall be installed on the electrode enclosure over GTO cable leading to the electrode enclosure during each test. The maximum operating temperatures of the polymeric neon electrode enclosure measured shall comply with Table 3.9.

4.6.6 Ratings

4.6.6.1 A polymeric neon electrode enclosure shall be rated for:

a) The location, dry only or dry and damp, it is intended for use in,

b) The neon tube electrode diameter it is intended for use with,

c) The voltage rating of a polymeric neon electrode enclosure shall be: 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground, and

d) Maximum current of 60 mA unless found to comply with a higher current rating.

4.6.7 Markings and installation instructions

4.6.7.1 A polymeric neon electrode enclosure shall be marked on its body with the following:

a) Maximum voltage,

b) Current in milliamps, and

c) The neon tube electrode diameter rating.

4.6.7.2 Installation instructions shall be provided inside each smallest unit container or at least twenty instruction sheets provided per carton of 100 receptacles.

4.6.7.3 Installation instructions are to be provided that illustrate the intended use of the electrode enclosure. The installation instructions shall include at least the following information:

a) The neon tube electrode must be inserted into the polymeric neon electrode enclosure to a depth that provides for minimum 1½ in spacing between the end of the neon tube and the mouth of the electrode enclosure;

b) The maximum voltage and current rating of the polymeric neon electrode enclosure;

c) A location designation relating to the type of environmental the polymeric neon electrode enclosure has been evaluated for use in – Dry Only or Dry and Damp locations;

d) That a polymeric neon electrode enclosure shall the diameter of neon tubing with which the electrode enclosure is suitable;

e) That a polymeric neon electrode enclosure with an open end and designated as suitable for use in dry and damp locations shall be accompanied by a condition of use indicating that when installed in a damp location the open end must be mounted in a horizontal position with the open end at the same height above ground or lower than the closed end of the electrode enclosure;

f) Instructions to not shorten or cut the electrode enclosure in any way to fit a neon tubing installation;

g) Instructions to not install the electrode enclosure outdoors where exposed to rain and snow and in a wet location; and

h) Instructions to make sure the neon tubing has been fully inserted inside the electrode enclosure;

4.7 Glass cup receptacles

4.7.1 General

4.7.1.1 These requirements cover glass cup receptacles that are for use in dry or dry and damp locations only. The types of glass cup receptacles include:

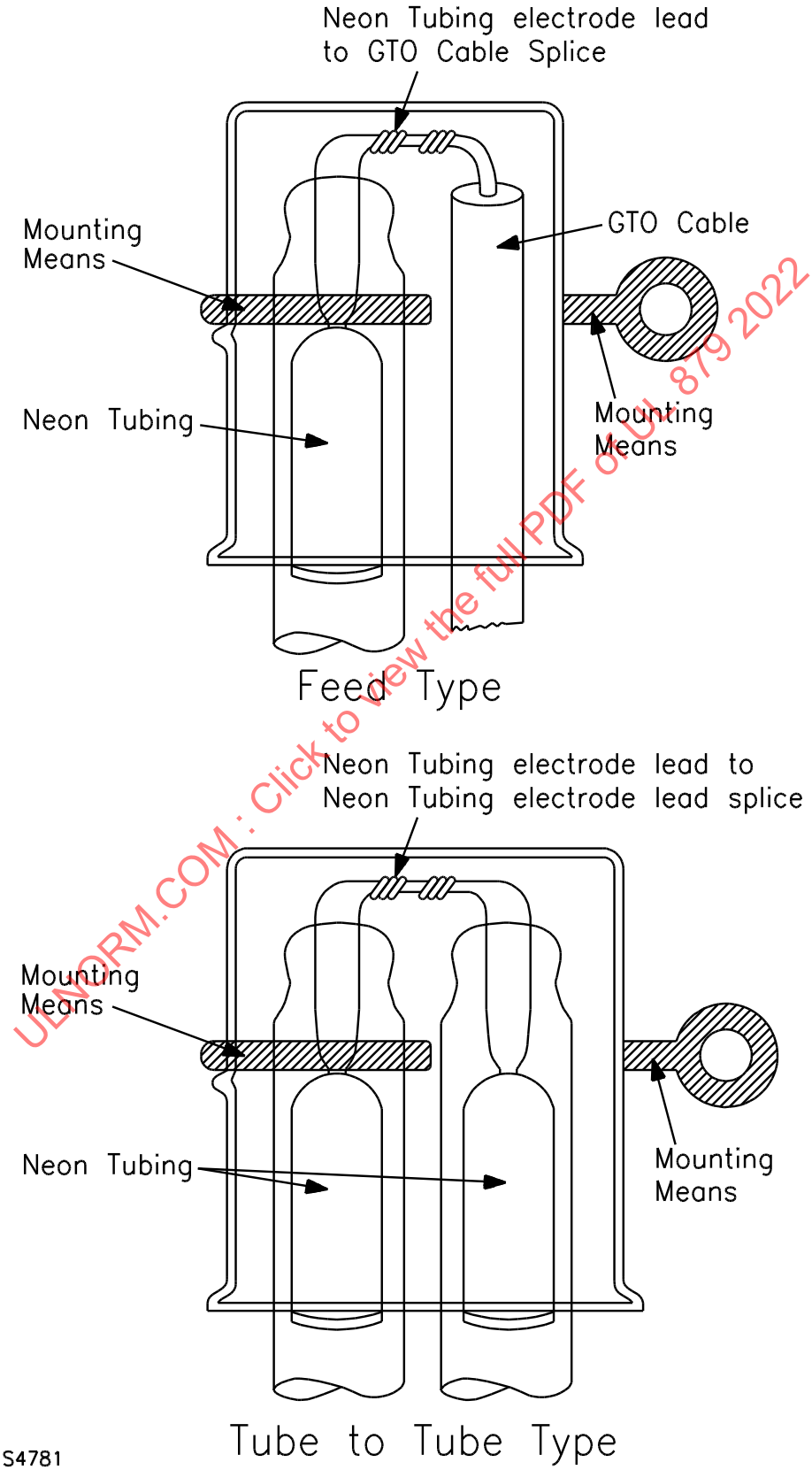
a) A cup that receives a neon tube electrode and GTO cable or GTO Cable assembly and the electrode leads and GTO Cable or GTO Cable assembly leads are spliced within the glass cup, and

b) A cup that receives two neon tube electrodes that are conductively connected through a common contact or a splice between the electrode leads within the cup.

4.7.1.2 Typical appearance of glass cup receptacles are shown in Figure 4.9.

Figure 4.9

Glass cups receptacles



4.7.2 Construction requirements

4.7.2.1 A glass cup suitable for use in dry and damp locations shall be of sufficient length to maintain a minimum across surface spacing of 38 mm (1.5 in) from the closest point of where exposed current carry parts of a splice is intended to be located to the open end of the cup.

4.7.3 Supply connection means

4.7.3.1 A glass cup receptacle shall be provided with a means for connection to a source of supply by either GTO Cable or neon tube electrode.

4.7.4 Mounting means

4.7.4.1 A glass cup shall be provided with a means of securing it to a building structure.

4.7.4.2 The mounting means of a glass cup shall provide at least 1/4-in spacing from the glass receptacle and the building surface plus the spacings required in 2.15.

4.7.5 Tests

4.7.5.1 A glass cup receptacle shall comply with the Dielectric Withstand Test in 3.4.2.5.

4.7.5.2 A glass cup receptacle designated for use in a damp location shall comply with Condensation Test in 3.4.2.9 and the material tests for inorganic, non-metallic materials specified in 3.2.

4.7.5.3 A glass cup receptacle rated for greater than 120 mA shall be subjected to a temperature test with neon tubing or cold cathode tubing having the higher rated current rating with the smallest electrode shell available. The temperature test is to be conducted with the glass cup installed on the diameter of mercury/argon tubing for which it is rated. The tubing shall have the highest gas pressure recommended for the current rating. The total length of the tubing shall be the maximum and then the minimum for the maximum voltage of transformer available for the higher current rating. Each assembly is to be operated at rated current during the temperature tests. The maximum operating temperatures of the glass cup receptacle measured shall comply with Table 3.9.

4.7.6 Ratings

4.7.6.1 A glass cup receptacle shall be rated for:

a) The location, dry only or dry and damp, it is intended for use in,

b) The voltage rating shall be: 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground, and

c) Maximum current of 120 mA unless found to comply with a higher current rating.

4.7.7 Markings and installation instructions

4.7.7.1 A glass cup receptacle shall be plainly marked with the maximum voltage and current rating.

4.7.7.2 Installation instructions shall be provided inside each smallest unit container or at least twenty instruction sheets provided per carton of 100 receptacles.

4.7.7.3 The installation instructions shall include the following:

a) For a feed type Glass cup, a condition of use shall be provided to instruct the installer to position the glass cup over the neon tube to a depth that will result in the splice of the neon tube leads are at a depth that provides for minimum 1½-in spacing between the end of the neon tube and the mouth the glass cup.

b) The maximum voltage and current rating and the maximum diameter of neon tubing for which the glass cup has been evaluated.

c) A location designation relating to the type of environmental the electrode receptacle has been evaluated for use in – Dry Only or Dry and Damp locations.

d) A glass cup designated as suitable for use in dry and damp locations shall be accompanied by a condition of use indicating that in a damp location the lampholder must be mounted with the mouth of the lampholder at the same height above ground or lower than the closed end of the lampholder.

e) The manufacturer's name and Cat. No. of the GTO sleeving, GTO cable with integral sleeving, conduit plug assembly or GTO cable assembly that are acceptable for use with the glass cup and

f) The mounting means provided with the glass cup must be installed to support the glass cup.

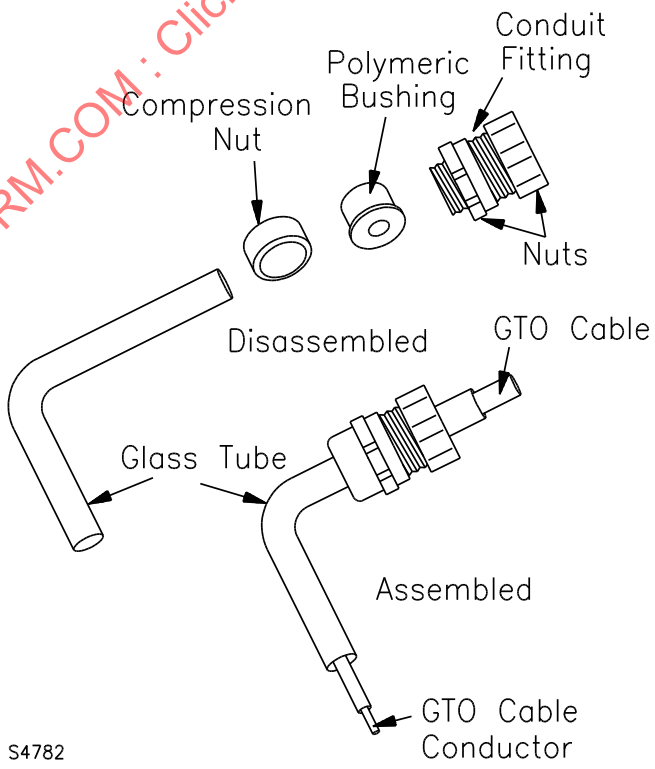
4.8 Glass tubing conduit assembly

4.8.1 General

4.8.1.1 This assembly consists of a rigid length of glass tubing that encloses GTO cable between conduit and a glass cup electrode receptacle as shown in Figure 4.10.

Figure 4.10

Conduit plug assembly



4.8.2 Construction requirements

4.8.2.1 The glass tube portion of the conduit assembly shall be a minimum of 0.254-mm (0.01-in) thick.

4.8.3 Supply connection means

4.8.3.1 A tubing conduit receptacle shall be provided with a means to secure to conduit and accept GTO cable.

4.8.4 Mounting means

4.8.4.1 A conduit assembly shall be provided with the means to be secured in place by securement to conduit.

4.8.5 Tests

4.8.5.1 The environmental conditioning test specified in 3.3.2 shall be conducted on the glass tubing of a conduit assembly except at the completion of the conditioning, the dielectric withstand test shall not be conducted. At the completion of the conditioning, the samples shall be visually examined and there shall be no evidence of cracking or breaking.

4.8.6 Rating

4.8.6.1 A conduit assembly shall be rated for use with a particular glass cup electrode receptacle.

4.8.7 Markings and installation instructions

4.8.7.1 A conduit assembly shall be plainly marked with the following:

a) The maximum diameter of GTO cable that will fit into the assembly, and

b) Warn to not use the component should the glass crack or break.

4.8.7.2 Installation instructions shall be provided inside each smallest unit container or at least twenty instruction sheets provided per carton of 100 receptacles.

4.8.7.3 The installation instructions for a conduit assembly shall include the following:

a) Identified for use with a glass cup receptacle,

b) Identify as suitable for use in dry and damp locations, and

c) Indicate the proper assembly of the conduit assembly.

4.9 GTO cable sleeving

4.9.1 General

4.9.1.1 These requirements cover GTO cable sleeving of polymeric material that is intended to enclose GTO cable.

4.9.2 Construction requirements

4.9.2.1 The GTO cable sleeving material shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.9.5.

4.9.2.2 GTO cable sleeving shall have an inside diameter of 9.4 – 9.65 mm (0.37 – 0.38 in) unless provided with the condition of use specified in 4.9.7.2 (d).

4.9.3 Supply connection means

4.9.3.1 GTO cable sleeving shall have an outer diameter that allows it to be installed in ½-in trade size conduit and an inside diameter as specified in 4.9.2.2 to accommodate GTO cable.

4.9.4 Mounting means

4.9.4.1 GTO cable sleeving shall be sized to secure in place onto a electrode enclosure or at a conduit fitting by a snug physical fit.

4.9.5 Tests

4.9.5.1 Three samples of a dry location polymeric GTO sleeving shall be subjected to the following conditioning; accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, and humidity conditioning in 3.2.1.6. Where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3, except with 6 kV applied. Where the same 3 samples have been subjected to the conditions specified, the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3, except with a 6 kV applied, shall be conducted only after all conditioning has been completed.

4.9.5.2 Three samples of a dry and damp location GTO cable sleeving shall be subjected to the following conditioning: accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, humidity conditioning in 3.2.1.6, and cold conditioning specified in 3.2.1.7. At the conclusion of the conditioning, where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3 except with 6 kV applied. Where the same 3 samples have been subjected to the conditions specified, the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3 shall be conducted with 6 kV applied only after all conditioning has been completed.

4.9.5.3 To determine compliance with the mounting means requirements in 4.9.4.1 for snug fitting, a GTO cable sleeving shall be subject to the Retention Test in 3.4.1.11.

4.9.6 Ratings

4.9.6.1 GTO sleeving shall be rated: 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground.

4.9.7 Markings and installation instructions

4.9.7.1 GTO cable sleeving shall be surface marked in intervals not less than 45.7 cm (18 in) with the electrical rating that is to include the maximum voltage rating and the voltage to ground.

4.9.7.2 Installation instructions are to be provided and include the following:

a) Suitable only for use in dry and damp locations,

b) Only suitable for use enclosing GTO cable type wiring,

c) Do not alter the GTO cable sleeving except as specified in the manufacturers installation instructions,

d) When the inside diameter does not comply with 4.9.2.2, the GTO cable sleeving is not suitable for use with cord connected neon supplies, and

e) GTO cable sleeving that complies with the temperature rating of 105°C (221°F) as specified in Line C of Table 4.3 part 2 shall be identified for use in portable signs only.

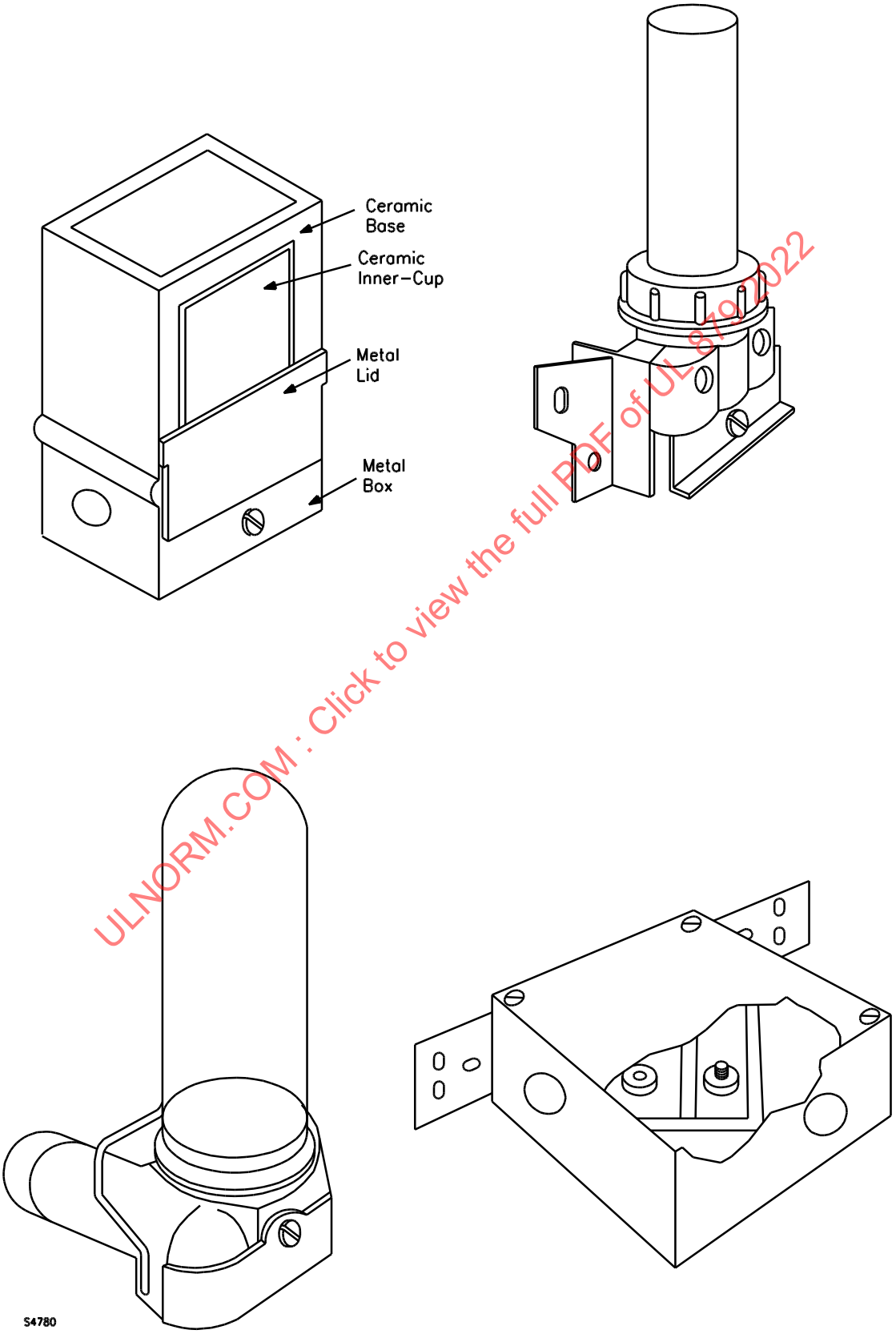
4.10 GTO cable splice enclosure

4.10.1 General

4.10.1.1 These requirements apply to devices intended to contain or enclose a splice or enclose and make a splice between two lengths of GTO cable. Examples of splice enclosures are shown in Figure 4.11.

Figure 4.11

Typical GTO cable splice enclosures



4.10.2 Construction requirements

4.10.2.1 The material of containment or that encloses a splice and is of metal or of an inorganic nonmetallic material shall comply with the enclosure requirements in 2.1.

4.10.2.2 The material of containment or that encloses a splice and is of a polymeric material shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.10.5.

4.10.2.3 When assembled as intended, there shall be no openings into the interior of the enclosure.

4.10.2.4 A GTO cable splice enclosure shall be provided with means for connecting standard trade sizes of metallic conduit or Electrical Metallic Tubing (EMT) of size greater than or equal to nominal ½-in trade size (12.7-mm) diameter.

4.10.2.5 A GTO cable splice enclosure with dead metal shall be provided with bonding means capable of terminating two 18 – 14 AWG (0.9 – 2.1 mm^2) conductors. One equipment grounding means or termination point shall be provided for each conductor unless a single grounding means has been investigated and found suitable to accommodate two conductors such as with the use of a pressure terminal connector rated for two conductors of the required range of wire sizes.

4.10.2.6 A GTO cable splice enclosure identified for use in dry and damp locations shall provide sufficient space for 63.5 mm (2.5 in) of GTO Cable insulation to not be stripped off the cable as measured from the entry point into the enclosure and the high voltage connection means.

4.10.3 Supply connection means

4.10.3.1 A GTO cable splice enclosure shall be shall be constructed to accommodate two lengths of GTO cable.

4.10.4 Mounting means

4.10.4.1 Unless provided with a strain relief means capable of withstanding a force of 44.5 N (10 lb) and weighing less than 4.54 kg (1 lb) and intended to be an in-line type splice enclosure, a GTO cable splice enclosure shall be provided with a means to be secured in place.

4.10.5 Tests

4.10.5.1 A GTO cable splice enclosure shall be provided with a strain relief means such that the splice connection is not subject to stress and is capable of withstanding a pull force of 13 N (3 lb) for a secured in place type splice enclosure or 44.5 N (10 lb) for an in-line type splice enclosure each for a period of one minute with no visible indication that stress is transmitted to the splice connection.

4.10.5.2 A GTO cable splice enclosure shall comply with the Dielectric Voltage Withstand Test in 3.4.2.5.

4.10.5.3 A dry location GTO cable splice enclosure with an all polymeric enclosure shall have three samples subjected to the following conditioning; accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, and humidity conditioning in 3.2.1.6. Where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3. Where the same 3 samples have been subjected to the conditions specified, the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3 shall be conducted only after all conditioning has been completed.

4.10.5.4 A dry and damp location GTO cable splice enclosure with an all polymeric enclosure shall have three samples subjected to the following conditioning; accelerated temperature aging in 3.2.1.1, ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5, humidity conditioning in 3.2.1.6, and cold conditioning specified in 3.2.1.7. At the conclusion of the conditioning, where three separate sample sets are used for each conditioning parameter, all samples of each set shall comply with the dielectric withstand test (for products rated greater than 1000 V) specified in 3.4.2.5.3. One set of 3 samples is to be subjected to the Condensation Test in 3.4.2.9. Where the same 3 samples have been subjected to the conditions specified, the samples shall comply with the Condensation Test in 3.4.2.9 when conducted after all other conditioning has been completed.

4.10.6 Ratings

4.10.6.1 The voltage rating of a polymeric neon electrode enclosure shall be: 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground.

4.10.7 Markings and installation instructions

4.10.7.1 A GTO cable splice enclosure shall be permanently marked on the body of the splice enclosure with the ratings, including the maximum voltage and voltage to ground.

4.10.7.2 Installation instructions are to be provided with each unit.

4.10.7.3 The installation instructions shall include the following:

a) The maximum open circuit voltage of 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground,

b) A location designation relating to the type of environmental the electrode receptacle has been evaluated for use in – Dry Only or Dry and Damp locations.

4.11 Sign body, awning and face material-not enclosure rated

4.11.1 General

4.11.1.1 These requirements cover rigid and flexible sign face materials used to form a sign face, sign body and awning and not intended to comply with enclosure requirements.

4.11.2 Construction requirements

4.11.2.1 Polymeric material shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.11.3.

4.11.2.2 A flexible sign face material shall be minimum 0.51-mm (0.020-in) thick unless designated and evaluated for use with a particular flexible sign face tensioning system.

4.11.3 Tests

4.11.3.1 A flexible sign face material shall comply with the Breaking Strength and Tear Resistance Tests in 3.2.2.8. Half of the samples for the Breaking Strength and Tear Resistance Tests shall be subjected to ultraviolet radiation conditioning as specified in 3.2.1.5 and ozone conditioning as specified in 3.2.1.4 before being tested.

4.11.4 Markings and installation instructions

4.11.4.1 Installation instructions shall include the following:

a) Illustrate the proper installation and securement of the material into or onto a sign;

b) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location); and

c) An indication that the material is only acceptable for use as an awning, sign face or sign body.

4.12 Enclosure sign face materials

4.12.1 General

4.12.1.1 These requirements apply to sign face and sign body materials where their use in an end product is to also function as an enclosure of current carrying parts.

4.12.2 Construction requirements

4.12.2.1 An enclosure sign face material shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.12.3. An enclosure sign face material designated only for use in portable cord connected products need only have a flammability rating of minimum V-2.

4.12.3 Tests

4.12.3.1 Three samples of enclosure sign face material samples prepared as specified for the Polymeric Sheet Material Impact Test in 3.2.2.9 shall be subjected to ozone conditioning in 3.2.1.4, ultraviolet radiation conditioning in 3.2.1.5 and then Impact test in 3.4.1.6.

4.12.3.2 An enclosure sign face material shall comply with the Torque, Bending Moment and Conduit Pullout Tests in 3.2.2.13.

4.12.3.3 An enclosure sign face material shall comply with the Component Support Test in 3.2.2.14 and upon completion of the Test Support Test.

4.12.4 Ratings

4.12.4.1 An enclosure sign face material shall be rated the maximum operating temperature and for the environmental conditions, dry, dry and damp or dry, damp and wet locations.

4.12.5 Markings

4.12.5.1 An enclosure sign face material shall be marked on the protective film provided over surface of material, with the company name and model designation. The marking shall be provided along both edges of the protective film repeating every 2 ft.

4.12.6 Installation instructions

4.12.6.1 The installation instructions shall include the following:

a) The mounting system of a sign face, such as channels, flanges or trim, must secure the sign face to the enclosure in such a way that the edges of the sign face are not exposed to the interior of the sign.

b) A heat producing component such as electrode, transformer, power supply and ballast is to be located no closer than 2.54 cm (1 in) of this material, or for a material with a minimum temperature rating of 105°C (221°F) or greater. This material is suitable for contact with heat producing components such as electrode, transformer, power supply and ballast in the end product.

c) An end product using this material must be marked anywhere where readily visible during servicing.

d) "Do not attempt to repair or service a damaged sign face, cable support, or high-voltage splice insulator. For servicing of this sign, contact _____." (Blank to be replaced by Applicant's Company name, City and State.) "Replace only with _____, Type _____." (Blanks to be replaced by Applicant's Company name and material Type or designation.)

e) "Danger – High Voltage – Disconnect Power Before Servicing."

f) This material must be a minimum of 2.5-mm (0.1-in) thick to be acceptable as an enclosure sign body and face material. This material in lesser thickness is acceptable as a sign face or sign body only.

g) This material has been investigated for the securement of conduit, electrode housings or the like.

4.13 Sign face tensioning systems

4.13.1 General

4.13.1.1 These requirements apply to a system of mechanical hardware to secure and put under tension flexible sign face material in a sign, such as a backlit banner sign.

4.13.2 Construction requirements

4.13.2.1 A sign tensioning system shall provide adequate tensioning of a flexible sign face material that is 5.1-mm (0.020-in) thick or greater.

4.13.2.2 A sign tensioning system shall not rely on a polymeric material to maintain the tension on a sign face.

4.13.2.3 A sign tensioning system shall be capable of securing a 0.5-mm (0.020-in) thick flexible sign face material and withstand a pull of at least 200 lbs as determined by the Sign Face Tensioning Test specified in 4.13.3.

4.13.3 Tests

4.13.3.1 Five samples of the sign tensioning system are to be tested with 0.5-mm (0.020-in) thick samples of flexible sign face material each 38.1-mm (1-1/2-in) wide mounted in sections of the Sign face tensioning system. Each assembly is to be mounted in an Instron tension testing machine and the force for breaking or slippage out of the material from the sign tensioning system is to be measured.

4.13.4 Markings and installation instructions

4.13.4.1 Installation instructions shall include the following:

a) An indication of its intended environmental location, suitable for use in dry, dry and damp or wet locations,

b) Indicate that its securement means is not acceptable where an electrical enclosure is required,

c) Where tension clips are part of the tensioning system, an indication of the maximum spacing between tension clips,

d) An indication that any frame dimension greater than 6 ft needs to be braced to prevent billowing.

4.14 Structural materials

4.14.1 General

4.14.1.1 These requirements apply to structural panels that incorporate polymeric or cellulosic (wood based) materials in their structure and may be relied upon to provide structural support in an end product.

4.14.2 Construction requirements

4.14.2.1 A structural panel shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.14.3.

4.14.2.2 A structural panel that is not designated for use in dry locations only shall be suitable for use in wet locations.

4.14.2.3 A structural panel intended for use in a wet location utilizing plywood in its construction shall utilize wood that is rated for outdoor use.

4.14.2.4 A structural panel that utilizes adhesive to bond layers of materials together shall utilize an adhesive that complies with the Standard for Polymeric Materials – Electrical Equipment Evaluations, UL 746C, for securement of the material involved or the combination be evaluated in accordance with 4.14.3.

4.14.3 Tests

4.14.3.1 A structural panel having layers bonded together by adhesive shall continue to bond the layers together and not be subject to a reduction in bond strength when subjected to the Adhesive Laminations Bond Strength Test in 3.2.2.12.

4.14.3.2 A structural panel intended for connection or support of conduit shall comply with the Torque, Bending Moment and Conduit Pullout Test, 3.2.2.13.

4.14.3.3 A structural panel intended for mounting and support of components shall comply with the Component Support Test, 3.2.2.14.

4.14.4 Markings and installation instructions

4.14.4.1 Installation instructions shall include the following:

a) Illustrate the proper cutting, pointing, installation, component securement and securement to a building surface of a structural panel;

b) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

c) Structural panels are acceptable for supporting enclosures, plastic faces, and moldings that are reliably secured to the panel;

d) Structural panels are not suitable to be used as the enclosure of bare live parts or wiring;

e) Components other than neon standoffs or small decorative parts must be secured to the panel by bolts, nuts and washers of minimum 7/16-in diameter;

f) All exposed edges of a structural panel, including drilled holes, etc., are be treated with two coats of outdoor paint or wood coating;

g) Sheet metal screws may be used when fastening a ballast or transformer weighing more than 3.4 kg (7-1/2 lbs); and

h) A letter made from a structural panel shall have at least two points of support and shall have no point more than 25.4 cm (10 in) from a point of support.

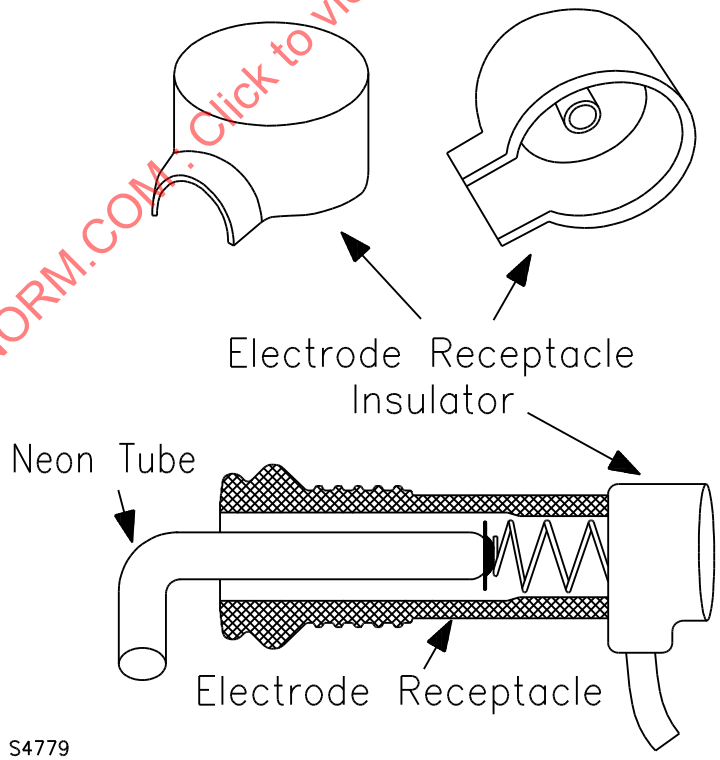
4.15 Electrode receptacle insulator

4.15.1 General

4.15.1.1 These requirements electrode receptacle insulators for use in dry or dry and damp locations only as shown in Figure 4.12.

Figure 4.12

Typical electrode receptacle insulator



4.15.2 Construction requirements

4.15.2.1 A polymeric electrode receptacle insulator shall have a flammability rating of at least V2 and be ozone and ultraviolet radiation resistant.

4.15.3 Mounting means

4.15.3.1 A polymeric electrode receptacle insulator shall be provided with a means of securement to the contact terminal of an electrode receptacle.

4.15.4 Tests

4.15.4.1 A polymeric electrode receptacle insulator shall comply with the Dielectric Withstand Test in 3.4.2.5. The dielectric withstand voltage is to be applied between the electrode receptacle terminal to which the insulator is secured and a sheet metal plate position at the top of the insulator cap.

4.15.4.2 A polymeric electrode receptacle insulator designated for use in a damp location shall comply with Condensation Test, 3.4.2.9.

4.15.5 Ratings

4.15.5.1 A polymeric electrode receptacle insulator shall be rated:

a) Environmental location, dry only or dry and damp, and

b) One of the following voltage ratings; 5 kV, 2.5 kV to ground; 10 kV, 5 kV to ground; or 15 kV, 7.5 kV to ground.

4.15.6 Markings and installation instructions

4.15.6.1 A polymeric electrode receptacle insulator shall be plainly marked with the maximum voltage rating.

4.15.6.2 Installation Instructions shall be provided inside each smallest unit container or at least twenty instruction sheets provided per carton of 100 polymeric electrode receptacle insulators.

4.15.6.3 The installation instructions shall specify the means of installing the polymeric electrode receptacle insulator to the electrode terminal including the routing of the GTO cable form the terminal

4.16 Trim cap

4.16.1 General

4.16.1.1 These requirements cover trim caps used to secure a sign face material to a channel letter. The signs face material is either of the non-enclosure rated or enclosure rated type.

4.16.2 Construction requirements

4.16.2.1 The material requirements of a polymeric trim cap shall comply with Table 4.3 part 1.

4.16.3 Mounting means

4.16.3.1 A polymeric trim cap shall be provided with a means of physical fit to the edge of a channel letter. Permanent securement by screws is acceptable.

4.16.4 Ratings

4.16.4.1 A polymeric trim cap shall be rated for dry, damp and wet locations.

4.16.5 Markings and installation instructions

4.16.5.1 A polymeric trim cap shall be provided with installation instructions on the reel inside each smallest unit container.

4.16.5.2 The installation instructions shall specify the means of installing the polymeric trim cap and include permanent securement instructions including spacing of fasteners.

4.17 Dimmers, flashers, controllers and animators

4.17.1 General

4.17.1.1 The requirements in this section apply to electromagnetic and electronic dimmers, flashers, controllers and animators for use with illumination, including light emitting diodes, electro luminescence and neon.

4.17.2 Construction requirements

4.17.2.1 A dimmer, flasher, controller and animator shall be capable of functioning properly through 100,000 cycle of operation at rated load.

4.17.2.2 A dimmer, flasher, controller and animator shall comply with the requirements for circuit interrupting devices in 3.4.2.11.

4.17.3 Supply connection means

4.17.3.1 A dimmer, flasher, controller and animator provided shall be provided with either a power supply cord and be suitable only for use in a portable sign or be provided with leads or terminal intended for factory installation.

4.17.4 Mounting means

4.17.4.1 A dimmer, flasher, controller and animator shall be provided with means to be mechanically secured in place within an enclosure or to a building structure in accordance with the National Electrical Code.

4.17.5 Mounting means

4.17.5.1 A sign dimmer, flasher, controller and animator shall be subjected to the basic product tests as follows:

a) Input Test, 3.4.2.2, under full load testing as specified in 4.17.5.2;

b) Normal Temperature Test, 3.4.2.3, under full load testing as specified in 4.17.5.2;

c) Dielectric Voltage Withstand Test, 3.4.2.5, with no load connected;

d) Abnormal Operation Tests, 3.4.2.7.2, with fans, and unit shorted and opened circuited. Where multiple outputs are provided, short circuit conditions shall be with other output loads and other outputs not loaded;

e) Ground Continuity Test, 3.4.2.6, with no load; and

f) Impact Test, 3.4.1.6, with no load.

4.17.5.2 Full load condition is when the maximum load current is drawn through a unit that creates the maximum heating condition. The maximum load current is to be determined to be a combination of the duty cycle frequency and the maximum on time with a setting that produces the brightest output with the maximum number of lighting units illuminated.

4.17.5.3 A sign dimmer, flasher, controller and animator shall be subjected to the following tests as applicable to the particular construction features provided:

a) Abnormal Component Breakdown Test, 3.4.2.7.3, when active electronic switching components are provided;

b) Circuit Interrupting Devices Tests – Overload and Endurance Tests, 3.4.2.11, when switching devices are electromagnetic contacts and not rated for at least 100,000 cycles;

c) Leakage Current Test, 3.4.2.4, for a cord connected unit;

d) Strain Relief Test, 3.4.1.3, when a non-detachable cord connected unit;

e) Printed Wiring Board Tests in 3.4.2.12, when a printed wiring board with greater than Class 2 energy is present and the printed wiring boards do not comply with the Standard for Printed Wiring Boards, UL 796.

f) Knockout Test, 3.4.1.2, when unit is provided with more than one opening that is not an open hole;

g) Mold Stress Relief Distortion Test, 3.4.1.1, when provided with a polymeric enclosure; and

4.17.6 Mounting means

4.17.6.1 A sign dimmer, flasher, controller and animator shall have at least the following electrical ratings:

a) The input ratings in voltage, amps, and frequency;

b) The output voltage rating(s) in DC or rms; and

c) The maximum output or throughput current rating(s).

4.17.6.2 The frequency rating described in 4.17.6.1(a) shall be designated in the words "cycles per second," "cycles/second," "hertz," "c/s," "cps," or "Hz."

4.17.6.3 When a sign dimmer, flasher, controller and animator is intended to operate only from a direct-current supply, it shall be marked either "direct-current" or "DC."

4.17.7 Markings and installation instructions

4.17.7.1 The installation shall include the following:

a) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

b) A dimmer, flasher, controller and animator shall have a condition of use that specifies the electrical ratings;

c) A dimmer, flasher, controller and animator unless provided with it own qualifying enclosure with input and output conduit connection means shall have a condition of use that specifies:

1) The unit must be enclosed in the end product, and

2) The minimum volume of an end product provided enclosure;

d) A dimmer, flasher, controller and animator shall specify the minimum distance between its exterior and any other heat producing component.

4.18 LED components

4.18.1 General

4.18.1.1 The requirements in this section apply to LED components including LED display units and the power source for use in Section Signs and LED Changing Message Signs.

Note: Requirements for LED Displays and arrays are covered in 4.18.1 to 4.18.4. Requirements for LED power sources are covered in 4.18.5 to 4.18.10. Requirements for LED panels are covered in 4.18.11 to 4.18.14.

4.18.1.2 LED components intended for factory installation in electric signs that comply with one of the standards specified in Table 4.4.0, shall additionally comply with applicable requirements of 4.18.

4.18.1.3 LED units intended to be supplied by a class 2, LPS, or LVLE power source are only required to comply with the applicable requirements of this standard.

Table 4.4.0
Applicable Standards for LED Components

Standard[a)]	LED display[b)]	LED panel[c)]	LED arrays
Electric Sign Components, UL 879 [d)]	X	X	X
Light Emitting Diode (LED) Equipment for Use in Lighting Products, UL 8750		X	X
Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1	X	X	
Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1	X	X	

[a)] See 4.18.5 for standards applicable to power sources intended for use with LED units.

[b)] LED displays evaluated to one of the information technology standards specified in this table shall additionally comply with applicable requirements of 4.18.2 – 4.18.4.

[c)] LED panels evaluated to one of the LED or information technology standards specified in this table shall additionally comply with applicable requirements of 4.18.11 – 4.18.14.

[d)] Except where specifically evaluated to UL 879 for factory installation in electric signs, an LED display unit shall fully comply with the applicable requirements of one of the standards specified in this table.

4.18.2 Construction

4.18.2.1 *Deleted*

4.18.2.2 LED displays and arrays intended for connection to a Class 2 power source in wet locations shall be suitable for connection to a power source with an output voltage of no greater than Notes 2 and 3 of Table 2.12 and Table 2.13 unless accompanied by an installation instruction requiring the units be kept dry in the end product.

4.18.2.3 LED Displays and arrays intended to connect remotely to a Class 2 power source shall be provided with Class 2 wiring methods in accordance with the National Electrical Code, NFPA 70.

4.18.3 Ratings

4.18.3.1 The rating for LED displays and arrays shall include the voltage and current.

4.18.4 Installation instructions

4.18.4.1 LED displays and arrays shall be provided with installation instructions that include the following:

a) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

b) For products rated Class 2, a statement that these products are only suitable for connection to a circuit powered from a Class 2 or LPS power source;

c) These products have not been evaluated for use when connected to a power source that does not comply with Class 2 voltage and energy limited supplies; and

d) For wet location products, "These products are not required to be enclosed or protected from weather."

4.18.5 Construction

4.18.5.1 Power supplies, LED drivers and transformers are required to operate within their rated input and output ratings.

4.18.5.2 Unless identified as suitable for field installation, power supplies, LED drivers and transformers shall be enclosed in an electrical enclosure.

4.18.5.3 Power supplies, LED drivers and transformers may have more than one Class 2 or LPS output.

4.18.5.4 Except for features specified in this standard, power supplies and LED drivers shall comply with one of the following applicable standards:

a) The Standard for Class 2 Power Units, UL 1310;

b) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1;

c) The Standard for Power Units Other Than Class 2, UL 1012;

d) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1; or

e) The Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products, UL 8750.

4.18.5.5 Power supplies and LED drivers for portable LED signs

4.18.5.6 Direct plug in or through cord style power supplies and LED drivers marked "Indoor Use" or “dry location” are suitable for portable signs only.

4.18.5.7 Direct plug in or through cord style power supplies marked for I.T.E. Use Only are suitable for portable signs only. I.T.E. denotes Information Technology Equipment.

4.18.5.8 Direct plug in or through cord style power supplies and LED drivers marked "Class 2" or "LPS" do not require an electrical enclosure for the LEDs. LPS denotes Limited Power Source.

4.18.5.9 Power supplies for permanently wired signs shall comply with the following:

a) Secondary circuits connected to the output of power supplies complying with the requirements in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, and having secondary circuits that are SELV or ELV, and that are not hazardous energy level, are to have the secondary circuits wired as Class 1 circuits.

b) Secondary circuits connected to the output of power supplies complying with the requirements in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, and having secondary circuits that are "LPS" may be wired as Class 2 circuits.

c) Power supplies evaluated for use in Pollution Degree 2 environments are restricted to indoor or dry location signs.

d) A Pollution Degree 2 evaluated power supply that is completely conformal coated or potted may be used in a damp, wet, or outdoor sign.

e) A Pollution Degree 2 evaluated power supply installed in an enclosure equivalent to a Type 3, 3S, or 4X enclosure may be used in a damp, wet, or outdoor sign.

f) A Pollution Degree 3 evaluated power supply installed in an enclosure equivalent to a Type 3R enclosure or an enclosure meeting the Water Exclusion requirements of the Standard for Electric Signs, UL 48, may be used in a wet or outdoor sign.

4.18.5.10 A transformer for permanently wired signs shall comply with the following:

a) Class 2 and Class 3 Transformers in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3;

b) The Standard for Transformer and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411;

c) Specialty Transformers 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; or

d) The Standard for Dry-Type General Purpose and Power Transformers, UL 1561.

4.18.5.11 A transformer and power supply shall be required to operate within its rated input and output ratings.

4.18.5.12 All live parts of a power supply and transformer shall be enclosed within a qualifying material with limited openings. The live parts that are required to be enclosed are all parts connected to an electrical circuit that is not designated as complying with Class 2 or LPS requirements and the live parts are not otherwise enclosed in accordance with the requirements in the Standard for Electric Signs, UL 48.

4.18.5.13 Power supplies and transformers with integral electrical enclosures with provision for permanent wiring in accordance with this standard are considered to comply.

4.18.5.14 Power supplies and transformers installed in a Type 3, 3R, 3S, or 4X enclosure are considered to comply.

4.18.5.15 Power supplies and transformers where the electrical enclosure is provided as part of a new factory built sign are not required to have an electrical enclosure.

4.18.5.16 Fuses shall be inaccessible by being located completely within an electrical enclosure unless the fuseholder is of the type that will prevent insertion of a higher current rated fuse (i.e. lockout type extractor fuseholder).

4.18.5.17 Where a fuse is provided, it shall be mounted in a fuseholder of the proper type and rating, or be soldered by pigtail style leads directly to a printed wiring board or be mounted using surface mount technology.

4.18.5.18 The fuse type identification and ampere rating shall be marked on, or adjacent to, the fuse and fuseholder.

4.18.5.19 A thermistor, Positive Temperature Coefficient (PTC) or Negative Temperature Coefficient (NTC) resistance, provided to limit the output of a unit to within the required current or power levels, or with maximum temperature requirements or otherwise used to obtain acceptable test results shall comply with the requirements of other appropriate standards listed in Appendix A of this standard, and shall have a Calibration Class of C1 or C2.

4.18.6 Supply connection means

4.18.6.1 Knockouts for trade size 1/2 fittings shall be provided when fittings or bushings are not provided for field supply connections. Knockouts shall withstand a 10-lb knockout test as specified in the Standard for Safety for Luminaries, UL 1598.

4.18.6.2 Secondary connections may be pig-tail leads a minimum 5-ft long, 6-in long pigtail leads within a wiring compartment, or a terminal connector. A terminal connector for connection to Class 2 output circuits is not required to be enclosed.

4.18.7 Mounting means

4.18.7.1 A power source shall be provided with a means to be mounted either to a building structure or to the body of an end product.

4.18.8 Tests

4.18.8.1 A LED power source shall be subjected to the basic product tests as follows:

a) Input Test, 3.4.2.2, under full load testing as specified in 4.17.5.2;

b) Normal Temperature Test, 3.4.2.3, under full load testing as specified in 4.17.5.2. An LED power source intended for factory installation within a sign enclosure shall be tested at an elevated ambient of 40 ±5°C (104 ±9°F) minimum;

c) Dielectric Voltage Withstand Test, 3.4.2.5, with no load connected;

d) Abnormal Operation Tests, 3.4.2.7.2, with fans, and unit shorted and opened circuited. Where multiple outputs are provided, short circuit conditions shall be with other output loads and other outputs not loaded;

e) Ground Continuity Test, 3.4.2.6, with no load; and

f) Impact Test, 3.4.1.6, with no load.

4.18.8.2 Power supplies or transformers provided with a fan or blower are to be tested with the rotor of the fan or blower stalled. Motor winding temperatures shall be measured during the test and shall not exceed 150°C (302°F) for a Class 105 insulation system.

4.18.8.3 A component shall not result in a risk of fire or electric shock as a result of being subjected to the stalled rotor test. A dielectric voltage withstand test is to be conducted after the abnormal operation test.

4.18.9 Ratings

4.18.9.1 A Class 2 power source shall have at least the following electrical ratings:

a) The input ratings in voltage, amps, and frequency;

b) The output voltage rating(s) in DC or rms; and

c) The maximum rated output current for each output.

4.18.9.2 The frequency rating described in 4.18.9.1 (a) shall be designated in the words "cycles per second," "cycles/second," "hertz," "c/s," "cps," or "Hz."

4.18.10 Markings and installation instructions

4.18.10.1 The installation instructions are to include the following:

a) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

b) Identification of each LED circuit that is restricted to Class 2 or LPS limits;

c) The suitability of rain enclosure shall be determined if intended for wet location;

d) Mounting position shall be specified if the enclosure has ventilation openings; and

e) The suitability of electrical enclosure and secondary wiring shall be determined if single circuit power requirements exceed Class 2 or LPS limits.

4.18.11 Construction

4.18.11.1 A LED panel shall comply with the enclosure requirements for the intended location.

4.18.11.2 Where a LED panel complies with the enclosure requirements based in part on its printed wiring board backing, the printed wiring board shall be rated minimum 105°C (221°F) with a minimum flammability rating of V-0.

4.18.11.3 Power supplies and transformers are required to operate within their rated input and output ratings.

4.18.11.4 Power supplies for LED panels shall comply with one of the following standards specified in 4.18.5.4.

4.18.11.5 Power supplies shall comply with the following:

a) Power supplies evaluated for use in Pollution Degree 2 environments are restricted to indoor or dry location signs.

b) A Pollution Degree 2 evaluated power supply that is completely conformal coated or potted may be used in a damp, wet, or outdoor sign.

c) A Pollution Degree 3 evaluated power supply is suitable for use mounted on the back side of a LED panel designated for use in a wet location.

4.18.11.6 A power supply provided with a LED changing message panel shall be required to operate within its rated input and output ratings.

4.18.12 Tests

4.18.12.1 Tests are required in the end product.

4.18.13 Ratings

4.18.13.1 The rating for LED panels shall include the input voltage and current of the LEDs or the input voltage and current of the power supply (ies) when provided.

4.18.14 Installation instructions

4.18.14.1 A LED changing message panel shall be provided with installation instructions that provide detailed diagrams and instructions showing the proper installation of the LED panels in a changing message sign.

4.19 Electroluminescent displays

4.19.1 General

4.19.1.1 The requirements in this section apply to electroluminescent displays provided as either a panel or strip for use in a sign.

4.19.2 Construction requirements

4.19.2.1 The polymeric materials of an electroluminescent panel shall have a minimum flammability rating of at least HB when connected to a Class 3 power source in portable applications and 5VA where used in permanently installed end products.

4.19.2.2 An electroluminescent panel shall be provided with an accessibility barrier unless connected to a power source that complies with the Class 3 power source requirements in 2.12.6.1.

4.19.3 Supply connection means

4.19.3.1 An electroluminescent panel shall be provided with either an integral or separable power source that is capable of being connected to a branch circuit source of supply.

4.19.4 Mounting means

4.19.4.1 An electroluminescent panel shall be provided with mounting means or include a condition of use specify the panel must be made inaccessible in the end product.

4.19.5 Tests

4.19.5.1 In addition to potential material evaluation tests related to enclosure and insulating material requirements, an electroluminescent panel or strip shall be subjected to the Input Test, 3.4.2.2, the Normal Temperature Test, 3.4.2.3, and the tests specified in 4.19.5.2 – 4.19.5.4.

4.19.5.2 An electroluminescent panel intended for use in portable and permanent end product use shall have most of the side that does not illuminate and the side that does illuminate covered by separate sheets of aluminum foil. The foil is to extend as close as possible to the edge of each side of the panel, but no close as to exceed the spacing requirements in 2.15. The size of the test sample shall have a width of up to 30.5 cm (12 in). The length of the panel shall be at least 30.5 cm (12 in) up to 91.5 cm (36 in) to obtain a total area of panel that is as close as possible to but does not exceed 930 cm^2 (144 in^2).

4.19.5.3 Using a sample of an electroluminescent panel prepared as specified in 4.19.5.2, the current between both sections of aluminum foil shall be measured using a current meter capable of measuring the operating frequency of the intended panel supply source. The current shall no exceed 0.5 mA.

4.19.5.4 Using a sample of an electroluminescent panel prepared as specified in 4.19.5.2, a dielectric withstand voltage of 1000 V at 60 Hz shall be applied between both sections of aluminum foil. There shall be no dielectric breakdown.

4.19.6 Ratings

4.19.6.1 An electroluminescent power source shall be provided with input voltage and current and the maximum are of electroluminescent panel the supply is for which the power supply is rated. The rating for an electroluminescent panel shall include the input voltage and the input current per mm^2 (in^2) or when provided.

4.19.7 Markings and installation instructions

4.19.7.1 The installation instructions shall include

a) Detailed diagrams and instructions showing the proper installation of the power source, cabling and panel.

b) The electroluminescent panel is suitable for installation in a dry or damp location.

c) The electroluminescent panel must be made inaccessible in the end product utilizing the thermoplastic barrier provided.

d) The power source/controller and cabling from the controller to the electroluminescent panel are intended to be made inaccessible in the end product.

4.20 Switch enclosures

4.20.1 General

4.20.1.1 The requirements in this section apply to Enclosures or covers intended to be installed over switches to prevent the entry of moisture when the switch activator is installed exposed to wet location conditions in an end product.

4.20.2 Construction requirements

4.20.2.1 The material of a polymeric neon electrode enclosure shall comply with the material properties specified in Table 4.3 part 1 and as determined by the product tests specified in 4.20.4.

4.20.2.2 A switch enclosure shall prevent the water from contacting the actuator portion of a switch.

4.20.2.3 A switch enclosure shall provide a water seal between the mounting surface through which a switch is installed and the switch enclosure to prevent the entry of water. To accommodate the means to seal against a surface a switch enclosure shall be capable of being mechanically secured to a switch and be tightened against the mounting surface around the switch.

4.20.3 Mounting means

4.20.3.1 A switch enclosure shall be capable of being mechanically secured to the switch it is intended to cover or be mechanically secured to the mounting surface around the switch.

4.20.4 Tests

4.20.4.1 The material of a switch enclosure shall remain flexible and not tear or crack when subjected to the conditioning and tests specified in 4.20.4.2 – 4.20.4.5.

4.20.4.2 Three samples of a switch enclosure not mounted to a switch are to be subjected to the Flexibility and Hardness Test specified in 3.2.2.10.

4.20.4.3 Three additional samples of a switch enclosure shall be installed in accordance with the manufacturer's installation instructions to samples of the intended switch mounted through a hole made in a 30.4 by 30.4 cm (12 by 12 in), 0.051 – 0.061-cm (0.020 – 0.024-in) thick segment of sheet steel or directly to the sheet steel. The hole in the sheet metal segment shall be the size recommended by the manufacturer of the switch.

4.20.4.4 The switch enclosures are to be subjected to the following sequence of tests and conditioning. During and between each test and conditioning sequence the switch enclosures are not to be tightened or adjusted in anyway. The tests and conditioning sequence shall be conducted in the following order: Mold Stress Relief Distortion Test, 3.4.1.1, Ultraviolet Radiation Exposure Conditioning, 3.2.1.5, Cold Conditioning, 3.2.1.7, Icing Test, 3.2.2.18, Thermal Cycling Exposure, 3.2.1.3, and Flexing Test, 3.4.1.12. Following these conditions and tests, the 3 samples are to be subjected to the Rain Test, 3.4.1.9. The switch enclosure shall continue to prevent the entry of simulated rain from entering the switch that it is intended to be mounted over. During the tests the side of the switch on the side of the sheet metal segment opposite the switch enclosure is to be covered or sealed to prevent moisture from entering the switch from what would normally constitute the inside of a sign. Due to being subjected to elevated temperatures, the switch is not required to remain functional at the conclusion of the testing.

4.20.4.5 The 3 switch enclosure samples subjected to the tests and conditioning specified in 4.20.4.4 are to be subjected to the Flexibility and Hardness Test specified in 3.2.2.10 and shall not have a flexibility and hardness that has decreased by more than 10 units.

4.20.5 Ratings

4.20.5.1 A switch enclosure shall be rated for a specific switch or a series of universally available snap switches of a common identifiable construction, such as a toggle switch.

4.20.6 Markings and installation instructions

4.20.6.1 All markings other than the certification mark shall be marked on the smallest unit package.

4.20.6.2 Installation instructions shall include the following:

a) This device is intended suitable for use in outdoor electric sign applications.

b) The ability of this product to prevent water from entering a switch needs to be evaluated in the end product.

c) The toggle switch for use with this switch enclosure shall comply with the following:

1) The toggle (switch actuator) shall be rounded to prevent abrasion and cutting of the switch enclosure.

2) The assembly shall be mounted on the bottom or side surface of a sign body only.

3) Unless the switch body is completely enclosed in a weatherproof enclosure, drain openings shall be provided in the bottom of the enclosure in which the switch is installed.

4) The toggle (switch actuator) shall be metal

4.21 Sign rotating equipment

4.21.1 General

4.21.1.1 The requirements in this section apply to motorized units intended to be placed between a mounting surface and a sign causing the sign to rotate and transferring power to the sign through commutator rings.

4.21.2 Construction requirements

4.21.2.1 A rotator shall be so designed that a risk of personal injury shall not occur when the rotator is installed as intended in service.

4.21.2.2 A rotator shall be capable of handling the maximum normal load rating without creating a risk of fire, electric shock, or injury to persons.

4.21.2.3 A motor winding shall resist the absorption of moisture.

4.21.2.4 With reference to the requirement in 4.21.2.3, film-coated wire is not required to be additionally treated to resist absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

4.21.2.5 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary not to cause accessible dead metal parts to become energized, and live parts to become accessible.

4.21.2.6 An appliance shall incorporate thermal or overload protection in accordance with 2.14.3 and 2.14.4 if it is intended to be permanently connected, continuous-duty, and manually started, employing a motor rated 1 horsepower (746 W output) or less, or remotely or automatically controlled.

4.21.2.7 For a multispeed rotator that employs a separate overload protective device to provide running overload protection, the requirement applies at all speeds at which the motor is intended to operate.

4.21.2.8 A rotator having load characteristics likely to result in an overload or stalled condition that will not be evident to the user is required to incorporate thermal or overload protection.

4.21.2.9 Overload devices employed for running overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system and in each ungrounded conductor of a 3-phase supply system.

4.21.2.10 Fuses employed for motor-running overload protection shall be located in each ungrounded conductor; and in each of the phases of a 3-phase, 3-wire, alternating-current motor.

4.21.2.11 An overload- or thermal-protective device shall have a current and voltage rating not less than the load that it controls.

4.21.2.12 Other than an operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the enclosure, a protective device shall be wholly inaccessible from outside the appliance without opening a door or cover.

4.21.2.13 A rotating or moving part that, if it should become disengaged, may create a risk of injury to persons shall be provided with a means to retain the part in place.

4.21.2.14 A rotating member, the breakage of which may create a risk of injury to persons, shall be constructed to reduce the likelihood of its breakage, or the release or loosening of a part that could become a risk of injury to persons.

4.21.3 Supply connection means

4.21.3.1 A sign rotator shall be provided with leads and terminals for the connection of input power to the motor and separate input and output leads and terminals for have the commutator rings.

4.21.4 Mounting means

4.21.4.1 A sign rotator shall have permanent mechanical means of being secured to a based structure and to the base of a sign.

4.21.5 Tests

4.21.5.1 A sign rotator shall comply with the Input in 3.4.2.2, Normal Temperature in 3.4.2.3, Dielectric Voltage Withstand Test in 3.4.2.5, Starting Motor in 3.4.2.10.1, Locked Rotor Tests in 3.4.2.10.2 and the Continuous Operation test in 4.22.6.2.

4.21.5.2 A sign rotator designated for use in a damp location shall comply with Condensation Test in 3.4.2.9.

4.21.5.3 A sign rotator shall comply with the Rain Test in 3.4.1.9. A sign rotator having a specific orientation for rotating a sign shall be tested in that orientation during the Rain Test shall not contact current carrying parts.

4.21.6 Ratings

4.21.6.1 A sign rotator shall have at least the following electrical ratings:

a) The input ratings in voltage, amps, and frequency;

b) The throughput voltage rating(s) in DC or rms; and

c) The maximum throughput current for each circuit.

4.21.6.2 The frequency rating described in 4.18.9.1 (a) shall be designated in the words "cycles per second," "cycles/second," "hertz," "c/s," "cps," or "Hz".

4.21.7 Markings and installation instructions

4.21.7.1 A sign rotator shall be permanently marked with the following:

a) Rated input voltage, current and frequency,

b) Maximum rated throughput voltage and current,

c) The maximum load by weight for which the rotator is intended.

4.21.7.2 A sign rotator shall be provided with installation instructions that include the following:

a) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

b) A sign rotator shall have a condition of use that specifies the electrical ratings;

c) A sign rotator unless provided with it own qualifying enclosure with input and output conduit connection means shall have a condition of use that specifies:

1) The unit must be enclosed in the end product, and

2) The minimum volume of an end product provided enclosure.

d) A sign rotator shall have a condition of use that specifies the maximum load in pounds of the product to be mounted onto it to be rotated.

4.22 Clock mechanisms

4.22.1 General

4.22.1.1 The requirements in this section apply to electronic circuits and motorized components intended to function as a clock mechanism.

4.22.2 Construction requirements

4.22.2.1 Any switching contacts of a clock mechanism shall comply with the requirements for circuit interrupting devices for the intended load in accordance with 2.14.2.

4.22.2.2 An electromechanical clock mechanism shall be constructed to make moving parts inaccessible during normal operation other than the time indicating parts of the clock mechanism.

4.22.2.3 An electromechanical clock mechanism shall be constructed with spacings specified in Table 4.4.

Table 4.4
Time recording motor spacings

Potential involved in V	Location of parts involved	Smallest acceptable through-air and over-surface spacings	
		mm	(in)
0 – 50	Commutator or collector rings of a motor	1.2	(3/64)
51 – 125	Commutator or collector rings of a motor	1.6	(1/16)
126 – 250	Commutator or collector rings of a motor	1.6	(1/16)
215 – 300	Commutator or collector rings of a motor	2.4	(3/32)

4.22.2.4 If insulation is provided in lieu of spacings between a magnetic coil winding and other uninsulated live parts or grounded dead metal parts, the type of insulation may differ from that required by 4.22.2.5 and 4.22.2.6. Crossover lead insulation and insulation under coil terminals secured to the coil winding need not comply with 4.22.2.5 and 4.22.2.6, if, for an insulation thickness of less than 0.33 mm (0.013 in), there is no indication of breakdown as a result of the Abnormal Operation Test in 3.4.2.7.

4.22.2.5 An insulating barrier or liner used as the sole separation between uninsulated live parts and grounded dead metal parts (including the enclosure), or between uninsulated live parts of opposite polarity, shall be of material that complies with 2.13 and shall be not less than 0.71-mm (0.028-in) thick.

4.22.2.6 An insulating barrier or liner used in conjunction with an air space in place of the required spacing through air shall be not less than 0.71-mm (0.028-in) thick. If the barrier or liner is of fiber, the air space shall be not less than 0.8 mm (1/32 in), and if the barrier or liner is of other material not acceptable for the support of uninsulated live parts, the air space provided shall be such that, upon investigation, it is found to fulfill the intent of the requirement.

4.22.3 Supply connection means

4.22.3.1 A clock mechanism sign shall be provided with leads and terminals for the connection of input power to the motor.

4.22.4 Mounting means

4.22.4.1 A clock mechanism shall have mechanical means of being secured to a sign.