Differences in Surge Protective Device Classification, Parameters and Test Methods: UL 1449 5th Edition vs. IEC 61643

WHITE PAPER

Introduction

Surge Protective Devices (SPDs) are excellent solutions to help safeguard electrical systems and sensitive equipment from harmful transient surges caused by lightning, switching operations, or other disturbances. Understanding the differences between SPD classifications, key parameters, and test methods according to both UL 1449 5th Edition (used primarily in the U.S.) and IEC 61643 (used internationally, including in Europe) is essential to selecting the right SPD for various types of applications.

This white paper defines the major parameters, and outlines the device categories and required test procedures that engineers need to know when determining the appropriate SPD that meets the level of protection and compliance standards necessary for their particular design.

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Key Parameters of SPDs

1. Impulse Current (I_{imp})

- **Definition:** Represents the peak value of the current pulse with a specific waveform, often used to simulate lightning strikes.
- **UL 1449:** Typically, not a specified parameter in UL standards; focuses more on voltage protection ratings.
- **IEC 61643:** I_{imp} is used primarily in Type 1 SPDs and is tested using a 10/350 µs waveform. The SPD must survive multiple impulses increasing in magnitude up to the maximum I_{imp}.

2. Maximum Discharge Current (Imax)

- **Definition:** The maximum surge current that the SPD can safely divert.
- **UL 1449:** Imax is typically included in the product's technical specifications rather than being a core focus of UL 1449 testing requirements.
- **IEC 61643:** Tested using an 8/20 µs waveform, Imax is a critical parameter for Class II SPDs (Type 2).

3. Nominal Discharge Current (I_n)

- **Definition:** The peak value of the current that the SPD can handle in 15 operations without degradation.
- **UL 1449:** I_n is typically tested using an 8/20 µs waveform.
- **IEC 61643:** Also uses an 8/20 µs waveform for testing I_n, ensuring the SPD can withstand multiple surges during its operational life.

4. Voltage Protection Rating (V_{PR}) vs. Voltage Protection Level (U_p)

- **V_{PR} (UL 1449):** The measured limiting voltage during surge testing, indicating the residual voltage that gets through the SPD to the protected equipment.
- **U_p (IEC 61643):** Similar to V_{PR}, it represents the voltage that appears at the SPD terminals under specific test conditions. The lower the U_p, the better the protection for the equipment.

Table 1. | Key Parameters of SPDs and Terminology

IEC 61643-11 Terminology	Equivalent UL 1449 Terminology	Description
I_{imp}	No equivalent	The maximum surge current rating for an SPD when subjected to a 10/350 µs wave shape.
Imax	Single surge current rating	The maximum surge current rating for an SPD when subjected to an 8/20 µs wave shape.
I_n	I_N	Nominal surge discharge current for an 8/20 µs wave shape.
I_{SCCR}	SCCR	Short-circuit current rating (withstand).
U_P	V_{PR}	Voltage protection level or let-through voltage level of the SPD when subjected to a test surge.
U_C	MCOV	Maximum Continuous Operational Voltage the SPD can be exposed to without failure.
U_N	Operational voltage	Nominal operational voltage or application voltage.

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SPD Category

1. Type 1 SPDs

- **UL 1449:** Suitable for installation between the secondary of the utility transformer and the service entrance or anywhere downstream. No external overcurrent protection is required.
- **IEC 61643:** Similar application, used at the main distribution board, primarily to protect against direct lightning strikes. Tested with I_{imp} using a 10/350 µs waveform.

2. Type 2 SPDs

- **UL 1449:** Installed on the load side of the main service panel and may require external overcurrent protection.
- **IEC 61643:** Installed downstream of Type 1 devices, primarily in distribution boards to protect against residual surges. Tested with Imax using an 8/20 µs waveform.

3. Type 3 SPDs

- **UL 1449:** Installed at least 10 meters from the distribution panel, typically at the point of use. These are often plug-in devices.
- **IEC 61643:** Installed close to the protected load, providing fine protection to sensitive equipment. Tested for low-energy surges.

4. Type 4 SPDs

- **UL 1449:** Component SPDs integrated into other devices. Not used as standalones.
- **Type 1, 2, 3 Component Assemblies:** Consists of a Type 4 component assembly with internal or external short circuit protection.

5. Type 5 SPDs

- **UL 1449:** 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.

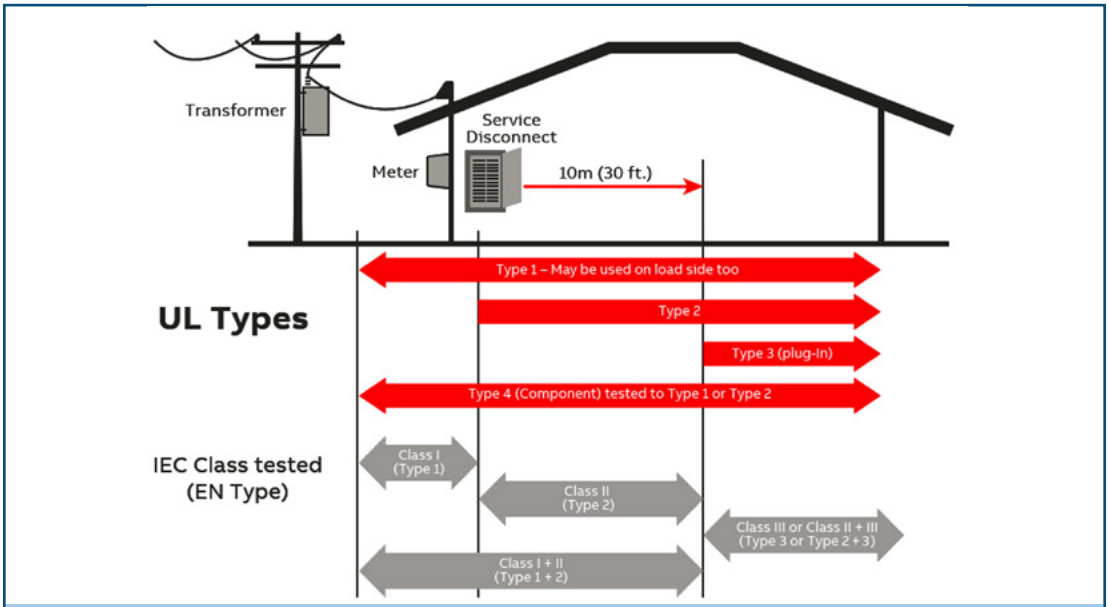

Figure 1. | *Diagram of SPD Categories*

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UL 1449 5th Edition Test Methods

1. Voltage Protection Rating (V_{PR})

- **Test Description:** V_{PR} is determined by subjecting the SPD to a specified combination wave (1.2/50 µs voltage, 8/20 µs current) surge and measuring the peak voltage across the device.
- **Purpose:** Indicates the maximum clamping voltage that the SPD allows through to the protected equipment.

2. Nominal Discharge Current (I_n)

- **Test Description:** The SPD is subjected to 15 impulses of 8/20 µs surge current at the nominal discharge current rating (I_n).
- **Purpose:** Ensures that the SPD can handle multiple surge events without degradation.
- **Test Levels:** Typically, 3 kA, 5 kA, 10 kA or 20 kA for Type 2 SPDs and 10 kA or 20 kA for Type 1 SPDs.

3. Maximum Continuous Operating Voltage (MCOV)

- **Test Description:** SPDs are tested to ensure they can continuously withstand a specified voltage without degradation.
- **Purpose:** Confirms that the SPD will not fail under normal operating conditions.

4. No such definition in UL 1449.

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IEC 61643 Test Methods

1. Voltage Protection Level (U_p)

- **Test Description:** Similar to UL's V_{PR}, U_p is determined by applying an 8/20 µs surge current and measuring the peak voltage across the SPD.
- **Purpose:** Indicates the clamping voltage the SPD allows through to the protected equipment.

2. Nominal Discharge Current (I_n)

- **Test Description:** The SPD is subjected to multiple 8/20 µs impulses at the nominal discharge current rating.
- **Purpose:** Ensures the SPD can handle repeated surge events without performance degradation.
- **Test Levels:** Typically defined by the manufacturer but standardized in some levels.

3. Impulse Current (I_{imp})

- **Test Description:** For Class I SPDs, the device is tested using a 10/350 µs waveform to simulate lightning surges.
- **Purpose:** Evaluates the SPD's ability to handle direct lightning strikes.
- **Test Method:** The SPD must survive a series of five impulses increasing to the maximum I_{imp}.

4. Maximum Discharge Current (Imax)

- **Test Description:** The maximum surge current the SPD can withstand is tested using an 8/20 µs waveform.
- **Purpose:** Determines the device's robustness under severe surge conditions.

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Market Demand and Compliance

UL 1449 (U.S. Market)

- **Adoption:** Widely adopted in North America due to the standard's stringent safety and performance requirements that protect both users and equipment.
- **Market:** Components that meet UL compliance are in high demand for commercial, residential, and industrial applications.
- **Certification:** SPDs must be UL listed or UL recognized (components) to be widely accepted in the U.S. market.

IEC 61643 (European and International Markets)

- **Adoption:** Commonly used in Europe and other parts of the world due to the standard's requirement for comprehensive testing of multiple surge conditions.
- **Market:** Compliance is considered essential in both public infrastructure and private sector installations.
- **Certification:** Compliance with IEC standards is crucial for market acceptance in Europe and many international regions.

Conclusion

By understanding the differences between the UL 1449 5th Edition and IEC 61643 standards, designers can better select the correct SPD type for their specific application. Both standards were developed to help ensure the safety and effectiveness of SPDs, but employ different testing methodologies and criteria to achieve these goals. Familiarity with these differences helps in making informed decisions when designing and installing surge protection systems for the broad range of markets and applications that need to be protected from the harmful effects of transient surges.

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