



# UL 1449

## **STANDARD FOR SAFETY**

### Surge Protective Devices

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UL Standard for Safety for Surge Protective Devices, UL 1449

Fourth Edition, Dated August 20, 2014

### **Summary of Topics**

***The Fourth Edition of the Standard for Safety for Surge Protective Devices, UL 1449, has been issued to reflect the latest ANSI approval date and to incorporate the proposals dated January 24, 2014 and May 30, 2014, which include the following:***

- ***Dielectric Voltage Test for varistors.***
- ***Component evaluations.***
- ***Clarification of requirements in 19.4.***
- ***Clarification of requirements for Direct Plug-in SPDs.***
- ***Dielectric Voltage Withstand Test - the use of lead shot.***
- ***Non-metallic enclosure and conduit connections.***
- ***Addition of requirements for USB circuitry and rechargeable batteries.***
- ***Addition of GDT Breakover Voltage Test.***
- ***Revision to Table 18.1 - Minimum Spacings.***
- ***Revisions to Figure 36.1 - Test Program Flow Charts.***
- ***Revision to the Impact Test.***
- ***Type 3 SPDs with IEC 320 receptacles.***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated January 24, 2014 and May 30, 2014.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

The following table lists the future effective dates with the corresponding reference.

| Future Effective Date | References                                                                       |
|-----------------------|----------------------------------------------------------------------------------|
| March 11, 2016        | 1.1, 3.7, Table 36.2, Section 41, Section 42, Section 69, Section 77, 79.2, 80.2 |
| December 30, 2017     | Supplement SA                                                                    |

AUGUST 20, 2014



ANSI/UL 1449-2014

1

UL 1449

## Standard for Surge Protective Devices

First Edition – August, 1985

Second Edition – August, 1996

Third Edition – September, 2006

### Fourth Edition

August 20, 2014

This ANSI/UL Standard for Safety consists of the Fourth Edition.

The most recent designation of ANSI/UL 1449 as an American National Standard (ANSI) occurred on August 20, 2014. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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

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## CONTENTS

## INTRODUCTION

|                              |    |
|------------------------------|----|
| 1 Scope .....                | 7  |
| 2 References .....           | 9  |
| 3 Glossary .....             | 9  |
| 4 Components .....           | 13 |
| 5 Units of Measurement ..... | 13 |

## CONSTRUCTION

|                                                                                                      |    |
|------------------------------------------------------------------------------------------------------|----|
| 6 General .....                                                                                      | 13 |
| 7 Enclosure .....                                                                                    | 14 |
| 7.1 Type 1 and Type 2 SPDs .....                                                                     | 14 |
| 7.2 Type 3 SPD Cord-Connected .....                                                                  | 19 |
| 7.3 Type 3 SPD Direct Plug-In .....                                                                  | 20 |
| 8 Protection Against Corrosion .....                                                                 | 23 |
| 9 Insulating Materials .....                                                                         | 24 |
| 9.1 General .....                                                                                    | 24 |
| 9.2 Bushings .....                                                                                   | 24 |
| 10 Current-Carrying Parts .....                                                                      | 25 |
| 11 Internal Wiring .....                                                                             | 25 |
| 12 Supplementary Protection .....                                                                    | 27 |
| 13 Accessibility of Live Parts .....                                                                 | 30 |
| 14 Supply Connections .....                                                                          | 30 |
| 14.1 Type 1 or Type 2 SPD .....                                                                      | 30 |
| 14.2 Type 3 SPD — Cord Connected .....                                                               | 33 |
| 14.3 Type 3 SPD — Direct Plug-In .....                                                               | 34 |
| 15 Mounting .....                                                                                    | 35 |
| 15.1 Type 1 or Type 2 SPD .....                                                                      | 35 |
| 15.2 Type 3 SPD — Cord Connected .....                                                               | 35 |
| 15.3 Type 3 SPD — Direct Plug-In .....                                                               | 36 |
| 16 Receptacles .....                                                                                 | 36 |
| 17 Grounding .....                                                                                   | 37 |
| 17.1 General .....                                                                                   | 37 |
| 17.2 Type 1 or Type 2 SPD .....                                                                      | 38 |
| 17.3 Type 3 SPD — Cord Connected .....                                                               | 39 |
| 17.4 Type 3 SPD — Direct Plug-In .....                                                               | 40 |
| 18 Spacings .....                                                                                    | 40 |
| 19 Clearance and Creepage Distances .....                                                            | 42 |
| 20 Switches .....                                                                                    | 44 |
| 21 Printed Wiring Boards .....                                                                       | 44 |
| 22 Electronic Circuits .....                                                                         | 45 |
| 23 Isolated Secondary Circuits .....                                                                 | 46 |
| 23.1 General .....                                                                                   | 46 |
| 23.2 Difference between the level of evaluation required within each type of secondary circuit ..... | 46 |
| 23.3 Class 2 circuit requirements .....                                                              | 48 |
| 23.4 Limited voltage/current circuit requirements .....                                              | 48 |
| 23.5 Limiting energy circuit requirements .....                                                      | 49 |
| 23.6 Limiting impedance circuit requirements .....                                                   | 50 |

|                                                                                                                    |    |
|--------------------------------------------------------------------------------------------------------------------|----|
| 24 Separation of Circuits .....                                                                                    | 51 |
| 25 Capacitors .....                                                                                                | 51 |
| 26 Electromagnetic Interference Filters .....                                                                      | 52 |
| 27 Protectors for Communication and Fire Alarm Circuits .....                                                      | 52 |
| 28 Antenna Connections for Audio-Video Products .....                                                              | 53 |
| 29 SPDs Intended for Use on Ungrounded Systems, Impedance Grounded Systems, or Corner Grounded Delta Systems ..... | 53 |
| 30 Uninterruptible Power Supply Equipment .....                                                                    | 53 |
| 31 SPD/Panelboard Extension Modules .....                                                                          | 53 |
| 32 Molded Case Surge Protective Devices .....                                                                      | 54 |
| 33 Interchangeability of Metal Oxide Varistors (MOVs) .....                                                        | 55 |
| 34 Supplementary Circuit .....                                                                                     | 56 |
| 35 Rechargeable Battery Pack .....                                                                                 | 56 |

## TEST PROGRAM

|                                                                                                      |     |
|------------------------------------------------------------------------------------------------------|-----|
| 36 General .....                                                                                     | 56  |
| 36.1 General .....                                                                                   | 56  |
| 36.2 Test environment and general sample discussion .....                                            | 57  |
| 37 Leakage Current Test – Type 3 SPDs Only .....                                                     | 63  |
| 38 Dielectric Voltage-Withstand Test .....                                                           | 68  |
| 38.1 Primary circuits .....                                                                          | 68  |
| 38.2 Isolated secondary circuits .....                                                               | 69  |
| 39 Temperature Test .....                                                                            | 69  |
| 40 Surge Testing .....                                                                               | 73  |
| 40.1 General .....                                                                                   | 73  |
| 40.2 Test equipment .....                                                                            | 74  |
| 40.3 Surge generator calibration .....                                                               | 79  |
| 40.4 Test procedure – Application and measurement points .....                                       | 82  |
| 40.5 Representative device - Sample preparation .....                                                | 84  |
| 40.6 Determination of voltage protection rating (VPR) .....                                          | 84  |
| 40.7 Nominal discharge current – For Type 1 and Type 2 SPDs and Type 1, 2 Component Assemblies ..... | 85  |
| 40.8 Operating duty cycle test – For Type 3 SPDs and Type 3 Component Assemblies ..                  | 86  |
| 40.9 Repeated voltage protection rating test .....                                                   | 86  |
| 41 Type 5 SPD Surge Testing .....                                                                    | 87  |
| 42 Type 4 Component Assemblies Surge Testing .....                                                   | 88  |
| 43 Operational Voltage Test .....                                                                    | 88  |
| 44 Current Testing .....                                                                             | 89  |
| 44.1 General .....                                                                                   | 89  |
| 44.2 Short circuit current rating test – For Type 1 and Type 2 SPDs .....                            | 92  |
| 44.3 Intermediate current test .....                                                                 | 95  |
| 44.4 Limited current abnormal overvoltage test .....                                                 | 96  |
| 45 Thermal Responsive Device Testing .....                                                           | 98  |
| 45.1 Temperature withstand .....                                                                     | 98  |
| 45.2 Repeat limited current test .....                                                               | 98  |
| 46 Thermal Responsive Device Testing .....                                                           | 98  |
| 47 Thermal Responsive Device Testing .....                                                           | 99  |
| 48 Grounding Continuity Test .....                                                                   | 101 |
| 49 Fault Current Test .....                                                                          | 101 |
| 50 Overcurrent Test .....                                                                            | 102 |
| 51 Withstand Test .....                                                                              | 103 |
| 52 Instrumentation and Calibration of High-Capacity Circuits .....                                   | 106 |

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|                                                             |     |
|-------------------------------------------------------------|-----|
| 52.1 General                                                | 106 |
| 52.2 Available current of 10,000 amperes or less            | 106 |
| 52.3 Available current more than 10,000 amperes             | 108 |
| 52.4 Instrumentation for test currents above 10,000 amperes | 110 |
| 53 Insulation Resistance Test                               | 112 |
| 54 Capacitor Endurance Test                                 | 112 |
| 55 Component Breakdown Test                                 | 113 |
| 56 Strain Relief Test                                       | 114 |
| 57 Push-Back Relief Test                                    | 115 |
| 58 Conductor Secureness Test                                | 115 |
| 59 Snap-On Cover Tests                                      | 116 |
| 60 Non-Metallic Enclosure Conduit Connection Tests          | 116 |
| 60.1 General                                                | 116 |
| 60.2 Pullout                                                | 117 |
| 60.3 Bending                                                | 117 |
| 60.4 Torque                                                 | 118 |
| 61 Enclosure Impact Tests                                   | 119 |
| 61.1 General                                                | 119 |
| 61.2 Drop impact test                                       | 119 |
| 61.3 Steel sphere impact test                               | 120 |
| 61.4 Low-temperature steel sphere impact test               | 123 |
| 62 Crushing Test                                            | 123 |
| 63 Mold Stress-Relief Distortion Test                       | 124 |
| 64 Mounting Hole Barrier Tests                              | 125 |
| 64.1 General                                                | 125 |
| 64.2 Mounting hole barrier impact test                      | 125 |
| 64.3 Mounting hole barrier probe test                       | 126 |
| 65 Adequacy of Mounting Test                                | 127 |
| 66 Accessibility Tests                                      | 129 |
| 66.1 Enclosure accessibility test                           | 129 |
| 66.2 Accessibility of live parts test                       | 129 |
| 67 Permanence of Cord Tag Test                              | 131 |
| 67.1 General                                                | 131 |
| 67.2 Conditioning                                           | 132 |
| 67.3 Test method                                            | 132 |
| 68 Capacitor Discharge                                      | 132 |
| 69 Metal Oxide Varistor Voltage                             | 134 |
| 70 Aging Test                                               | 134 |
| 71 Pullout Insertion and Withdrawal Test                    | 134 |
| 72 Capacitor Failure Test                                   | 134 |
| 73 Breakdown Voltage Measurement Test                       | 135 |

## MANUFACTURING AND PRODUCTION-LINE TESTS

|                                      |     |
|--------------------------------------|-----|
| 74 General                           | 135 |
| 75 Dielectric Voltage-Withstand Test | 135 |
| 76 Grounding Continuity Test         | 136 |
| 77 Nominal Varistor Voltage          | 137 |
| 78 Breakdown Voltage Measurement     | 137 |

## RATINGS

|            |     |
|------------|-----|
| 79 General | 137 |
|------------|-----|

**MARKINGS**

|                  |     |
|------------------|-----|
| 80 Details ..... | 138 |
|------------------|-----|

**INSTRUCTION MANUAL**

|                  |     |
|------------------|-----|
| 81 Details ..... | 144 |
|------------------|-----|

**SUPPLEMENT SA - PHOTOVOLTAIC (PV) SPDs**

|                                                                      |     |
|----------------------------------------------------------------------|-----|
| SA1 Scope .....                                                      | SA1 |
| SA2 Glossary .....                                                   | SA1 |
| SA3 Spacings .....                                                   | SA1 |
| SA4 Dielectric Voltage Withstand Test (Section 38) for PV SPDs ..... | SA1 |
| SA5 DC Voltage Test Source Requirements .....                        | SA2 |
| SA6 Voltage Protection Rating Test (Section 40.6) .....              | SA2 |
| SA7 Nominal Discharge Current (In) Test (Section 40.7) .....         | SA2 |
| SA8 Current Tests (Section 44) .....                                 | SA3 |
| SA9 Temperature Withstand Test (Section 45) .....                    | SA4 |
| SA10 Thermal Responsive Device Testing (Section 46) .....            | SA4 |
| SA11 PV SPD Leakage (Quiescent) Current (Iq) Test .....              | SA4 |
| SA12 Markings .....                                                  | SA4 |

**APPENDIX A**

|                               |    |
|-------------------------------|----|
| Standards for Components..... | A1 |
|-------------------------------|----|

**APPENDIX B**

## INTRODUCTION

### 1 Scope

1.1 These requirements cover 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 designated as follows:

Type 1 – Permanently connected SPDs 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 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 80.3. 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 44.4.

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.

1.1 effective March 11, 2016

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 44.1.

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 and direct plug-in SPDs intended for indoor use 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 26.

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 27.

1.8 These requirements cover SPDs employing antenna connections for audio-video products. See Section 28.

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 30.

1.10 These requirements cover SPDs/Panelboard Extension Modules. These products shall also comply with the Standard for Panelboards, UL 67. See Section 31.

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 Protection 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.

## 2 References

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.

## 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  $\mu$ s and a time to half-value of 50  $\mu$ s delivered across an open circuit.

3.3 8/20 CURRENT WAVE – Current surge with a virtual front time of 8  $\mu$ s and a time to half-value of 20  $\mu$ s 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 1.2/50 $\mu$ s voltage wave across an open circuit, and delivering an 8/20  $\mu$ s 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.

3.7 effective March 11, 2016

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

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

3.14 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.

3.15 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.

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

3.17 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.

3.18 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.

3.19 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).

3.20 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 3.32 – 3.34 for description of a Molded Case SPD of the "Pullout" configuration.

3.21 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.

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

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

3.24 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).

3.25 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.

3.26 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.

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

3.28 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.

3.29 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.

3.30 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.

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

3.32 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.

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

3.34 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.

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

3.36 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 1500 $\Omega$  resistor connected across the potential exceeds 0.5 mA.

3.37 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 8 A 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.

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

3.39 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.

3.40 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.

3.41 **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.

3.42 **SURGE PROTECTIVE DEVICE (SPD)** – A device composed of at least one non-linear component (see 3.49 and 3.50) 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.

3.43 **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.

3.44 **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.

3.45 **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.

3.46 **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.

3.47 **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.

3.48 **VOLTAGE PROTECTION RATING (VPR)** – A rating selected from a list of preferred values as given in Table 79.1 and assigned to each mode of protection. The value of VPR is determined as a higher value taken from Table 79.1 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.

3.49 **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.

3.50 **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 Appendix A 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 Appendix A, 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.

## 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 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 59.

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<sup>2</sup> (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<sup>2</sup> (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 Tables 7.1 and 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 Tables 7.1 and 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 Tables 7.1 and 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 enclosure 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 <sup>a</sup>        |        | With supporting frame or equivalent reinforcing <sup>a</sup> |  |                                           |         | Minimum acceptable thickness  |  |                         |                             |
|-------------------------------------------|--------|--------------------------------------------------------------|--|-------------------------------------------|---------|-------------------------------|--|-------------------------|-----------------------------|
| Maximum width <sup>b</sup><br>cm (inches) |        | Maximum length <sup>c</sup><br>cm (inches)                   |  | Maximum width <sup>b</sup><br>cm (inches) |         | Maximum length<br>cm (inches) |  | Uncoated<br>mm (inches) | Metal coated<br>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)                 |  |                         |                             |

<sup>a</sup> See 7.1.3.3.

<sup>b</sup> 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.

<sup>c</sup> 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.

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**Table 7.2**  
**Thickness of metal for enclosures of aluminum, copper, or brass**

| Without support frame <sup>a</sup> |          |                             |          | With supporting frame or equivalent reinforcing <sup>a</sup> |          |                |          | Minimum acceptable thickness |         |
|------------------------------------|----------|-----------------------------|----------|--------------------------------------------------------------|----------|----------------|----------|------------------------------|---------|
| Maximum width <sup>b</sup>         |          | Maximum length <sup>c</sup> |          | Maximum width <sup>b</sup>                                   |          | Maximum length |          |                              |         |
| 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)  |                              |         |

<sup>a</sup> See 7.1.3.3.

<sup>b</sup> 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.

<sup>c</sup> 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, 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, UL 489.*

*Exception No. 4: The enclosure of a Pullout SPD shall comply with the enclosure requirements in paragraph 32.2.*

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 60, 61, 62, and 63, 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 the area of a 22.2 mm (7/8 inch) diameter circle. Nonmetallic parts protruding through a hole, the area of which is greater than the area of a 22.2 mm (7/8 inch) diameter circle, shall be made of materials that comply with the requirements in 7.1.4.1.

*Exception: An enclosure evaluated to the Standard 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,<br>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 maximum 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 66.1.

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 64.

## 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.

7.2.3.2 The enclosure shall comply with the Strain Relief, Enclosure Impact, Crushing, and Mold Stress-Relief Distortion Test requirements of Sections 56, 61, 62, and 63 respectively, of this Standard.

## 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.*

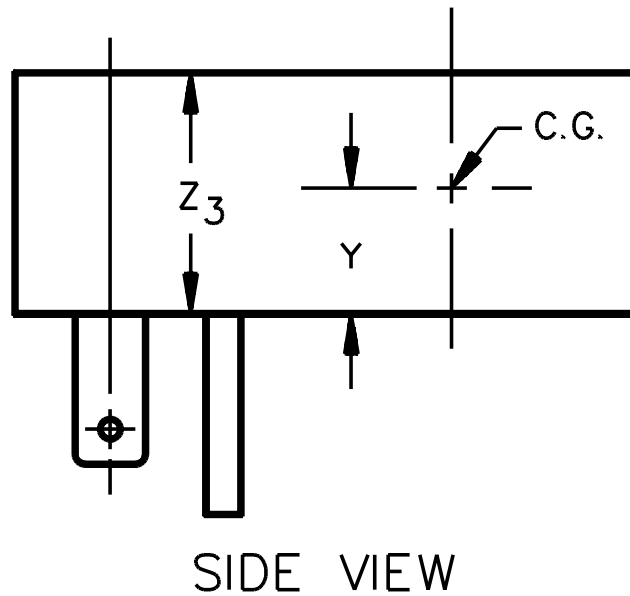
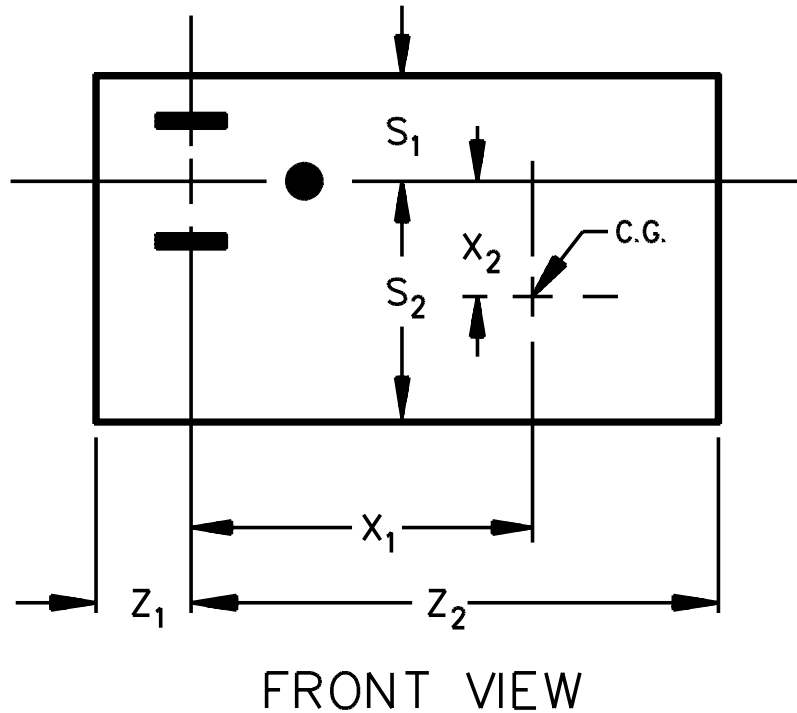
7.3.1.2 A unit shall:

- 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**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $WY/Z \leq 1.36 \text{ kg (48 ounces)}$<br>$WY/S \leq 1.36 \text{ kg (48 ounces)}$<br>$WX \leq 0.56 \text{ N}\cdot\text{m (80 ounce-inches)}$                                                                                                                                                                                                                                                                                                                                                                                   |
| <p><i>in which:</i></p> <p><i>W is the weight in kg (ounces)</i></p> <p><i>Y is the distance, in mm (inches), illustrated in Figure 7.1</i></p> <p><i>Z is the shorter distance, in mm (inches), of <math>Z_1</math> or <math>Z_2</math> illustrated in Figure 7.1</i></p> <p><i>S is the shorter distance, in mm (inches), of <math>S_1</math> or <math>S_2</math> illustrated in Figure 7.1</i></p> <p><i>X is the longer distance, in mm (inches), of <math>X_1</math> or <math>X_2</math> illustrated in Figure 7.1</i></p> |

Figure 7.1  
Dimensions of a plug-in product



C.G. = Center of Gravity

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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 61, 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 63.

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.

## 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 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<sup>2</sup> (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<sup>2</sup> (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<sup>2</sup> (0.06 inches)] or larger wire shall be Type T, RH or RHW or equivalent.

11.4 For a Type 1 or Type 2 SPD, line and ground connecting conductors shall not be smaller than 14 AWG (2.1 mm<sup>2</sup>) copper or 12 AWG (3.3 mm<sup>2</sup>) aluminum.

11.5 If the use of a short length of insulated conductor – such as a short coil lead – is not practical, electrical insulating tubing may be used on each conductor. The tubing is not to be subjected to sharp bends, tension, compression, or repeated flexing or to contact with sharp edges, projections, or corners. The wall thickness shall comply with the individual requirements for the tubing.

11.6 Extruded insulating tubing shall be rated for temperature and voltage application and shall comply with the requirements in the Standard for Extruded Insulating Tubing, UL 224.

11.7 The internal wiring and electrical connections between parts of a device shall be protected or enclosed.

11.8 Wires within an enclosure, compartment, raceway, or the like shall be so positioned or protected that contact with any rough, sharp, or movable part is prevented.

11.9 A screw provided for use in mounting the device to an outlet box or other enclosures shall not project more than 22.2 mm (7/8 inch) beyond the strap or cover and shall have flat or blunt ends. The end of the screw may have thread-cleaning slots or grooves but shall not have any burrs, fins, or other sharp edges that could damage wiring.

11.10 Screw threads, including those of sheet metal screws, shall not be exposed for more than 4.76 mm (3/16 inch) inside a compartment containing wiring and shall be so located that contact with conductor insulation is unlikely.

11.11 Suitably insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the product.

11.12 A bare conductor or a conductor utilizing noncarbonizable beads for insulation shall not be employed outside of an enclosure device. A bare conductor, if used within an enclosure, shall be so supported that the spacings required elsewhere in this Standard will be maintained. If necessary, a force of 10 N (2.25 lbf) shall be applied to any point on internal parts in an endeavor to reduce the spacing while taking measurements.

11.13 All splices and connections shall be mechanically secure and shall make reliable electrical contact. Solder connections shall be made mechanically secure prior to soldering. A lead is considered to be mechanically secure if it is:

- a) Wrapped at least halfway (180 degrees) around a terminal;
- b) Provided with at least one right angle bend when passed through an eyelet or opening; or
- c) Twisted with other conductors.

*Exception: Wiring through openings on printed wiring boards need not be mechanically secure before soldering.*

11.14 A splice shall be provided with insulation equivalent to that of the wires involved if the required spacing between the splice and other metal parts is not permanently maintained.

11.15 In determining whether splice insulation consisting of coated-fabric, thermoplastic, or another type of tape or tubing is acceptable, consideration is to be given to such factors as mechanical strength, dielectric properties, heating and moisture-resistant characteristics, and the like.

11.16 Where stranded wiring is connected to a wire-binding screw, the construction shall be such that any loose strand of wire is prevented from contacting live parts of opposite polarity or dead metal parts that may be grounded. This can be accomplished by use of upturned lugs on the terminal plate, pressure terminal connectors, soldering lugs, crimped eyelets, or equivalent means.

11.17 Soldered stranded (bunch tinned/solder dipped/tinned bonded) wire shall not be used with the terminals of a receptacle unless the receptacle has been investigated for such use.

11.18 The internal wiring of a cord-connected two-port SPD shall be at least of the same gauge (AWG) as the power-supply cord.

*Exception No. 1: Non-load current-carrying conductors need not be of the same gauge as the power-supply cord.*

*Exception No. 2: Smaller AWG conductors may be used if:*

- a) Supplementary overcurrent protection is provided; and

*b) The results of the Temperature Test (Section 39), the Fault Current Test (Section 49) for grounding-path conductors only, and the Overcurrent Test (Section 50) are acceptable using the smaller AWG size.*

11.19 The internal wiring of a direct plug-in two-port SPD shall be at least of the same gauge (AWG) as the branch-circuit conductors on which the device is intended to be installed.

*Exception No. 1: Non-load current-carrying conductors need not be of the same gauge as the branch circuit conductors.*

*Exception No. 2: Smaller AWG conductors may be used if:*

*a) Supplementary overcurrent protection is provided; and*

*b) The results of the Temperature Test (Section 39), the Fault Current Test (Section 49) for grounding-path conductors only, and the Overcurrent Test (Section 50) are acceptable using the smaller AWG size.*

*Exception No. 3: A direct plug-in two-port SPD rated 15 A or less may employ 14 AWG internal wiring.*

## 12 Supplementary Protection

12.1 Supplementary overcurrent or overtemperature protection, if provided in SPDs, shall be readily replaceable or resettable.

*Exception: The supplementary protection need not be readily replaceable or resettable if, when it opens, the entire SPD is intended to be replaced and the supplementary protection is inaccessible to the user by the use of ordinary tools (such as slotted or phillips type screwdrivers, pliers, etc.), or the unit is otherwise sealed.*

12.2 All supplementary overcurrent protection devices shall be capable of clearing a fault current of not less than that indicated in Table 12.1. A supplementary overcurrent protection device, in series with the load, shall also comply with UL 1077, including overload testing in UL 1077 for motor starting at 6 times the AC full load current.

*Exception No. 1: A fuse that is capable of clearing a fault current of not less than that indicated in Table 12.1 and complies with the requirements in the Standard for Low-Voltage Fuses – Part 14: Supplemental Fuses, UL 248-14, is able to be used as a supplementary protection device.*

*Exception No. 2: A circuit breaker or fuse that complies with 12.12 is able to be used as a supplementary protector.*

**Table 12.1**  
**Available fault current<sup>a</sup>**

| Permanently connected devices <sup>b</sup> |                                               | Cord connected or direct plug-in devices <sup>b</sup> |                             |                                  |
|--------------------------------------------|-----------------------------------------------|-------------------------------------------------------|-----------------------------|----------------------------------|
| Rating, A                                  | Available fault current, amperes <sup>c</sup> | Rating volts                                          | Rating, volts times amperes | Available fault current, amperes |
| 100 A or less                              | 5,000                                         | 250 ac or less                                        | 1175 or less                | 200                              |
| 101 – 400 A                                | 10,000                                        |                                                       | 1176 to 1920                | 1000                             |
| Over 400 A                                 | 25,000                                        |                                                       | 1921 to 4080                | 2000                             |
|                                            |                                               |                                                       | 4081 to 9600                | 3500                             |
|                                            |                                               |                                                       | More than 9600              | 5000                             |
|                                            |                                               | More than 250 ac                                      | 1920 or less                | 1000                             |
|                                            |                                               |                                                       | More than 1920              | 5000                             |

<sup>a</sup> Available fault current either at the point of application of the SPD or equal to or greater than the rating of the panel in which it is installed.”

<sup>b</sup> For one-port SPD, the rating shall be based on the ampere rating of the circuit that the SPD is intended to be connected to, in accordance with the manufacturer's instructions. See 79.1.

<sup>c</sup> Higher fault current ratings, as detailed in Table 80.2 are able to be used.

12.3 A thermal-Link device provided in a Type 1, 2, 3 SPD or Type 1, 2, 3 Component Assembly and not connected in series with the load, shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

*Exception No. 1: For a one port Type 1, 2 SPD or Type 1, 2 Component assembly compliance with 45 satisfies this requirement.*

*Exception No. 2: For a Type 3 SPD or Type 3 Component Assembly compliance with 46 satisfies this requirement where the temperature of the thermal link does not exceed 40°C.*

12.4 A thermal-Link device provided in a Type 3 SPD or Type 3 Component Assembly and connected in series with the load, shall be capable of clearing a fault current of not less than that indicated in Table 12.1 and shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. The thermal link shall have a general purpose rating.

*Exception: Compliance with 47 satisfies the second part of this requirement.*

12.5 A thermal responsive device, provided as part of the SPD, in a one port Type 1 or Type 2 SPD, or a Type 1, 2 Component Assembly, and not connected in series with the load, shall comply with the requirements in Section 45.

12.6 A thermal responsive device or a thermal link, provided as part of an SPD, in a two port Type 2 SPD or a Type 2 Component Assembly where the thermal responsive device is in series with the load, shall comply with the requirements in 46. The thermal responsive devices shall also be capable of clearing a fault current of not less than that indicated in Table 12.1.

*Exception: If the thermal disconnect is not in series with the load and does not exceed 40°C during normal operation it shall comply with 45.*

12.7 A thermal responsive device provided in a Type 3 SPD or a Type 3 Component Assembly that's in series with the load shall comply with the requirements in 47 and shall also be capable of clearing a fault current of not less than that indicated in Table 12.1.

12.8 A thermal responsive device provided in a Type 3 SPD or a Type 3 Component Assembly that's not in series with the load where the temperature does not exceed 40°C shall comply with the requirements in 46.

12.9 An MOV provided with an integral thermal responsive device or thermal link, intended to be connected in series with the load, shall comply with the requirements in 47, and shall also be capable of clearing a fault current of not less than that indicated in Table 12.1.

12.10 An MOV provided with an integral thermal responsive device or thermal link, not intended to be connected in series with the load, shall comply with the requirements in 46.

12.11 A thermal responsive device or a thermal link provided in a Type 4 Component Assembly shall comply with the requirements specified in 12.9 or 12.10 as appropriate.

12.12 A circuit breaker or fuse, provided in series with the load in a permanently connected two-port SPD, shall be suitably rated, capable of clearing a fault current of not less than that indicated in Table 12.1 and acceptable for branch-circuit protection in accordance with the National Electrical Code, ANSI/NFPA-70 – for example, circuit breakers or Class CC, J, T, G, H, K, L, RK1 or RK5 cartridge fuses or Type S or Edison-base plug fuses are acceptable for the application. Other types of overcurrent protection devices are to be investigated to determine their acceptability for the application.

12.13 An SPD that is provided with fuses that are intended to be replaced in the field shall be marked in accordance with 80.7.

12.14 Fuses that are intended to be replaced in the field in a permanently connected SPD shall be either installed in an extractor type fuse holder or located behind a hinged cover as indicated in 7.1.1.6.

12.15 A supplementary protection device shall not be connected as to interrupt the equipment grounding conductor path.

12.16 A supplementary protection device shall not open during the Temperature Test, Section 39 or the Surge Testing, Section 40.

12.17 A cord-connected SPD with four or more receptacle outlets shall be provided with supplementary overcurrent protection as specified in the Standard for Relocatable Power Taps, UL 1363.

12.18 A single-pole supplementary protection device shall be connected in the ungrounded (line) conductor of the supply circuit, only. A double-pole device shall be connected on both the ungrounded and grounded (neutral) conductors such that when it operates, it opens both ungrounded and grounded conductors.

### 13 Accessibility of Live Parts

13.1 The electrical parts of a SPD that do not require use of a tool to access, shall be so located or enclosed that persons are protected against inadvertent contact with uninsulated current-carrying parts and film-coated magnet wire and accessibility shall be evaluated by performing the accessibility of live parts test in 66.2.

*Exception: The exposed terminals of Receptacle Type and Molded Case SPDs, that are intended to be enclosed after installation, need not comply with the accessibility of live parts.*

### 14 Supply Connections

#### 14.1 Type 1 or Type 2 SPD

##### 14.1.1 General

14.1.1.1 Supply connections are considered to be those that are made in the field when a device is installed.

14.1.1.2 An outlet box, terminal box, wiring compartment, or the like in which connections to the power-supply circuit are to be made in the field shall be free from sharp edges, including screw threads, burrs, fins, moving parts, or the like, that can damage the insulation on a conductor.

14.1.1.3 An SPD shall be provided with factory-installed wiring terminals or leads for connection to the power supply.

14.1.1.4 A terminal box or compartment on a fixed device shall be so located that wire connections therein will be accessible for inspection, without disturbing the wiring, after the device is installed in the intended manner.

*Exception No. 1: Wire connections to a device intended to be mounted on an outlet box may be accessible upon removal of the device from the outlet box.*

*Exception No. 2: An electrical component, such as a switch, fuseholder, overcurrent protective device, or the like, may be mounted on a wiring compartment cover provided that:*

- a) A component connecting leads are of sufficient length to provide for the making, and examination, of field-wiring connections without placing additional stress on the component wiring terminals;*
- b) Any of the component connections are not to be field wired;*
- c) Strain relief is provided to prevent stress from being transmitted to the component wiring terminations, and comply with the Strain Relief Test, Section 56;*
- d) The minimum size of the component leads is 18 AWG (0.82 mm<sup>2</sup>); and*
- e) Wiring terminals on the component are recessed or protected by barriers of insulating material or the equivalent that will provide protection from contact with wiring installed in the box.*

14.1.1.5 An SPD provided with integral pigtail leads intended for connection in the field to a power supply circuit conductor shall be provided with a conduit connection means that is acceptable in accordance with the National Electrical Code, ANSI/NFPA-70.

14.1.1.6 For one port SPD Types 1 and 2, the pigtail lead shall not be smaller than 14 AWG (2.1 mm<sup>2</sup>) copper or 12 AWG (3.3 mm<sup>2</sup>) aluminium.

*Exception: SPD Types 1, 2 and 4 Component Assemblies with integral pigtail leads intended to be connected to a power supply circuit conductor shall not be smaller than 18 AWG (0.82 mm<sup>2</sup>) and shall not be shorter than 152 mm (6 inches), when measured from the point of exit from the conduit connector. Insulation on such a lead shall be:*

- a) At least 0.8 mm (1/32 inch) thick thermoplastic; or*
- b) At least 0.4 mm (1/64 inch) thick rubber plus a braid cover for 300 V or less applications; or*
- c) At least 0.8 mm (1/32 inch) thick rubber plus a braid cover for applications between 301 and 600 V.*

14.1.1.7 A pigtail lead, described in 14.1.1.5 shall comply with the Conductor Secureness Test, Section 58.

14.1.1.8 A permanently-connected SPD shall have a field-wiring terminal, wiring lead, conduit fitting, a knockout or other opening in the enclosure and wire bending space, for the connection of a wiring system in accordance with the National Electrical Code, ANSI/NFPA-70 and acceptable for the purpose.

*Exception: An enclosure need not have provision for the connection of a wiring system, such as a conduit hub, a knockout or a fitting, if it is intended to be drilled or punched in the field to accommodate a wiring system and is provided with appropriate installation instructions.*

14.1.1.9 An SPD that is acceptable for use with a fitting for only one type of wiring system shall be supplied with such a fitting. Installation instructions shall be provided if use of the fitting is not explicit.

14.1.1.10 If a lead intended for field connection to the supply circuit terminates at an accessible terminal screw, the terminal screw shall be staked, soldered, or otherwise rendered non-removable.

#### 14.1.2 Terminals

14.1.2.1 Terminal parts to which supply connections are to be made shall be acceptable for connection of conductors to ensure a thoroughly good connection without damaging the conductors. Some examples are pressure connectors (including set-screw type), solder lugs, or splices to flexible leads.

14.1.2.2 Pressure wire connectors or solder lugs shall be used.

*Exception: For a 10 AWG (5.3 mm<sup>2</sup>) or smaller wire, the parts to which wiring connections are to be made may consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.*

14.1.2.3 A wire-binding screw employed at a wiring terminal shall not be smaller than No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for the connection of a 14 AWG (2.2 mm<sup>2</sup>) conductor.

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

14.1.2.5 A wire-binding screw shall thread into metal.

14.1.2.6 A field-wiring terminal intended for the connection of a grounded conductor shall be substantially white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided instead of terminals, the surface of the grounded conductor shall be finished to show white or grey color and shall be easily distinguishable from the other leads.

14.1.2.7 In order to polarize the wiring of a permanently-wired device intended to be connected to a supply circuit rated at 125 V or 125/250 V or less, and employing an overcurrent-protective device other than an automatic control, one terminal or lead shall be identified for the connection of the grounded conductor of the supply circuit. See 14.1.2.6 for identification requirements. The grounded conductor or a terminal identified for this use shall be the one to which no overcurrent-protective devices of the single-pole type is connected.

## 14.2 Type 3 SPD — Cord Connected

### 14.2.1 General

14.2.1.1 A metal strain-relief clamp or band without auxiliary protection is acceptable with a Type SJ, SJO, SJT, SJTO, SO, ST, STO, or equivalent cord. A metal strain-relief clamp or band is acceptable with a Type SP-3, SPT-3 or equivalent cord only if acceptable auxiliary mechanical protection that is not electrically conductive is provided over the cord.

14.2.1.2 The flexible cord shall be Type S, SO, ST, SJ, STO, SJO, SJT, SJTO or shall be a type at least as serviceable for the particular application.

*Exception: SPT-3 or SP-3 may be used on an SPD rated 15 A, or less, if marked in accordance with 80.15.*

14.2.1.3 A cord set shall comply with the Standard for Cord Sets and Power-Supply Cords, UL 817.

14.2.1.4 The supply cord shall have a voltage rating not less than the rated voltage of the SPD, and shall have an ampacity not less than the current rating of the SPD. The power-supply cord of a cord-connected SPD must also comply with the power-supply cord gauge requirements in the Standard for Relocatable Power Taps, UL 1363.

*Exception: An SPD employing one or two receptacles is not prohibited from having a smaller ampacity supply cord when the cord ampacity complies with the:*

- a) Table for Allowable Ampacity for Flexible Cords and Cables in the National Electrical Code;*
- b) Temperature Test, Section 39;*
- c) Fault Current Test, Section 49; and*
- d) Overcurrent Test, Section 50.*

14.2.1.5 The length of a supply cord measured from the outside surface of the enclosure of a SPD to the plane of the face of the attachment plug shall not be less than 0.45 m (1.5 ft) or be more than 7.6 m (25 ft.).

*Exception: SPDs with only one or two receptacles are not required to comply with the minimum supply cord length.*

14.2.1.6 For an SPD employing an outlet cord as described in 16.1, the total length of the outlet cord including the receptacle shall not be more than 1.8 m (6 ft). The total length of a supply cord, measured from inlet to outlet including the body of the SPD, shall not be more than 7.6 m (25 feet).

14.2.1.7 A detachable power-supply cord shall not be used.

*Exception: An SPD with one or two receptacles is able to employ a detachable power-supply cord when rated 12 amperes or less.*

14.2.1.8 If the attachment plug is other than the non-polarity type, one of the circuit conductors in the flexible cord shall be identified for connection of the grounded supply conductor if the SPD is rated at 125 V or less or at 125/250 V or less (3 wires).

14.2.1.9 An attachment plug shall have a current rating not less than the rated current of the SPD, and a voltage rating consistent with the voltage rating of the SPD. An attachment plug shall comply with the applicable requirements in the Standard for Attachment Plugs and Receptacles, UL 498 and in accordance with Wiring Devices - Dimensional Specifications, ANSI/NEMA WD6.

14.2.1.10 An SPD that employs one or two receptacles is able to be provided with an IEC 320 attachment plug. An IEC 320 attachment plug shall comply with the applicable requirements in the Standard for Attachment Plugs and Receptacles, UL 498.

14.2.1.11 An SPD that employs one or two receptacles is able to be provided with a cord set with an IEC 320 attachment plug. The cord set shall comply with the Standard for Cord Sets and Power-Supply Cords, UL 817.

#### 14.2.2 Strain relief

14.2.2.1 Strain relief shall be provided so that a mechanical stress on a supply cord is not transmitted to terminals, splices, or interior wiring.

14.2.2.2 Means shall be provided so that the supply cord cannot be pushed into the SPD through the cord-entry hole if such displacement is likely to subject the cord to mechanical damage or expose it to a temperature higher than that for which the cord is rated or if such displacement is likely to reduce spacings, such as to a metal strain-relief clamp, below the minimum acceptable values.

14.2.2.3 The strain-relief means shall comply with the Strain Relief and Push-Back Relief Test requirements, Sections 56 and 57.

14.2.2.4 A knot shall not be employed to provide strain relief.

#### 14.3 Type 3 SPD — Direct Plug-In

14.3.1 An SPD provided with blades for direct plug-in at a receptacle shall comply with applicable requirements in the Standard for Current Taps and Adapters, UL 498A.

14.3.2 An attachment plug shall have a current rating not less than the rated current of the SPD, and a voltage rating consistent with the voltage rating of the SPD. An attachment plug shall comply with the applicable requirements in the Standard for Attachment Plugs and Receptacles, UL 498 and in accordance with Wiring Devices - Dimensional Specifications, ANSI/NEMA WD6.

14.3.3 An SPD provided with two sets of line blades shall be constructed so that no electrical connection exists between the two sets of line blades associated with each outlet of the duplex receptacle.

## 15 Mounting

### 15.1 Type 1 or Type 2 SPD

15.1.1 Provisions shall be made for securely mounting an SPD to a supporting surface. A bolt, screw, or other part used to mount a component integral to the SPD shall not be used for securing the SPD to the supporting surface.

### 15.2 Type 3 SPD — Cord Connected

15.2.1 Cord-connected SPD shall not have means for permanent mounting.

15.2.2 Cord-connected SPDs may be provided with a means for temporary mounting. A tool shall not be required for dismounting.

15.2.3 A means for temporary mounting shall provide for secure positioning that requires a positive, deliberate action by the user to dismount it.

15.2.4 A keyhole slot, notch, or similar means for temporary mounting, shall be located so that the screw head, nail head, hook, or other supporting device is not accessible for further securing of the SPD once it is mounted.

*Exception: A temporary mounting means that does not comply with the above requirement may be acceptable if investigated for the purpose.*

15.2.5 If a temporary mounting means is provided, installation instructions shall be furnished with the product. If the mounting means requires special hardware, the hardware shall be provided with the product.

*Exception: Installation instructions need not be furnished if it is determined that the mounting means is obvious.*

15.2.6 The temporary mounting means shall comply with the construction requirements in 7.2.3, the Mounting Hole Barrier Test, Section 64, and the Adequacy of Mounting Test, Section 65.

### 15.3 Type 3 SPD — Direct Plug-In

15.3.1 Direct plug-in SPDs shall not have a means for permanent mounting except as specified in the Exception to 7.3.1 for the mounting tab defined in 7.3.1.1.

15.3.2 A mounting tab shall not be provided with a unit unless all of the following conditions are met:

- a) The unit is intended for use on a 15 A, 125 V receptacle;
- b) A screw is provided and constructed so as to secure the mounting tab of the unit to a standard parallel-blade duplex receptacle cover-mounting screw;
- c) For a unit without a grounding pin, the mounting tab is constructed so that the unit may be mounted to both grounding and nongrounding receptacles; and
- d) Marking as specified in 80.13 is provided.

### 16 Receptacles

16.1 The receptacle outlets shall comply with the applicable requirements in the Standard for Attachment Plugs and Receptacles, UL 498 and in accordance with Wiring Devices - Dimensional Specifications, ANSI/NEMA WD6.

16.2 An SPD employing one or two receptacles is able to employ a maximum of two IEC 320 receptacles. The IEC 320 receptacles shall comply with the applicable requirements in the Standard for Attachment Plugs and Receptacles, UL 498.

16.3 An SPD is able to employ only one receptacle outlet at the end of a single cord set. The cord set shall comply with the requirements in the Standard for Cord Sets and Power-Supply Cords, UL 817. One or two cords may be provided.

16.4 A receptacle provided as part of an SPD shall be rated not more than the current rating of the SPD per 79.1 and a voltage rating consistent with the voltage rating of the SPD.

16.5 The receptacle outlets of cord-connected SPDs employing three or more receptacles shall have a current rating of 15 or 20 A and a voltage rating of 125 or 250 V.

16.6 The receptacle outlets of direct plug-in SPD shall comply with applicable requirements in the Standard for Current Taps and Adapters, UL 498A.

16.7 The contact components of a receptacle shall have a voltage and current rating equal to that of the attachment plug.

*Exception: A 15 A receptacle may be used with an SPD rated 20 A with a 20 A attachment plug.*

16.8 A receptacle shall be of the grounding type if, and only if, the SPD is provided with a grounding-type attachment plug or other means for grounding. See Grounding, Section 17.

*Exception: All of the receptacle outlets of cord-connected SPDs employing three or more receptacles shall be of the grounding type.*

16.9 Receptacles may be of the same or different slot configurations (locking and non-locking).

16.10 The output receptacle(s) of a direct plug-in SPD shall be integral with the device (not cord-connected).

16.11 Each receptacle outlet provided in an SPD with mounting means or intended for use in a fixed application, having the 5-15 or 5-20 configuration specified in Wiring Devices - Dimensional Specifications, ANSI/NEMA WD6, shall comply with the Grounding Contact Test requirements specified in the Standard for Attachment Plugs and Receptacles, UL 498.

## 17 Grounding

### 17.1 General

17.1.1 SPDs shall be provided with a means for grounding all exposed dead metal parts that might become energized.

17.1.2 The equipment grounding termination shall be connected by a clamp, bolt, screw, braze, weld or an equivalent positive means that cannot be loosened from the outside and may include a corrosion resistant strap or jumper. Mechanical connections shall be secured. A solder connection may be used if the grounding lead is mechanically secure to the enclosure in accordance with 11.13. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel.

17.1.3 The grounding continuity between the grounding pin, blade, or terminal and the accessible dead metal parts of the SPD that might become energized is to comply with the Grounding Continuity Test, Section 48.

17.1.4 An equipment-grounding conductor shall be of copper, copper alloy, or other material that has been investigated for use as an electrical conductor. A ferrous metal part in the grounding path shall be protected against corrosion.

17.1.5 Metal parts in a bonding path shall be galvanically compatible so as to reduce electrolytic action between dissimilar metals.

17.1.6 A bonding member shall:

- a) Be protected from mechanical damage;
- b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is not likely to be omitted after removal or replacement of the fastener; and
- c) Have the flexibility needed to withstand mechanical stress.

17.1.7 If a bonding means depends on screw thread, two or more screws shall be employed, or at least two full threads of a single screw shall engage metal.

17.1.8 A receptacle provided as part of an SPD shall have its grounding contact, if provided, conductively connected to the grounding means. See 16.8.

17.1.9 Connections in the grounding conductor path from the receptacle grounding contact to the grounding conductor shall be welded, bolted, mechanically secured and soldered, or made by equivalent positive means. A quick connect, or similar friction fit connector shall not be used in the grounding conductor path.

17.1.10 If a receptacle used is provided with a grounding screw, the grounding screw shall be used to provide the ground connection to the receptacle. The yoke or faceplate mounting screws of the receptacle shall not be used to provide or maintain the grounding means of the receptacle or enclosure of an SPD.

*Exception: The yoke mounting screw of a Self-Grounding Receptacle (a receptacle which includes a spring clip or other part to provide for electrical continuity between the grounded device yoke and the yoke mounting screw) is able to be used to provide or maintain the grounding means of the receptacle or enclosure of an SPD. This Exception is applicable when the yoke mounting screw of a permanently-connected SPD is not able to be loosened from the outside, the mounting screw penetrates nonconductive coatings, such as paint and vitreous enamel, and the SPD complies with the Fault Current Test, Section 49, and the Overcurrent Test, Section 50.*

17.1.11 A copper-base-alloy rivet that is used to secure parts in the grounding path, or that forms a part of the grounding path, shall contain not less than 80 percent copper.

17.1.12 The internal grounding wiring shall be at least of the same gauge (AWG) as the ungrounded wire.

*Exception: Smaller wire may be used if the results of the Fault Current Test, Section 49 and the Overcurrent Test, Section 50, are acceptable using the smaller AWG size.*

17.1.13 An SPD that has an equipment grounding conductor path through traces on a printed wiring board shall comply with the Fault Current Test, Section 49, and Overcurrent Test, Section 50.

## 17.2 Type 1 or Type 2 SPD

17.2.1 A wire-binding screw intended for the connection of a grounding conductor shall have a green-colored head that is hexagonal shaped, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G," "GR," "GND," "Ground," "Grounding," or the like; or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during normal servicing of the unit.

17.2.2 A terminal for connection of a grounding conductor shall be capable of securing a conductor of the size acceptable for the particular application, in accordance with the National Electrical Code, ANSI/NFPA 70, and shall be constructed as specified in 14.1.2.1 – 14.1.2.4.

17.2.3 A grounding terminal for 10 AWG (5.3 mm<sup>2</sup>) or smaller wire may consist of a threaded stud welded to the enclosure or equivalent. Such terminal shall be of acceptable material – for example, plated if of steel; and shall also comply with 17.2.1, 17.2.2 and 14.1.2.1 – 14.1.2.4.

17.2.4 A solder lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector, shall not be used for the grounding terminal.

17.2.5 A lead intended for the connection of a grounding conductor shall not be smaller than 14 AWG (2.1 mm<sup>2</sup>) and sized in accordance with the National Electrical Code, ANSI/NFPA-70. The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead visible to the installer in the field in a field-wiring-terminal compartment shall be so identified.

17.2.6 A hinge on a metal enclosure shall not be relied upon as a suitable grounding connection for the cover. The cover shall be provided with a separate bonding conductor, sized in accordance with 17.2.5, connected from the grounding terminal to the cover.

### 17.3 Type 3 SPD — Cord Connected

17.3.1 The grounding conductor of a flexible cord of a cord-connected SPD, that is required to be grounded, shall be conductively connected to a metallic enclosure or frame and to the ground terminal(s) of the output receptacle(s) of the SPD.

*Exception No. 1: Dead metal parts that are isolated from grounded metal and are not a part of the enclosure need not be connected to the grounding conductor of the power-supply cord.*

*Exception No. 2: A small metal part, such as an adhesive-attached foil label, a screw, or the like, that is on the exterior of the enclosure and separated from all electrical components by grounded metal or is electrically isolated from all components need not be connected to the grounding conductor of the power-supply cord.*

17.3.2 The grounding conductor in a power-supply cord shall be green with or without one or more yellow stripes and of at least the same size as the current-carrying conductors. No other lead in the power-supply cord shall be so identified.

17.3.3 The grounding conductor shall be welded, bolted, mechanically secured and soldered, or connected by other equivalent positive means to a metallic frame or enclosure such that it is not likely to be removed during ordinary servicing not involving the power-supply cord.

17.3.4 The grounding conductor shall be connected to the grounding blade or equivalent fixed contacting member of an attachment plug.

17.3.5 A cord-connected SPD (having a 125/250 V rating) shall not use the neutral circuit conductor as the grounding conductor.

17.3.6 The line and neutral conductor path shall not be connected to the grounding circuit conductor path.

*Exception: Connections between the line or neutral circuit conductor path and the grounding conductor path are able to be made when the components are investigated for the application (such as certain capacitors permitted as detailed in Section 25 - Capacitors).*

## 17.4 Type 3 SPD — Direct Plug-In

17.4.1 A direct plug-in SPD required to be grounded shall be provided with a grounding pin as one of the attachment-plug contacts conductively connected to a metallic enclosure or frame and to the ground terminal(s) of the output receptacle(s) of the SPD.

*Exception No. 1: Dead metal parts that are isolated from grounded metal and are not a part of the enclosure need not be connected to the grounding conductor of the power-supply cord.*

*Exception No. 2: A small metal part, such as an adhesive-attached foil label, a screw, or the like, that is on the exterior of the enclosure and separated from all electrical components by grounded metal or is electrically isolated from all components need not be connected to the grounding conductor of the power-supply cord.*

## 18 Spacings

18.1 The spacings in an SPD shall not be less than those indicated in Table 18.1.

*Exception No. 1: Greater spacings may be required if the enclosure, because of its size, shape, or the material used, is not considered to be sufficiently rigid to warrant the minimum spacings.*

*Exception No. 2: As an alternative to Table 18.1, lesser spacings may be acceptable when determined in accordance with the requirements for Clearance and Creepage Distances, Section 19.*

*Exception No. 3: The acceptability of the inherent spacings of a component shall be based on the requirements for the component.*

*Exception No. 4: Circuits that comply with the requirements for Isolated Secondary Circuits, Section 23 need not be evaluated for spacings. The spacing between these circuits and other circuits shall comply with Table 18.1.*

**Table 18.1**  
**Minimum spacings**

|             |                                        | Spacings, in mm (inches)                                                                                                                                                                                                       |                                                                                                                                          |                   |
|-------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
|             |                                        | Between any uninsulated live part and an uninsulated live part of opposite polarity, and uninsulated grounded dead metal part other than the enclosure, or exposed dead metal part that is isolated (insulated) <sup>e,f</sup> | Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable <sup>b,c,e,f</sup> |                   |
| Product     | Potential involved in volts-RMS (peak) | Through air or oil                                                                                                                                                                                                             | Over surface                                                                                                                             | Shortest distance |
| Type 3 SPDs | 0 – 50 (70.7 or less)                  | 1.2 (3/64)                                                                                                                                                                                                                     | 1.2 (3/64)                                                                                                                               | 1.2 (3/64)        |
|             | 51 – 125 over 70.7 – 176.8)            | 1.6 (1/16)                                                                                                                                                                                                                     | 1.6 (1/16)                                                                                                                               | 6.4 (1/4)         |
|             | 126 – 250 (over 176.8 – 353.5)         | 2.4 (3/32)                                                                                                                                                                                                                     | 2.4 (3/32)                                                                                                                               | 6.4 (1/4)         |
|             | 251 – 600 (over 353.5 – 848.4)         | 9/5 <sup>d</sup> (3/8) <sup>d</sup>                                                                                                                                                                                            | 12.7 <sup>d</sup> (1/2) <sup>d</sup>                                                                                                     | 12.7 (1/2)        |

Table 18.1 Continued

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        | Spacings, in mm (inches)                                                                                                                                                                                                       |                                                                                                                                          |                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        | Between any uninsulated live part and an uninsulated live part of opposite polarity, and uninsulated grounded dead metal part other than the enclosure, or exposed dead metal part that is isolated (insulated) <sup>e,f</sup> | Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable <sup>b,c,e,f</sup> |                   |
| Product                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Potential involved in volts-RMS (peak) | Through air or oil                                                                                                                                                                                                             | Over surface                                                                                                                             | Shortest distance |
| Type 1 or Type 2 SPDs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0 – 150 (212.1 or less)                | 3.2 <sup>a</sup> (1/8) <sup>a</sup>                                                                                                                                                                                            | 6.4 (1/4)                                                                                                                                | 12.7 (1/2)        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 151 – 300 (over 212.1 – 424.3)         | 6.4 (1/4)                                                                                                                                                                                                                      | 9.5 (3/8)                                                                                                                                | 12.7 (1/2)        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 301 – 600 (over 424.3 – 848.5)         | 9.5 (3/8)                                                                                                                                                                                                                      | 12.7 (1/2)                                                                                                                               | 12.7 (1/2)        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 601 – 1000 (849.9 – 1414.2)            | 14 (.55)                                                                                                                                                                                                                       | 21.6 (.85)                                                                                                                               | 25.4 (1)          |
| <p><sup>a</sup> The spacing between field wiring terminals of opposite polarity and between a wiring terminal and a grounded or exposed dead metal part shall not be less than 6.4 mm (1/4 inch) if short circuiting or grounding of such terminals may result from projecting strands of wire.</p> <p><sup>b</sup> For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce the spacing between the metal piece and uninsulated live parts.</p> <p><sup>c</sup> The spacing to a metal enclosure does not apply to the housing or frame of a device intended for installation with an end product enclosure.</p> <p><sup>d</sup> These spacings apply to the sum of the spacings involved whenever an isolated dead metal part is interposed.</p> <p><sup>e</sup> Reduced spacings in accordance with Section 19 may be acceptable on a printed wiring board provided with a conformal coating that complies with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E; and are judged based on the tests performed.</p> <p><sup>f</sup> A printed wiring board intended to be completely encapsulated in an acceptable potting compound or epoxy shall not have any spacing less than 0.8 mm (1/32 inch).</p> |                                        |                                                                                                                                                                                                                                |                                                                                                                                          |                   |

18.2 The spacing at wiring terminals is to be measured with wires representative of field wiring in place and connected to the terminals as in actual service.

18.3 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirement in 18.5, and shall be investigated on the basis of the highest voltage involved.

18.4 For the purposes of these requirements any uninsulated live part that is completely encapsulated in an acceptable potting compound or epoxy shall be considered insulated for the purpose of accessibility of live parts.

18.5 A live screw head or nut on the underside of an insulating base shall be prevented from loosening and shall be insulated or spaced from the mounting surface. This may be accomplished by:

- a) Countersinking such parts not less than 3.2 mm (1/8 inch) in the clear and then covering them with a waterproof, insulating sealing compound that does not soften at a temperature 15°C (27°F) higher than its normal operating temperature in the device, and not less than 65°C (149°F) in any case, or

- b) Securing such parts and insulating them from the mounting surface by means of a barrier or the equivalent, or by means of through-air or over-surface spacings as required by Table 18.1.

18.6 In multicomponent equipment, the spacings from one component to another, from any component to the enclosure, or to other uninsulated dead metal parts excluding the component mounting surface, are based on the maximum voltage rating of the complete equipment and not on the individual component ratings. The inherent spacings within an individual component are investigated on the basis of the voltage used and controlled by the individual component. Spacings between metal oxide varistors, capacitors, and other components shall comply with the minimum spacing requirements in Table 18.1.

*Exception: Components that comply with the requirements in the Standard for Fixed Capacitors for Use in Electronic Equipment, UL 60384-14, need not comply with the minimum spacing requirements between components in Table 18.1.*

18.7 Spacings at a fuse and fuseholder are to be measured with a fuse in place that has the maximum standard dimensions for the rating, and such spacings are to not be less than those specified in Table 18.1.

18.8 A barrier or liner of insulating material used in areas where spacings are otherwise insufficient, shall comply with the requirements for internal barriers outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, it shall be resistant to moisture absorption, and shall be secured in place or its position fixed by space limitations. An adhesive used to position a barrier shall be investigated for the effects of temperature, humidity, and cyclic conditions outlined in the Standard for Polymeric Materials – Use in Electrical Equipment, Evaluations, UL 746C.

## 19 Clearance and Creepage Distances

19.1 As an alternative approach to the spacing requirements specified in 18.1, and other than as noted in 19.2 and 19.3, clearances and creepage distances are able to be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 19.4.

19.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in Table 18.1. The clearances shall be determined by physical measurement.

19.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 18.

*Exception: If the design of the field wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field wiring terminal may be evaluated in accordance with the Standard for Insulation Coordination including Clearances and Creepage Distances for Electrical Equipment, UL 840.*

19.4 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

- a) Unless specified elsewhere in this standard, the pollution degree within an SPD housing, based on the presence of contaminants and possibility of condensation or moisture, shall be pollution degree 2 – Normal.

b) SPD intended for specific macro- environments, attainable within the SPD by the use of specific conditions or housings may alternatively be tested to one of the following macro-environments:

- 1) Pollution Degree 1 – No pollution or only dry, nonconductive pollution. The pollution has no influence.
- 2) Pollution Degree 2 – Normal nonconductive pollution. However, a temporary conductivity caused by condensation may be expected.
- 3) Pollution Degree 3 – Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected.
- 4) Pollution Degree 4 – Pollution that generates persistent conductivity through conductive dust or rain and snow.

c) The macro-environment within which this SPD may be installed to achieve the required pollution degree, shall be identified by installation instructions provided with the SPD, Means to obtain such an environment if not inherent to the SPD housing itself shall be provided.

d) SPD intended for installation as or with service entrance equipment shall be evaluated as Overvoltage Category III. Other SPD covered under this standard shall be evaluated as Overvoltage Category II;

e) Pollution degree 2 exists on a printed wiring board between adjacent conductive material which is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

f) Any printed wiring board which complies with the requirements in the Standard for Printed Wiring Boards, UL 796, shall be considered to provide a Comparative Tracking Index (CTI) of 100, and if it further complies with the requirements for Direct Support in UL 796 then it provides a CTI of 175;

g) For the purposes of compliance with the requirements for coatings of printed wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, complies with the requirements;

h) Pollution degree 1 is also achievable at a specific printed wiring board location by application of at least a 0.79 mm (1/32 inch) thick layer of silicone rubber or for a group of printed wiring boards through potting, without air bubbles, in epoxy or potting material.

i) Evaluation of clearances, only, to determine equivalence with current through air spacings requirements are able to be conducted in accordance with the requirements for Clearance A (Equivalency) of UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as would be required for the Dielectric Voltage-Withstand Test, Section 38;

j) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), and Creepage Distances;

k) The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product if no isolating transformer is provided. The System Voltage used in the evaluation of secondary circuitry is able to be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance; and

l) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements for Measurement of Clearance and Creepage Distances of UL 840.

## 20 Switches

20.1 Each switch shall have voltage and current ratings of not less than the load it is intended to control.

20.2 A switch provided in an SPD shall comply with the requirements in the Standard for Special-Use Switches, UL 1054 or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1. The switch shall have as a minimum a general use rating.

*Exception: A switch that complies with the requirements of the Standard for General-Use Snap Switches, UL 20, for a general-use ac switch shall be acceptable for use in an SPD.*

20.3 A switch shall open all ungrounded circuit conductors, and may, in addition, open the grounded circuit conductor.

20.4 Each switch shall indicate to the user when its associated circuit is energized. Such indication shall be by a means such as an integral pilot light, a separate pilot light adjacent to the switch, an on-off marking, or other readily understood visible indication of whether or not the switch is "on" or "off". See 80.17.

*Exception: An SPD may be provided with indicator or pilot lights such as neon-series-resistor, LED type, or the like, to show which receptacles are live or to indicate that the unit is energized.*

## 21 Printed Wiring Boards

21.1 A printed-circuit board shall comply with all requirements, including those for direct support and shall be marked with the triangle symbol as described in the Standard for Printed-Wiring Boards, UL 796. A printed-circuit board shall also be classed V-0, V-1, or V-2 and rated minimum 105°C (221°F) in accordance with the requirements for the tests for flammability of plastic materials for parts in devices and appliances, UL 94. For a material classed V-2 a closed bottom in the equipment beneath the material or barrier evaluated for the use shall be provided.

21.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-circuit board to form a printed-circuit assembly shall be secured so that it cannot be displaced to cause a risk of electric shock or fire by a force likely to be exerted on it during assembly, operation, or servicing of the SPD.

Note: Consideration is to be given to a barrier or a partition that is part of the device and that provides mechanical protection and electrical insulation of a component connected to the printed-circuit board.