UL 1449

STANDARD FOR SAFETY

Surge Protective Devices

UL Standard for Safety for Surge Protective Devices, UL 1449

Fifth Edition, Dated January 8, 2021

Summary of Topics

This revision of ANSI/UL 1449 dated December 15, 2022 includes the following changes in requirements:

- ***Addition of UL 969A as Alternate Option for Marking and Labeling; 68.1.1***
- ***Clarifications and Updates to Table 48.1 (Test Program);***
- ***Revisions to Capacitor Testing; 26.1, 26.3, 26.4, 69.1, 73.1, 85.42***
- ***Clarification and Additional Text to SA8.3 – SA8.4 Covering Current Tests***
- ***Clarification to SB7 for Testing SPDs that Permit Follow Current; SB7.1***
- ***Clarification of Clause SB8.2 Regarding SCCR Levels***
- ***Correction to Number of Test Samples in Clause SB10.1;***
- ***Clearances for Altitude Over 2000 m; 19.2***
- ***Type 4 Component Assemblies Surge Testing; 43.2***
- ***Temperature Testing of Plug Blades in Direct Plug-In SPDs; Table 40.1, 40.14, 40.17***

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 March 4, 2022 and October 14, 2022.

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Standard for Surge Protective Devices

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Fifth Edition

January 8, 2021

This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through December 15, 2022.

The most recent designation of ANSI/UL 1449 as an American National Standard (ANSI) occurred on December 15, 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.

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INTRODUCTION

1 Scope

1.1 These requirements cover enclosed and open-type Surge Protective Devices (SPDs) designed for repeated limiting of transient voltage surges as specified in the standard on 50 or 60 Hz power circuits not exceeding 1000 V and for PV applications up to 1500 V dc and designated as follows:

Type 1 – One port, permanently connected SPDs, except for watt-hour meter socket enclosures, intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and Molded Case SPDs intended to be installed without an external overcurrent protective device. Type 1 SPDs for use in PV systems can be connected between the PV array and the main service disconnect.

Type 2 – Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device; including SPDs located at the branch panel and Molded Case SPDs.

Type 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected. See marking in 85.4. The distance (10 meters) is exclusive of conductors provided with or used to attach SPDs.

Type 4 Component Assemblies – Component assembly consisting of one or more Type 5 components together with a disconnect (integral or external) or a means of complying with the limited current tests in 45.4.

Type 1, 2, 3 Component Assemblies – Consists of a Type 4 component assembly with internal or external short circuit protection.

Type 5 – Discrete component surge suppressors, such as MOVs that may be mounted on a PWB, connected by its leads or provided within an enclosure with mounting means and wiring terminations.

1.2 Except as indicated in 1.3, the products covered by this Standard are rated and intended for connection to circuits or supply sources having nominal voltage ratings as specified in Table 45.1.

1.3 A product intended for connection to an ac circuit or supply source other than that specified in 1.2 may be examined and tested in accordance with the intent of the requirements in this standard and, if found to be substantially equivalent, may be judged to comply with this Standard.

1.4 These requirements cover cord-connected direct plug-in, and permanently connected SPDs intended for indoor and outdoor use in accordance with the National Electrical Code, ANSI/NFPA 70.

1.5 These requirements do not cover the interconnection of multiple field installed SPDs.

1.6 These requirements cover SPDs that may include components specifically intended to function as filters for conducted electromagnetic interference (EMI) or noise, in addition to limiting transient voltage surges. See Section 27.

1.7 These requirements cover SPDs employing circuit components intended to provide secondary protection for telephone communication circuits and circuit components intended to protect data communication or fire alarm circuits. See Section 28.

1.8 These requirements cover SPDs employing antenna connections for audio-video products. See Section 29.

1.9 An SPD that has a battery backup feature or other uninterruptible power supply equipment shall also comply with the applicable requirements in the Standard for Uninterruptible Power Supply Equipment, UL 1778. See Section 31.

1.10 These requirements cover SPDs/Panelboard Extension Modules. These products shall also comply with the Standard for Panelboards, UL 67. See Section 32.

1.11 These requirements do not evaluate the effect of SPDs on connected loads, the effect of SPDs on harmonic distortion of the supply voltage, the degree of attenuation provided by SPDs, nor the adequacy of the voltage protection rating of SPDs to protect specific connected equipment from upset or damage.

1.12 This standard does not cover cord connected or direct plug-in SPDs intended for use with medical equipment. Medical equipment is typically intended for use in General Patient Care Areas or Critical Patient Care Areas as defined by Article 517 of the National Electrical Code for Health Care Facilities. SPDs intended for such use shall comply with the requirements of the Standard for Safety of Medical Electrical Equipment, Part 1: General Requirements, UL 60601-1, and the Standard for Safety Requirements for Medical Electrical Systems, IEC 60601-1-1.

1.13 An SPD intended to serve as an outlet cover plate or outlet box hood shall comply with the requirement for faceplates in the Standard for Cover Plates for Flush Mounted Wiring Devices, UL 514D.

1.14 An SPD intended for use in a Lightning Protection System (LPS) shall comply with the Surge Protection requirements in the Standard for Installation Requirements for Lightning Protections Systems, UL 96A.

1.15 A Type 3 SPD may employ additional low voltage supplementary circuitry to power a USB charger.

1.16 A cord-connected or direct plug-in Type 3 SPD may employ a replaceable or non-replaceable rechargeable battery to power a USB output circuit.

1.17 A direct plug-in SPD employing more than two receptacles shall also comply with the applicable requirements in the Standard for Current Taps and Adapters, UL 498A.

1.18 A cord-connected SPD employing more than two receptacles shall also comply with the applicable requirements in the requirements in the Standard for Relocatable Power Taps, UL 1363 or the Standard for Furniture Power Distribution Units, UL 962A.

2 Referenced Publications

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

2.2 The following publications are referenced in this Standard:

ANSI C84.1, *Electric Power Systems Voltage Ratings (60 Hz)*

ASTM E230/E230M, *Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

IEC 320, Power Cords

IEC 60601-1-1, *Safety Requirements for Medical Electrical Systems*

IEC 60664-1, *Insulation Coordination for Equipment within Low-voltage Supply Systems – Part 1: Principles, Requirements and Tests*

IEEE C37.09, *AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

IEEE C62.45, *Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits*

NEMA/WD 6, *Wiring Devices – Dimensional Specifications*

NFPA 70, *National Electrical Code*

UL 20, *Snap Switches*

UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

UL 67, *Panelboards*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 96A, *Installation Requirements for Lightning Protections Systems*

UL 224, *Extruded Insulating Tubing*

UL 248-14, *Low-Voltage Fuses – Part 14: Supplemental Fuses*

UL 248-16, *Low-Voltage Fuses – Part 16: Test Limiters*

UL 414, *Meter Sockets*

UL 452, *Antenna-Discharge Units*

UL 486A-486B, *Wire Connectors*

UL 486E, *Wiring Terminals for Use With Aluminum and/or Copper Conductors*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

UL 497, *Protectors for Paired-Conductor Communication Circuits*

UL 497A, *Secondary Protectors for Communication Circuits*

UL 497B, *Protectors for Data Communication and Fire Alarm Circuits*

UL 497C, *Protectors for Coaxial Communication Circuits*

UL 498, *Attachment Plugs and Receptacles*

UL 498A, *Current Taps and Adapters*

UL 508, *Industrial Control Equipment*

UL 514A, *Metallic Outlet Boxes*

UL 514B, *Conduit, Tubing, and Cable Fittings*

UL 514C, *Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers*

UL 514D, *Cover Plates for Flush Mounted Wiring Devices*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 746E, *Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards*

UL 796, *Printed Wiring Boards*

UL 817, *Cord Sets and Power-Supply Cords*

UL 840, *Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment*

UL 962A, *Furniture Power Distribution Units*

UL 969, *Marking and Labeling Systems*

UL 991, *Tests for Safety-Related Controls Employing Solid-State Devices*

UL 1059, *Terminal Blocks*

UL 1077, *Supplementary Protectors for Use in Electrical Equipment*

UL 1283, *Electromagnetic Interference Filters*

UL 1310, *Class 2 Power Units*

UL 1363, *Relocatable Power Taps*

UL 1429, *Pullout Switches*

UL 1434, *Thermistor-Type Devices*

UL 1492, *Audio-Video Products and Accessories*

UL 1557, *Electrically Isolated Semiconductor Devices*

UL 1577, *Optical Isolators*

UL 1778, *Uninterruptible Power Supply Equipment*

UL 2054, *Household and Commercial Batteries*

UL 5085-1, *Low Voltage Transformers – Part 1: General Requirements*

UL 5085-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

UL 60065, *Audio, Video, and Similar Electronic Apparatus Safety Requirements*

UL 60384-14, *Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains*

UL 60601-1, *Medical Electrical Equipment, Part 1: General Requirements*

UL 60691, *Thermal-Links – Requirements and Application Guide*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 61058-1, *Switches for Appliances – Part 1: General Requirements*

3 Glossary

3.1 For the purpose of this Standard, the following definitions apply.

3.2 1.2/50 VOLTAGE WAVE – Voltage surge with a virtual front time of 1.2 µs and a time to half-value of 50 µs delivered across an open circuit.

3.3 8/20 CURRENT WAVE – Current surge with a virtual front time of 8 µs and a time to half-value of 20 µs delivered into a short circuit.

3.4 AC POWER INTERFACE – The electrical points where the SPD is electrically connected to the ac power system.

3.5 CIRCUIT BREAKER SPD – Combination circuit breaker and surge-protective devices (SPDs) designed to serve the dual function of providing overcurrent protection, and for repeated limiting of transient-voltage surges.

3.6 COMBINATION WAVE – (Also called "combination surge") A surge delivered by a generator which has the inherent capability of applying a 1.2/50µs voltage wave across an open circuit, and delivering an 8/20 µs current wave into a short circuit. The exact wave that is delivered is determined by the generator's fictive impedance.

3.7 COMPONENT – SURGE PROTECTIVE DEVICE – An SPD intended solely for factory installation in another component, device or product and designated as Type 4 Component Assemblies, Type 1, 2 or 3 Component Assemblies or Type 5 SPD.

3.8 CORD CONNECTED (CC) – An SPD provided with a power-supply cord terminating in an attachment plug for connection of the device to a receptacle in the AC power circuit.

3.9 CREST (PEAK) VALUE (OF A WAVE, SURGE, OR IMPULSE) – The maximum value that a wave, surge, or impulse attains.

3.10 DIRECT PLUG-IN (DPI) – An SPD incorporating integral blades for direct insertion into a standard wall receptacle.

3.11 ELECTROMAGNETIC INTERFERENCE FILTER – A device intended to attenuate unwanted radio-frequency signals (such as noise or interference) generated from electromagnetic sources. EMI filters consist of capacitors and inductors used alone or in combination with each other and may be provided with resistors.

3.12 ENCLOSED SPD – An SPD provided with a complete enclosure in accordance with the construction requirements of this standard.

3.13 EQUIPMENT UNDER TEST (EUT) – Refers to the SPD being tested.

3.14 FACTORY WIRING – The connection of a wire, under controlled conditions, at a manufacturer's location.

3.15 FAULT CURRENT – The current from the connected power system that flows in a short circuit.

3.16 FIELD WIRING – The connection of a wire in the field, in accordance with the National Electrical Code, NFPA 70.

3.17 FOLLOW (POWER) CURRENT – The current from the connected power source that flows through an SPD during and following the passage of discharge current. Examples of devices that permit follow current are gas discharge tubes and thyristors.

3.18 HERMETICALLY SEALED DEVICE – A device that is sealed against the entrance of an external atmosphere and in which the seal is made by fusion; e.g., soldering, brazing, welding, or the fusion of glass to metal.

3.19 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolating source (such as a transformer, optical isolator, limiting impedance or electro-mechanical relay) and having no direct connection back to the primary circuit (other than through the grounding means). A secondary circuit that has a direct connection back to the primary circuit is considered part of the primary circuit.

3.20 MAXIMUM CONTINUOUS OPERATING VOLTAGE (MCOV) – The maximum designated root-mean-square (rms) value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.

3.21 MEASURED LIMITING VOLTAGE – The maximum magnitude of voltage, measured at the leads, terminals, receptacle contacts, and similar locations after the application of an impulse of specified waveshape and amplitude.

3.22 MODES OF PROTECTION – Electrical paths where the SPD offers defense against transient overvoltages. Examples include, Line to Neutral (L-N), line to Ground (L-G), Line to Line (L-L) and Neutral to Ground (N-G).

3.23 MOLDED CASE SPD – A One-Port SPD incorporated within a molded case and intended for use in a space normally occupied by a circuit breaker within a panelboard complying with the Standard for Panelboards, UL 67. Molded Case SPD's may consist of a one piece SPD or may be of a two piece, "Pullout SPD" design. See 3.36 – 3.38 for description of a Molded Case SPD of the "Pullout" configuration.

3.24 NOMINAL DISCHARGE CURRENT (I_n) – Peak value of the current, selected by the manufacturer, through the SPD having a current waveshape of 8/20 where the SPD remains functional after 15 surges.

3.25 NOMINAL SYSTEM VOLTAGE – A nominal value assigned to designate a system of a given voltage class in accordance with ANSI C84.1. For the purpose of this standard, nominal system voltages include, but are not limited to, 120, 208, 240, 277, 347, 480, 600 Vac.

3.26 NOMINAL VARISTOR VOLTAGE – The voltage across the varistor at 1mA, DC.

3.27 NORMAL OPERATING VOLTAGE RATING – The normal ac power frequency voltage rating assigned to an SPD by the manufacturer. For an SPD, other than a Component-SPD, it is generally equal to the nominal value of the root-mean-square power-frequency phase voltage of the ac circuit (for example, 120, 208, 240, 347, 480, or 600 Vrms).

3.28 ONE-PORT SPD – An SPD having provisions (terminals, leads, plug) for connection to the ac power circuit but no provisions (terminals, leads, receptacles) for supplying current to ac power loads.

3.29 OPEN-TYPE SPD – A Type 1, 2 or 3 SPD, with an incomplete or partial enclosure and with field wiring terminals and/or leads, suitable for field installation, in accordance with the National Electrical Code, ANSI/NFPA 70, within a suitable enclosure.

3.30 OPPOSITE POLARITY – A difference in potential between two points, such that shorting of these two points would result in a condition involving an overload, rupturing of printed wiring-board-tracks, components, or fuses, and the like.

3.31 PEAK LET-THROUGH CURRENT (I_p) – The maximum current through a circuit during a fault.

3.32 PERMANENTLY CONNECTED (PC) – An SPD provided with terminals or leads for field connection to wiring systems in accordance with the National Electrical Code, ANSI/NFPA 70.

3.33 PHASE ANGLE – The point on the ac power sine wave, expressed in terms of electrical degrees between 0 and 360, at which the transient surge is applied.

3.34 POWERED TESTING – Refers to surge testing that is done while the SPD is electrically connected to the ac power system, at the nominal system voltage, or the manufacturer's operating voltage rating, whichever is greater.

3.35 PRIMARY CIRCUIT – A circuit in which the wiring and components are conductively connected to the AC power interface.

3.36 PULLOUT BASE – An assembly designed for mounting in place of a plug-in circuit breaker within a panelboard, that is for use with specified SPD pullout module(s) as part of a Pullout SPD.

3.37 PULLOUT MODULE – An SPD incorporated within a housing that is detachable from its pullout base, intended to be replaceable and field installable.

3.38 PULLOUT SPD – A Molded Case SPD that consists of a detachable "pullout module" and "pullout base", intended for use in a space normally occupied by a circuit breaker within a panelboard complying with the Standard for Panelboards, UL 67.

3.39 RACK-MOUNTED CORD-CONNECTED TYPE 3 SPD – A cord-connected Type 3 SPD provided with mounting means for securement to a stationary (intended to be fastened in place or located in a dedicated space) or portable (capable of being easily moved by hand from place to place in normal use) equipment rack.

3.40 RECEPTACLE SPD – A receptacle outlet incorporating an integral SPD.

3.41 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist at any part if:

a) The potential between the part and earth ground or any other accessible part is more than 30 V rms (42.4 V peak); and

b) The continuous current flow through a 1500Ω resistor connected across the potential exceeds 0.5 mA.

3.42 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where:

a) The open circuit voltage is more than 30 Vrms (42.4 V peak) and the energy available to the circuit under any condition of load including short circuit, results in a current of 8A or more after 1 minute of operation; or

b) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

3.43 SERVICEABLE PART – A part or component of an SPD that is intended to be replaced or otherwise serviced during the life of the SPD.

3.44 SERVICE EQUIPMENT OVERCURRENT DEVICE – The first overcurrent protection device between the service transformer secondary and the service entrance.

3.45 SHORT CIRCUIT CURRENT RATING (SCCR) OF SPD – The suitability of an SPD for use on an AC power circuit that is capable of delivering not more than a declared rms symmetrical current at a declared voltage during a short circuit condition.

3.46 SUPPLEMENTARY PROTECTION DEVICE – A device intended for use as overcurrent, over- or under-voltage, or over-temperature protection within electrical equipment where branch circuit overcurrent protection is already provided, or is not required.

3.47 SURGE – A transient wave of current, potential or power in an electric circuit. For the purposes of this standard, surges do not include temporary overvoltages (TOV) consisting of an increase in the power frequency voltage for several cycles.

3.48 SURGE PROTECTIVE DEVICE (SPD) – A device composed of at least one non-linear component (see 3.55 and 3.56) and intended for limiting surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions as specified. SPDs were previously known as Transient Voltage Surge Suppressors or secondary surge arresters.

3.49 SPD DISCONNECTOR – Device(s) (internal and/or external) required for disconnecting an SPD from the power system. These devices may provide overcurrent (fuse or circuit breaker) and/or over temperature (thermal responsive devices) protection.

3.50 THERMAL-LINK – A non-resettable device incorporating a thermal element (a metallic or non-metallic fusible material that is part of a THERMAL-LINK and is responsive to temperature by a change of state such as from solid to liquid at the temperature for which it is calibrated – as defined in UL 60691) which will open a circuit once only when exposed for a sufficient length of time to a temperature in excess of that which it has been designed.

3.51 THERMAL RESPONSIVE DEVICE – A non-resettable device or mechanical element that will disconnect a series connected circuit or component, when exposed for a sufficient length of time to a temperature in excess of that which it has been designed.

3.52 TWO-PORT SPD – An SPD having provisions (terminals, leads, plug) for connection to the ac power circuit and provisions [terminals, leads, receptacles(s)] for supplying current to one or more ac

power loads. SPDs provided with a minimum of two adjacent terminals for each circuit conductor may be considered and tested as a two-port SPD.

3.53 VOLTAGE AND CURRENT LIMITING TYPE SPD – An SPD that has a high impedance to surges at the input, such as a series connected inductor, followed by voltage limiting or voltage switching components.

3.54 VOLTAGE PROTECTION RATING (VPR) – A rating selected from a list of preferred values as given in Table 84.1 and assigned to each mode of protection. The value of VPR is determined as a higher value taken from Table 84.1 to the average measured limiting voltage determined during the first set of measured limiting voltages tests during the transient-voltage surge suppression test using the combination wave generator at a setting of 6kV, 3kA.

3.55 VOLTAGE-LIMITING-TYPE SPD – An SPD that has a high impedance when no surge is present, but will reduce it continuously with increased surge current and voltage. Common examples of components used as nonlinear devices are varistors and suppressor diodes. These SPDs are sometimes called "clamping-type" SPDs.

3.56 VOLTAGE-SWITCHING-TYPE SPD – An SPD that has a high impedance when no surge is present, but can have a sudden change in impedance to a low value in response to a voltage surge. Common examples of components used as nonlinear devices are spark gaps, gas tubes, and silicon-controlled rectifiers. These SPDs are sometimes called crowbar-type SPDs.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this Standard shall comply with the requirements for that component. See 2.2 for a list of standards covering components generally used in the products covered by this Standard.

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

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

b) Is superseded by a requirement in this standard. For example, when two or more testing methods are allowed in a standard or standards listed in 2.2, and one or more of those testing methods are documented in this standard, only the testing method or methods documented in this standard shall be used in component evaluation.

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

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

5 Units of Measurement

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

5.2 All units of voltage and current specified in this standard are root-mean-square values unless otherwise indicated.

CONSTRUCTION

6 General

6.1 An SPD shall be so formed and assembled that it has the strength and rigidity necessary to withstand the handling that can be encountered during shipment, installation and use without increasing the risk of fire, electric shock, and injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other defects.

6.2 A direct plug-in type SPD shall comply with the general requirements for current taps and adapters in the Standard for Current Taps and Adapters, UL 498A.

6.3 A cord-connected type SPD shall comply with the general requirements in the Standard for Relocatable Power Taps, UL 1363.

6.4 Watt-hour meter socket adapter Type 1 SPDs shall also comply with the applicable requirements of the Standard for Meter Sockets, UL 414.

6.5 A Type 3 SPD intended for outdoor use shall not exceed 0.45 m (18 in.) in length including the cord and plug, and shall be constructed such that the Enclosure does not obstruct a receptacle hood when in use.

6.6 Unless specified otherwise, open-type SPDs shall comply with the applicable requirements for the SPD Type, as specified in this standard.

7 Enclosure

7.1 Type 1 and Type 2 SPDs

7.1.1 General

7.1.1.1 An enclosure and a part of an enclosure, such as door, cover, or tank, shall be provided with means for firmly securing it in place.

7.1.1.2 An enclosure other than a Type 1 (indoor use only) enclosure shall comply with the requirements for the type designation indicating the conditions for which it is intended, as specified, for Enclosure Types, in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

7.1.1.3 Sheet-metal screws threading directly into metal shall not be used to attach a cover, door, or other part that is to be removed to install field wiring or for operation of the equipment. Sheet-metal screws may thread into sheet-metal nuts that are permanently mounted and protected against corrosion. Machine screws and self-tapping machine screws may thread-directly into sheet-metal walls.

7.1.1.4 Sheet-metal screws mounting internal components that are not removed for installation or operation may thread directly into metal.

7.1.1.5 A snap-on cover giving access to uninsulated live parts that does not require a tool for removal shall perform acceptably when subjected to the Snap-On Cover Tests, Section 60.

7.1.1.6 An enclosure cover shall be hinged if it gives access to a fuse or any other overload-protective device, the functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the SPD.

Exception: A hinged cover is not required for an SPD when the fuse or overload protector is not in series with a load circuit and opens only in the event of a malfunction of a discrete suppression component.

7.1.1.7 A door or cover giving access to a fuse shall shut closely against a 6.4 mm (1/4 inch) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the walls of the box and shall overlap the edges of the box by not less than 12.7 mm (1/2 inch). A combination of flange and rabbet or a construction that affords equivalent protection is acceptable.

7.1.1.8 Strips used to provide rabbets, or angle strips fastened to the edges of a door, shall be secured at:

a) Not less than two points;

b) Not more than 38.1 mm (1-1/2 inches) from each end of strip; and

c) Points between these end fastenings to be not more than 152 mm (6 inches) apart.

7.1.2 Cast metal

7.1.2.1 Cast metal for an enclosure shall be at least 3.2 mm (1/8 inch) thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 6.4 mm (1/4 inch) thick at tapped holes for conduit.

Exception No. 1: At other than at plain or threaded conduit holes, die-cast metal shall not be less than 2.4 mm (3/32 inch) thick for an area greater than 154.8 cm^2 (24 square inches) or having any dimensions greater than 152 mm (6 inches), and shall not be less than 1.6 mm (1/16 inch) thick for an area of 154.8 cm^2 (24 square inches) or less and having no dimension greater than 6 inches (152 mm). The area limitation for metal that is 1.6 mm (1/16 inch) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

Exception No. 2: Cast metal that is a minimum 0.89 mm (0.035 inch) thick may be employed instead of 1/16 inch-thick (1.6 mm) die-cast metal if the enclosure is not intended to be used as a splice box and if the voltage rating of the complete device is such that the voltage between any two conductors is 250 V or less and is limited to direct current or single-phase alternating current.

7.1.3 Sheet metal

7.1.3.1 The thickness of a sheet-metal enclosure shall not be less than that indicated in Table 7.1 and Table 7.2, except that uncoated steel shall not be less than 0.81 mm (0.032 inch) thick, zinc-coated steel shall not be less than 0.86 mm (0.034 inch) thick, and nonferrous metal shall not be less than 1.14 mm (0.045 inch) thick at points at which a wiring system is to be connected.

7.1.3.2 Table 7.1 and Table 7.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

7.1.3.3 With reference to Table 7.1 and Table 7.2, a supporting frame is a structure of angle or channel, or a folded rigid section of sheet metal that is firmly attached to and has essentially the same outside dimensions as the enclose surface and that has such torsional rigidity as to resist bending moments that may be applied by the enclosure surface when it is deflected. A construction that is considered to have equivalent reinforcing is one that produces a structure that is as rigid as one built with a frame of angles or channels. Constructions that are considered to be without supporting frame include:

a) Single sheet with formed flanges (formed edges);

b) A single sheet that is corrugated or ribbed;

c) An enclosure surface loosely attached to a frame; for example, with spring clips; and

d) An enclosure surface having an unsupported edge.

Table 7.1
Thickness of Metal for Enclosures – Carbon Steel or Stainless Steel

Without support frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum acceptable thickness			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length		Uncoated		Metal coated	
cm	(inches)	cm	(inches)	cm	(inches)	cm	(inches)	mm	(inches)	mm	(inches)
10.2	(4.0)	Not limited		15.0	(6.25)	Not limited		0.51	(0.020)	0.58	(0.023)
12.1	(4.75)	14.6	(5.75)	17.1	(6.75)	21.0	(8.25)				
15.2	(6.0)	Not limited		24.1	(9.5)	Not limited		0.66	(0.026)	0.74	(0.029)
17.8	(7.0)	22.2	(8.75)	25.4	(10.0)	31.8	(12.5)				
20.3	(8.0)	Not limited		30.5	(12.0)	Not limited		0.81	(0.032)	0.86	(0.034)
22.9	(9.0)	29.2	(11.5)	33.0	(13.0)	40.6	(16.0)				
31.8	(12.5)	Not limited		49.5	(19.5)	Not limited		1.07	(0.042)	1.14	(0.045)
35.6	(14.0)	45.7	(18.0)	53.3	(21.0)	63.5	(25.0)				
45.7	(18.0)	Not limited		68.6	(27.0)	Not limited		1.35	(0.053)	1.42	(0.056)
50.8	(20.0)	63.5	(25.0)	73.7	(29.0)	91.4	(36.0)				
55.9	(22.0)	Not limited		83.8	(33.0)	Not limited		1.52	(0.060)	1.60	(0.063)
63.5	(25.0)	78.7	(31.0)	88.9	(35.0)	109.2	(43.0)				
63.5	(25.0)	Not limited		99.1	(39.0)	Not limited		1.70	(0.067)	1.78	(0.070)
73.7	(29.0)	91.4	(36.0)	104.1	(41.0)	129.5	(51.0)				
83.8	(33.0)	Not limited		129.5	(51.0)	Not limited		2.03	(0.080)	2.13	(0.084)
96.5	(38.0)	119.4	(47.0)	137.2	(54.0)	167.6	(66.0)				
106.7	(42.0)	Not limited		162.6	(64.0)	Not limited		2.36	(0.093)	2.46	(0.097)
119.4	(47.0)	149.9	(59.0)	172.7	(68.0)	213.4	(84.0)				
132.1	(52.0)	Not limited		203.2	(80.0)	Not limited		2.74	(0.108)	2.82	(0.111)
152.4	(60.0)	188.0	(74.0)	213.4	(84.0)	261.6	(103.0)				
160.0	(63.0)	Not limited		246.4	(97.0)	Not limited		3.12	(0.123)	3.20	(0.126)
185.4	(73.0)	228.6	(90.0)	261.6	(103.0)	322.6	(127.0)				

[a] See 7.1.3.3.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only of the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

Table 7.2
Thickness of Metal for Enclosures of Aluminum, Copper, or Brass

Without support frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum acceptable thickness	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
cm	(inches)	cm	(inches)	cm	(inches)	cm	(inches)	cm	(inches)
7.6	(3.0)	Not limited		17.8	(7.0)	Not limited		0.58	(0.023)
8.9	(3.5)	10.2	(4.0)	21.6	(8.5)	24.1	(9.5)		
10.2	(4.0)	Not limited		25.4	(10.0)	Not limited		0.74	(0.029)
12.7	(5.0)	15.2	(6.0)	26.7	(10.5)	34.3	(13.5)		
15.2	(6.0)	Not limited		35.6	(14.0)	Not limited		0.91	(0.036)
16.5	(6.5)	20.3	(8.0)	38.1	(15.0)	45.7	(18.0)		
20.3	(8.0)	Not limited		48.3	(19.0)	Not limited		1.14	(0.045)
24.1	(9.5)	29.2	(11.5)	53.3	(21.0)	63.5	(25.0)		
30.5	(12.0)	Not limited		71.1	(28.0)	Not limited		1.47	(0.058)
35.6	(14.0)	40.6	(16.0)	76.2	(30.0)	94.0	(37.0)		
45.7	(18.0)	Not limited		106.7	(42.0)	Not limited		1.91	(0.075)
50.8	(20.0)	63.4	(25.0)	114.3	(45.0)	139.7	(55.0)		
63.5	(25.0)	Not limited		152.4	(60.0)	Not limited		2.41	(0.095)
73.7	(29.0)	91.4	(36.0)	162.6	(64.0)	198.1	(78.0)		
94.0	(37.0)	Not limited		221.0	(87.0)	Not limited		3.10	(0.122)
106.7	(42.0)	134.6	(53.0)	236.2	(93.0)	289.6	(114.0)		
132.1	(52.0)	Not limited		312.4	(123.0)	Not limited		3.89	(0.153)
152.4	(60.0)	188.0	(74.0)	330.2	(130.0)	406.4	(160.0)		

[a] See 7.1.3.3.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have common supports and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

7.1.4 Nonmetallic

7.1.4.1 The enclosure shall comply with the applicable mechanical/electrical property considerations, flammability, moisture-absorptive properties and thermal requirements for fixed and stationary equipment as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: The enclosure of a Receptacle SPD shall comply with the enclosure requirements in the Standard for Attachment Plugs and Receptacles, UL 498.

Exception No. 2: The enclosure of a Circuit Breaker SPD shall comply with the enclosure requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception No. 3: The enclosure of a one-piece Molded Case SPD shall comply with the enclosure requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception No. 4: The enclosure of a Pullout SPD shall comply with the enclosure requirements in 33.2.

7.1.4.2 The enclosure shall comply with the Non-Metallic Enclosure Conduit Connection, Enclosure Impact, Crushing and Mold-Stress Relief Test requirements of Sections 61, 62, 63, and 64, respectively, of this Standard.

7.1.4.3 A part such as a dial or nameplate that is considered to be a part of the enclosure shall be of metal or other material as specified for the enclosure in 7.1.2.1 – 7.1.3.2.

7.1.4.4 A nonmetallic part such as a reset knob, lever , polymeric overlay, or button protruding through a hole in the enclosure shall be of a material classified as V-0, V-1, V-2 as determined by the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if the area of the hole is not greater than 650 mm^2 (1 in^2). Nonmetallic parts protruding through a hole, the area of which is greater than 650 mm^2 (1 in^2), shall be made of materials that comply with the requirements in 7.1.4.1.

Exception: An enclosure evaluated to the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, satisfies the requirements of 7.1.4.4.

7.1.5 Wiring openings

7.1.5.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be less than three or more than five threads in the metal. The construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal. In addition, there shall be a smooth, well-rounded inlet hole for the conductors that provides protection to the conductors equivalent to that provided by a standard conduit bushing, and the inlet hole shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

7.1.5.2 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging the conduit.

7.1.5.3 Clamps and fasteners for the attachment of raceways, such as conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, or service cable, that are supplied as a part of an enclosure shall comply with the requirements in the Standards for Metallic Outlet Boxes, UL 514A; Conduit, Tubing, and Cable Fittings, UL 514B; and Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

7.1.5.4 A knockout in a sheet-metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

7.1.5.5 A knockout shall be provided with a flat surrounding surface for proper seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in unacceptable spacing between uninsulated live parts and the bushing.

7.1.5.6 For an enclosure not provided with conduit openings, or knockouts, spacings not less than the minimum required in Spacings, Section 18 shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a full-scale drawing furnished with the device may be used to limit such a location.

7.1.5.7 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in 7.1.5.5 and 7.1.5.6, it is to be assumed that a bushing having the dimensions indicated in Table 7.3 is in place, and that a single locknut is installed on the outside of the enclosure.

Table 7.3
Dimensions of Bushings

Trade size of conduit, inches	Bushing dimensions, mm (inches)			
	Overall diameter		Height	
1/2	25.4	(1)	9.5	(3/8)
3/4	31.4	(1-15/64)	10.7	(27/64)
1	40.5	(1-19/32)	13.1	(33/64)
1-1/4	49.2	(1-15/16)	14.3	(9/16)
1-1/2	56.0	(2-13/64)	15.1	(19/32)
2	68.7	(2-45/64)	15.9	(5/8)
2-1/2	81.8	(3-7/32)	19.1	(3/4)
3	98.4	(3-7/8)	20.6	(13/16)
3-1/2	112.7	(4-7/16)	23.8	(15/16)

7.1.5.8 No wire other than wires leading to a part mounted on a door or cover shall be brought out through the door or cover.

7.2 Type 3 SPD cord-connected

7.2.1 General

7.2.1.1 The enclosure shall not have any openings or knockouts that may be used for permanent mounting or connection to a permanent wiring system.

7.2.1.2 An opening in an enclosure shall have such size and shape – or shall be so covered by screening or barrier or by an expanded, perforated, or louvered panel – that a test rod having a diameter of 1.6 mm (1/16 inch) shall be prevented from contacting uninsulated current-carrying parts. Accessibility shall be evaluated by performing the enclosure accessibility test in 67.1.

7.2.1.3 A keyhole slot, notch, or similar means for temporary mounting, if provided, shall be so located that the supporting screws or the like cannot damage any electrical insulation or reduce spacings to live parts.

7.2.1.4 A barrier that covers a mounting hole and thereby forms part of the required enclosure shall be subjected to the Mounting Hole Barrier Tests, Section 65.

7.2.1.5 An SPD intended for outdoor use shall comply with the applicable performance requirements for a Type 3R enclosure as specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

7.2.2 Metallic

7.2.2.1 A metal enclosure of a Type 3 SPD shall have a minimum thickness in accordance with Table 7.4.

Table 7.4
Minimum Acceptable Thicknesses of Enclosure Metal

Metal	At small, flat unreinforced surfaces and at surfaces of a shape or size to provide adequate mechanical strength		At relatively larger unreinforced flat surfaces	
	mm	(inch)	mm	(inch)
Die-cast metal	1.2	(3/64)	2.0	(5/64)
Cast malleable iron	1.6	(1/16)	2.4	(3/32)
Other cast metal	2.4	(3/32)	3.2	(1/8)
Uncoated sheet steel	0.66	(0.026)	0.66	(0.026)
Galvanized sheet steel	0.74	(0.029)	0.74	(0.029)
Nonferrous sheet metal	0.91	(0.036)	0.91	(0.036)

7.2.3 Nonmetallic

7.2.3.1 A nonmetallic enclosure shall comply with the applicable mechanical/electrical property considerations, flammability and thermal requirements for non-attended, non-intermittent duty portable equipment as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: A rack-mounted cord-connected Type 3 SPD intended for use in stationary equipment shall comply with the flammability requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for stationary equipment.

7.2.3.2 The enclosure shall comply with the Strain Relief, Enclosure Impact, Crushing, and Mold Stress-Relief Distortion Test requirements of Sections 57, 62, 63, and 64 respectively, of this Standard.

7.2.3.3 An SPD intended for outdoor use having a nonmetallic enclosure shall additionally comply with the Water Resistance and UV exposure requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.3 Type 3 SPD direct plug-in

7.3.1 General

7.3.1.1 The enclosure shall comply with the enclosure requirements in the Standard for Current Taps and Adapters, UL 498A, and with the requirements specified in 7.2.1.1, 7.2.3.1 and 7.2.3.2, as applicable.

Exception: The enclosure may have means for permanent attachment to a (duplex) receptacle rated 15A, 125V. When provided with means for permanent attachment, the SPD need not comply with requirements specified in 7.3.1.2 and 7.3.1.3 but shall comply with the Grounding Contact Test as specified in 16.11.

7.3.1.2 A unit shall:

a) Have a mass of 0.79 kg (28 ounces) or less; and

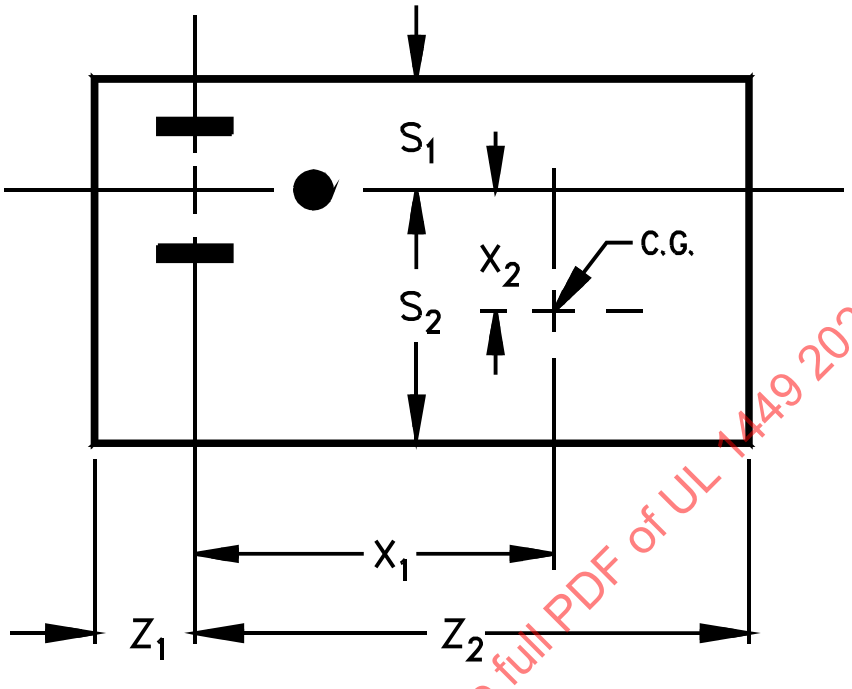
b) Comply with the specifications in Table 7.5.

Table 7.5
Specifications for Plug-In Products

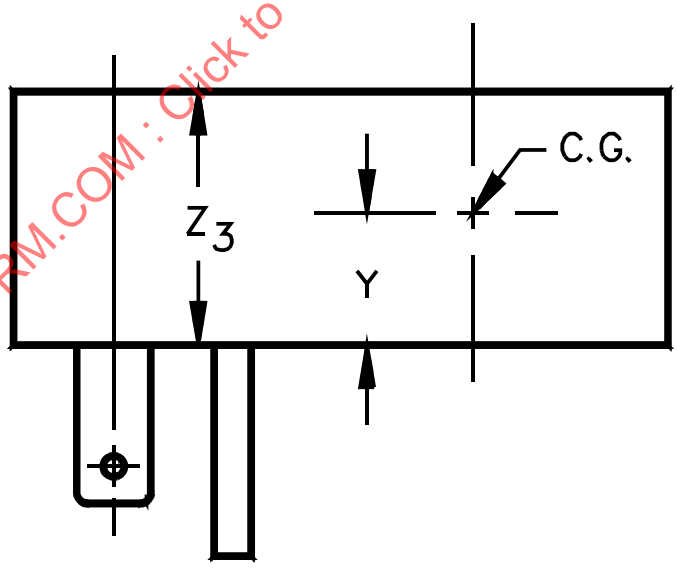
WY/Z ≤ 1.36 kg (48 ounces) WY/S ≤ 1.36 kg (48 ounces) WX ≤ 0.56 N·m (80 ounce-inches)
in which: *W is the weight in kg (ounces)* *Y is the distance, in mm (inches), illustrated in Figure 7.1* *Z is the shorter distance, in mm (inches), of Z_1 or Z_2 illustrated in Figure 7.1* *S is the shorter distance, in mm (inches), of S_1 or S_2 illustrated in Figure 7.1* *X is the longer distance, in mm (inches), of X_1 or X_2 illustrated in Figure 7.1*

Figure 7.1

Dimensions of a Plug-In Product



FRONT VIEW



SIDE VIEW

C.G. = Center of Gravity

7.3.1.3 When determining the moment and weight specified in 7.3.1.2, a mounting tab is not to be included in measurements of the linear dimensions for the purpose of determining moments unless:

a) The tab and enclosure withstand the Enclosure Impact Tests, Section 62, with one impact on the tab itself, without deformation; and

b) For a non-metallic unit having an integral tab, the tab and enclosure do not distort when subjected to the Mold Stress-Relief Distortion Test, Section 64.

7.3.1.4 When inserted in a parallel-blade duplex receptacle, any part of a unit shall not interfere with full insertion of an attachment plug into the adjacent receptacle.

Exception: A unit that renders the adjacent receptacle completely unusable is acceptable.

7.3.1.5 The enclosure of a unit shall be capable of being gripped for removal from the receptacle to which it is connected, and the perimeter of the face section from which the blades project shall not be less than 6.4 mm (1/4 inch) from any point on either blade.

7.4 Open-type SPDs

7.4.1 Any part of an open-type SPD intended to be installed through an opening in or as part of an enclosure shall comply with the Enclosure requirements for the SPD Type.

8 Protection Against Corrosion

8.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. This applies to all springs and other parts upon which proper mechanical operation may rely.

Exception No. 1: Parts such as bearings, thermal elements, if such protection is impracticable.

Exception No. 2: Small minor parts of iron or steel such as washers, screws, or bolts that are not current-carrying and are not in the equipment grounding conductor path, if corrosion of such unprotected parts is not likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 3: Parts made of stainless steel, properly polished or treated if necessary.

8.2 The requirements in 8.1 apply to all enclosing cases whether of sheet steel or cast iron, and to all springs and other parts upon which mechanical operation may depend.

9 Insulating Materials

9.1 General

9.1.1 A barrier or integral part, such as an insulating washer or bushing, and a base or support for the mounting of live parts, shall be of a moisture-resistant material that will not be damaged by the temperature and stresses to which it may be subjected under conditions of actual use.

9.1.2 An insulating material is to be investigated with respect to its acceptability for the application in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Materials, such as mica, ceramic, or some molded compounds are usually acceptable for use as the sole support of live parts. If it is necessary to investigate a material to determine its acceptability, consideration is to be given to such factors as its mechanical strength, resistance to ignition sources, dielectric strength, insulation resistance, and heat-resistant properties in both the aged and unaged

conditions, the degree to which it is enclosed, and any other features affecting the risk of fire and electric shock.

9.1.3 When required by 9.1.2, the Inclined-Plane Tracking Test, UL 746C, shall be conducted on the insulating material used in SPDs rated over 600V at the rated voltage of the SPD. For dc rated SPDs, the equivalent ac voltage may be used where $V_{ac} = V_{dc} / 1.414$.

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

9.2 Bushings

9.2.1 At a point where a cord or lead passes or is intended to pass through an opening in a wall, barrier, or enclosure case, there shall be a bushing or the equivalent that shall be secured in place and that shall have a smoothly rounded surface against which the lead or cord may bear.

9.2.2 If the cord hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smoothly rounded surface is considered to be the equivalent of an insulating bushing.

9.2.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings.

9.2.4 A fiber bushing shall not be less than 1.2 mm (3/64 inch) thick, and shall be so formed and secured in place so as not to be affected adversely by conditions of ordinary moisture. It shall be employed only where it is not subjected to a temperature higher than 90°C (194°F) under normal operating conditions.

9.2.5 If an insulated metal grommet is employed instead of an insulating bushing, the insulating material shall not be less than 0.8 mm (1/32 inch) thick and shall completely fill the space between the grommet and the metal in which it is mounted.

10 Current-Carrying Parts

10.1 A current-carrying part shall have mechanical strength, an ampacity acceptable for the service, and shall be of metal that is acceptable for the particular application.

10.2 Uninsulated live parts, including terminals, shall be so secured to their supporting surfaces – by methods other than friction between surfaces – so as not to turn or shift in position if such motion may result in reduction of spacings to less than those required elsewhere in this standard.

10.3 A lockwasher is generally acceptable at a terminal or connection stud.

11 Internal Wiring

11.1 Wire employed for the internal wiring of a device shall be acceptable for the particular application.

11.2 The internal wiring shall be rated for the voltage and temperature to which it may be subjected to under normal operating conditions.

11.3 18 AWG [0.82 mm^2 (0.04 inches)] rubber-covered wire when provided as part of a device shall be at least Type RFH-1 or equivalent, if a potential of 300 V or less is involved 18 and 16 AWG [0.82 and 1.3 mm^2 (0.04 and 0.05 inches)] wires shall be at least Type RFH-2 or equivalent, if a potential greater than 300 V is involved. A 14 AWG [2.1 mm^2 (0.06 inches)] or larger wire shall be Type T, RH or RHW or equivalent.