

ANSI /UL 1449 Third Edition Safety Standard *(New UL and NEC standards means new performance levels, test procedures and markings to SPD products and manufacturers)*

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The past two years have seen many changes in codes and standards of surge protective devices (SPDs). The specific standards are from Underwriters Laboratories (UL), and the National Fire Protection Association (NFPA). The changes in the two standards are widespread, but they primarily affect the application of the SPD, not the performance or safety of the devices.

Underwriters Laboratories

Underwriters Laboratories (UL) *Standard for Safety, Transient Voltage Surge Suppressors* (UL 1449) has undergone a number of changes and will continue to drive application changes throughout the industry. This includes a change in nomenclature from transient voltage surge suppressors (TVSS) to surge protective devices (SPDs) and recognition of the standard by the American National Standard Institute (ANSI) [1]. The adoption of the third edition of UL 1449 also affects performance testing methodologies, SPD ratings, and the appropriate application of SPDs.

As with previous changes of the UL standard, there are no grandfather clauses and all SPDs must be retested, recertified and compliant by September 2009 [1]. Unlike the introduction of UL 1449 second edition and subsequent amendments, the latest changes do not dramatically affect the product safety of an SPD, but are intended to clarify performance testing, SPD ratings, and applications of an SPD.

Location Types

Previous versions of UL 1449 only identified two types” of SPDs: permanently connected or cord-connected. Permanently connected SPDs can be applied to many locations: service entrance, distribution panels, or end-use equipment. Permanently connected SPDs are installed by electricians or technicians. Cord-connected SPDs could be located anywhere within a facility as long as there was an outlet. Cord-connected SPDs can be applied 10 meter from service entrance at locations close to the service entrance, branch panel locations, or end-use equipment through standard electrical outlets. In addition to UL 1449, another class of SPDs, denoted as surge arresters and classified by UL as OWHX, were tested to an outdated revision of an IEEE standard.

The third edition of UL 1449 has combined all categories of SPDs into a formalized classification for use in specific applications. The types identified are Type 1, Type 2, Type 3, and Type 4 [1]. Each type can consist of permanently connected or cord-connected SPDs, but each type has consistent testing and application requirements.

Type 1 SPDs were formally denoted as *Secondary Surge Arresters* (SSA) and are intended to be installed between the secondary side of the service transformer and the primary side of the service entrance disconnect (Figure 1). SPDs intended for application in a Type 1 location are required to have overcurrent protective devices either installed internally to the SPD, or are included with the Type 1 SPD. While Type 1 SPDs are primarily intended for installation before the main service disconnect, Type 1 SPDs can be installed in Type 2 and Type 4 locations: distribution panels, end-use equipment, etc.

Type 2 SPDs are intended to be connected on the secondary side of the main service disconnect (Figure 1) [1]. While some Type 2 SPDs will have internal overcurrent protective components, Type 2 SPDs **can** rely on the service entrance overcurrent disconnect device for overcurrent protection. Type 2 SPDs can be installed in service equipment, distribution panels, end-use equipment. Type 2 SPDs are permanently connected.

Type 3 SPDs are intended to be connected to at least 10 meters (33 feet) from the service entrance; this does not include the length of the SPD conductors [1]. Based on the definition of a Type 3 SPD, these devices are cord-connected devices, and are intended to be used in end-equipment locations. Type 3 SPDs **can** rely on external overcurrent protective devices for overcurrent protection. Type 3 SPDs that are cord-connected are required to comply with leakage current requirements to ensure unwanted (objectional) currents are not injected on the ground conductor.

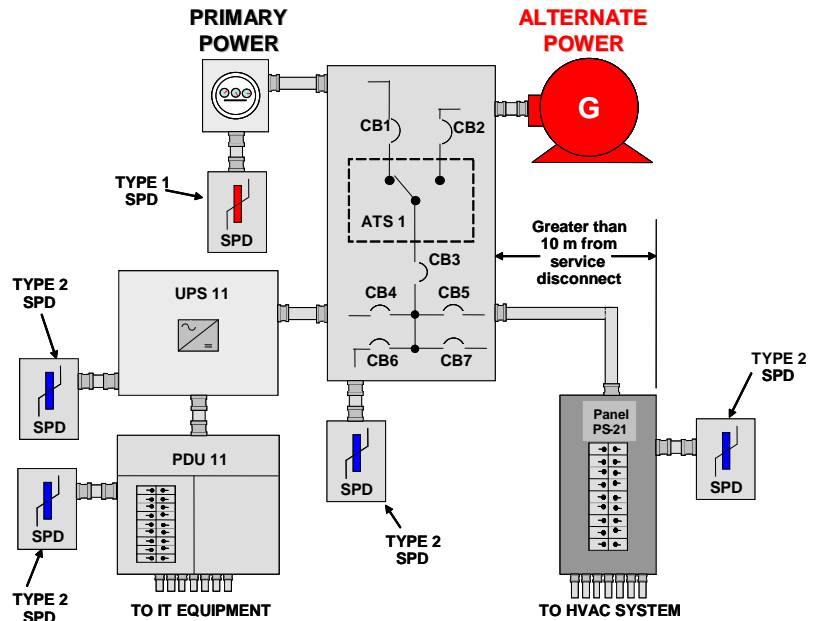
Type 4 SPDs are component or assembly devices [1]. Type 4 SPDs are incomplete in their construction, or the safety testing (e.g. limited-current abnormal overvoltage test, intermediate current test, etc) and are intended to be tested in the final assembly. Type 4 SPDs that are incomplete in construction or testing has the identifying information denoted in the requirements section of the manufacturer's UL report. Unfortunately, there is no documentation of the additional testing requirements for a Type 4 SPD on the labeling or installation instructions. Type 4 component SPDs range from single components (MOVs, SADs) to complex devices intended for installation into distribution equipment (panelboards, switchboards, etc).

Voltage Protection Rating

One of the primary ratings of an SPD has been the surge voltage rating (SVR), which has been used to determine the protection an SPD can provide. This SVR has changed from the first edition of UL 1449 to the second edition of UL 1449. To avoid confusion of the SVR in the marketplace, the third edition of UL 1449 has changed the nomenclature and testing of the protection rating of an SPD.

SPDs tested in accordance to the third edition of UL 1449 will now be marked with a voltage protection rating (VPR). All SPDs will be tested on three samples of all declared modes of the SPD to the Institute of Electrical and Electronic (IEEE) combination wave at rated voltage [1]. The IEEE combination wave consists of an open circuit voltage and a short circuit current. The amplitude of the open circuit voltage of the 1.2/50 μ s waveform is 6 kV, and the amplitude of the 8/20 μ s short circuit current is 3 kA [2]. All measurements for parallel SPDs are achieved by measuring the let-through voltage of the SPD at a distance of 150 mm (6 inches) from the exit of the conductors from the enclosure [1].

**FIGURE 1
SPD LOCATIONS BY UL 1449 TYPES**



**TABLE 1
SPD VOLTAGE PROTECTION RATING (VPR)**

330
400
500
600
700
800
900
1000
1200
1500
1800
2000
2500
3000
4000
5000
6000

Once the SPD has completed the voltage protection testing, it must undergo the nominal discharge current test. If the SPD successfully completes the test sequence, the per mode average of the let-through voltages measured are compared to a predetermined list of values (Table 1). The voltage protection rating (VPR) of the SPD is the value that is greater than the measured averages. The VPR is part of the UL marking requirements and is marked on the SPD.

Nominal Discharge Current

The nominal discharge current is a new part of the testing regime and was adopted from the IEC standards for SPDs, with some differences [3]. The nominal discharge current test is part of the voltage protection rating test, and is a measure of the SPDs endurance capability. The nominal discharge current uses the 8/20 μ s current waveform, which has a rise time from ten to ninety percent (t_r) of 8 μ s, and a time from initialization to the fifty percent decay point (t_d) of 20 μ s (Figure 2) [4].

SPD manufacturers designate the amplitude of the nominal discharge current that the SPD is to be tested to. The nominal discharge current test is only applicable to Type 1 and Type 2 SPDs. The nominal discharge current for Type 1 SPDs is 10 kA or 20 kA [2]. For Type 2 SPDs, the nominal discharge currents are 3 kA, 5 kA, 10 kA, or 20 kA [2].

The test methodology consists of Three(3) groups of Five(5) impulses for a total of fifteen (15) impulses. At the completion of each applied impulse, the maximum continuous operating voltage (MCOV) shall be applied within 1 sec to the SPD for 1 minute. After each group of tests, the SPD can rest for up to thirty minutes. At the completion of the nominal discharge current test, the SPD is subjected to the maximum continuous operating voltage (MCOV) and for verification of the voltage protection rating. The maximum continuous operating voltage (MCOV) is applied for fifteen minutes. The voltage protection rating is verified by applying the IEEE combination wave to the SPD and measuring the let-through voltage.

The value of the nominal discharge current obtained through testing is required to be marked on the data label of the product. This is identified by the abbreviation I_N .

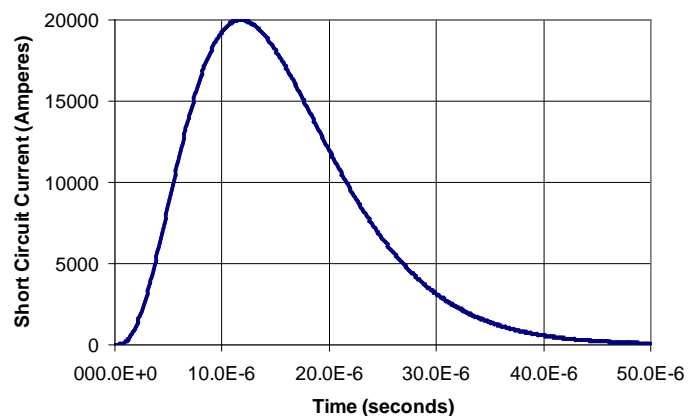
National Electric Code

The *Occupational Safety & Health Administration* (OSHA), an organization under the Department of Labor, is the department within the US federal government responsible for workplace safety. One aspect of workplace safety is the safe use and application of electricity and electrical equipment. Workplace safety is achieved through a partnership between OSHA and the individual States. The States are responsible for determining standards that will ensure workplace safety. Each State determines what standards and revisions are appropriate, and the timeline for reviewing such standards. In some States, the responsibility for the adoption of workplace safety has been delegated to local municipalities.

For electrical safety, all States and Municipalities have adopted the *National Electric Code*, which is developed by the National Fire Protection Association (NFPA). The revision cycle of the *National Electric Code* occurs every three years (e.g. 2002, 2005, 2008, etc.). However, not all States and Municipalities have adopted the same version of the *National Electric Code* (Figure 3).

States such as Massachusetts, North Carolina, Arkansas, Ohio, New Mexico, Colorado, Wyoming, Idaho, Montana and Oregon has adopted the 2008 revision of the *National Electric Code*. Tennessee remains the only state to utilize the 2002 revision of the *National Electric Code*. States such as Nevada, Arizona, Texas, Oklahoma, Illinois, Maryland, and Iowa have delegated standards responsibility to the local level. The remaining states still utilize the 2005 revision of the *National Electric Code*.

FIGURE 2
20 kA 8/20 μ s NOMINAL DISCHARGE CURRENT



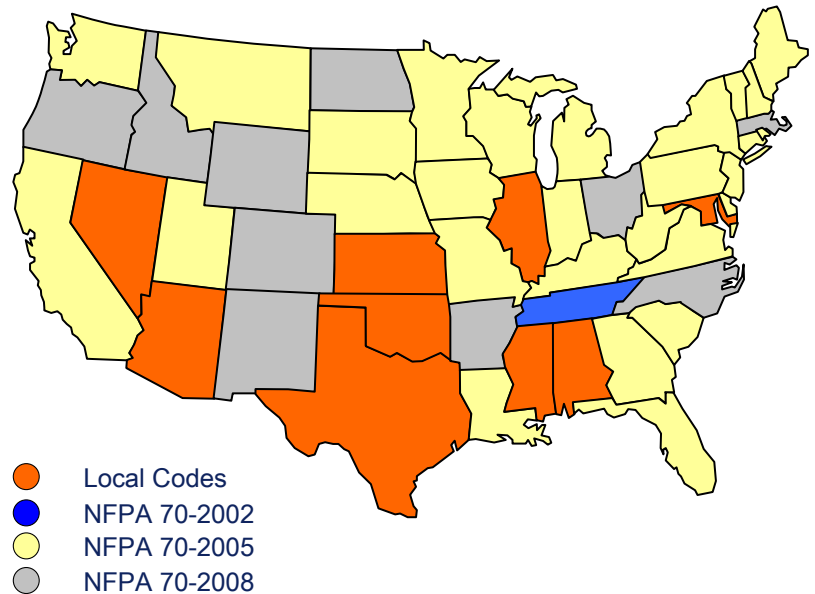
The 2005 revision of the *National Electric Code* had two types of SPDs: secondary surge arresters (SSAs), transient voltage surge suppressors (TVSSs). The application requirements of SSAs were detailed in Article 280, whereas the application requirements of TVSSs were detailed in Article 285. The requirements for both SSA and TVSS devices rated for use on systems of 1,000 volts or less were nearly identical. However, the testing methodologies utilized by Underwriters Laboratories were not.

Article 285

The adoption of the *Standard for Safety, Surge Protective Devices* by UL and American National Standards Institute (ANSI) required changes to the *National Electric Code*. Unlike many changes to the *National Electric Code*, which requires changes to product safety standards, the product safety standard is necessitating the change to the *National Electric Code*. The two sections of the *National Electric Code* associated with SPDs are Article 280 and Article 285. Article 280 of the 2008 revision of the *National Electric Code* is for surge arresters over 1,000 volts.

Article 285 in the 2008 revision of the *National Electric Code* provides the requirements for connecting all surge protective devices (SPDs) rated 1,000 volts or less to the electrical distribution system of a facility. The location of SPDs ranges from the secondary terminals of the service transformer to end-use equipment.

**FIGURE 3
ADOPTION OF NATIONAL ELECTRIC CODE IN UNITED STATES**



The changes between the 2005 and the 2008 revision of Article 285 of the *National Electric Code* are minor. Items that are the same between the two revisions are:

- Article 285.3 – SPDs shall not be used on ungrounded, impedance grounded, or corner grounded systems unless approved for use,
- Article 285.4 – Where used, SPDs shall be connected to each ungrounded conductor,
- Article 285.5 – SPDs shall be Listed,
- Article 285.6 – SPDs shall be marked with a short circuit current rating (SCCR), and shall not be installed at a point on the system where the available fault current exceeds the SCCR of the SPD,
- Article 285.11 – SPDs can be connected indoors or outdoors, and shall be inaccessible to unqualified persons,
- Article 285.12 – Conductors used to connect the SPD to the system shall be as short as possible,
- Article 285.26 – Conductors used to connect the SPD to the system shall be greater than 14 AWG copper, or 12 AWG aluminum, and
- Article 285.27 – SPDs shall be permitted to be connected between any two conductors of the system: grounded, ungrounded, or grounding conductors. Connection of the grounded and grounding conductors shall only be interconnected during a surge

Changes or additions to the 2008 revision of the *National Electric Code* are associated with the three types and their applicable locations of use, as defined by the *Standard for Safety, Surge Protective Devices*.

Article 285.23 identifies the applicable installation locations for a Type 1 SPD. Type 1 SPDs are permitted to be installed on the supply side or the line side of the service disconnect. When Type 1 SPDs are installed on the supply side of the service disconnect, the grounding conductor of the SPD shall be connected to either the grounded service conductor, the grounding electrode conductor, the grounding electrode for the service, or the grounding terminal in the service equipment.

Article 285.24 identifies the application requirements and installation locations for a Type 2 SPD. Type 2 SPDs are permitted to be installed only on the load side of the service disconnect overcurrent device. In installations with multiple buildings or structures, a Type 2 SPD can only be installed downstream of the first overcurrent device. Similarly, on separately derived systems, Type 2 SPDs must be connected on the load side of the first overcurrent device.

Article 285.25 identifies the application requirements and installation locations for a Type 3 SPD. Type 3 SPDs must be located on the load side of the service disconnect overcurrent device, on the load side of branch circuit overcurrent protection, and at least 10 meters (30 feet) of conductor distance from the service disconnect.

Conclusion

Recent changes in the Underwriter Laboratories (UL) *Standard for Safety, Surge Protective Devices*, UL 1449 third edition has mandated changes to the 2008 revision of the *National Electric Code*. The UL 1449 third edition will become effective in 2009 September, requiring all SPDs to be evaluated to the new standard. However, most State codes and subsequently, Code Inspectors will not be ready to apply these changes.

The changes in the UL and NFPA documents will provide additional information on the application of SPDs. There will also be changes related to the performance measurements of an SPD; although they are not significant. The areas of performance that will be noticeable are the new voltage protection rating (VPR), and the nominal discharge current. Since the surge current that is used to determine the VPR has increased from 500 amperes to 3,000 amperes, VPR levels will increase. Data labels will also have a nominal discharge current (I_N) of up to 20 kA. In some cases, the nominal discharge current rating will be the maximum surge rating of the device. In others cases, additional testing to other standards will be performed by the manufacture to determine the maximum capabilities of the SPD. However, the impact of both documents on the marketplace will be small to SPD manufacturers that had already meet UL's *Standard for Safety, Transient Voltage Surge Suppressors*, UL 1449 second edition, and were able to document their products clamping characteristics and surge current capabilities.

References

1. Underwriters Laboratories (2006), *Standard for Safety, Surge Protective Devices*, ANSI/UL 1449, third edition, Northbrook, IL USA
2. Underwriters Laboratories (1996), *Standard for Safety, Transient Voltage Surge Suppressors*, UL 1449, second edition, Northbrook, IL USA
3. International Electrotechnical Commission (IEC).
4. National Fire Protection Association (2004), *Lightning Protection Systems*, NFPA 780, Quincy, MA USA
5. National Fire Protection Association (2008), *National Electric Code*, NFPA 70, Quincy, MA USA

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