White Paper
Common Causes of SPD Degradation
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When surge protective devices (SPDs) are properly specified and installed, they provide effective protection against transient overvoltages. In normal operation, SPDs shunt transient overvoltages to ground, allowing only current with a small portion of the surge current to pass the SPD toward the load equipment. Nevertheless, conditions can arise that degrade SPD performance. This paper describes possible causes of SPD degradation and provides responding recommendations for preserving integrity of surge protection systems.

SUSTAINED OVERVOLTAGES

A sustained overvoltage condition is a common cause of SPD degradation. Most SPDs are parallel-connected devices that draw little current. The metal oxide varistors (Figure 1) used in most SPDs remain nonconductive when nominal line voltages are present, as shown Figure 1. They become conductive when voltages exceed the component’s Maximum Continuous Operating Voltage (MCOV). When this occurs, the SPDs shunt current to ground, as shown in Figure 2.

![Figure 1: Examples of MOV components](image)

![Figure 2: Circuit activity during overvoltage conditions](image)

SURGES AND SPDs DEFINED

Terms used to describe and discuss electrical “surges” are often misapplied. Read our paper entitled Surges and SPDs Defined to learn about surge terminology.
Parallel connected SPDs are designed to shunt transient overvoltages that occur and decay very quickly, with typical durations of one-half cycle or less. On a 60 Hertz system, one-half cycle equates to transients that occur and decay in less than 120th of a second. Transient overvoltages occurring over longer durations are considered sustained overvoltages. Because sustained overvoltages produce heat that SPDs are not designed to dissipate, they can overheat internal components, leading to damage, loss of protection, and in the worst cases, risk of fire. Voltage waveforms for sub-cycle transient overvoltages and sustained overvoltages are shown in Figures 3 and 4, respectively.
To avoid overheating, UL-approved SPDs are manufactured with internal thermal protection, as shown at left in Figure 5. These devices are designed to disconnect an SPD from its power source before overheating damages components. A disconnected SPD is shown at right in Figure 5.

**EXCESSIVE SURGE CURRENTS**

Excessive surge currents can also degrade or damage an SPD. Very large surges could be induced onto conductors in a power distribution system when lightning strikes occur near to or directly onto a building. While SPDs are designed to shunt excess voltage, they are only designed to shunt current up to their kA ratings.

When the line voltage exceeds the MCOV and the associated line current exceeds the kA rating, the SPD will attempt to shunt as much current as possible, up to the surge current rating of the SPD. If the overvoltage condition is sustained, the associated current can heat the metal oxide varistors (MOVs) within an SPD. If an MOV is unable to manage all of the current presented by the surge, excess heat could damage its semi-conductor materials. If the SPD cannot pass all of the current, the remaining excess line current may travel to load equipment, as shown in Figure 6.

When surges occur, the impedance of conductors reduces the propagation of transient overvoltages with increasing distance from the transient’s source. To maximize service life, facilities can install SPDs with large kA ratings. To maximize protection, *IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment* recommends installing SPDs at service entrances, distribution panels, and sensitive load equipment, particularly when buildings are not equipped with lightning protection systems.

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**Figure 5:** The SPD at left is equipped with thermal protection. If excessive current passes through the SPD, the thermal protection device opens to prevent the downstream metal oxide varistor from overheating.

**Figure 6:** Circuit activity during overvoltage/overcurrent conditions
SPD WEAR-AND-TEAR

Transient overvoltages routinely occur on most power distribution systems for multiple reasons. Transients from external sources such as lightning and utility switching are commonly recognized as sources of surges. However, the majority of transient overvoltages originate inside buildings from sources such as capacitor and motor switching. While many of these types of surges may be relatively small, repeated exposure to transient overvoltages will degrade MOVs over time.

One method for increasing the life expectancy of an SPD is to provide redundant MOVs in an array within a single mode of protection. If one MOV fails, the redundant MOVs provide the necessary protection against surge currents. Figure 7 shows how the loss of a single MOV in a seven-MOV array leaves six others online to protect the circuit.

A number of factors affect the occurrence and characteristics of surges that SPDs might experience. These include:

- the level of regional lightning activity
- the quality of power provided by a utility
- the location of an SPD within a building’s power distribution system
- the types of loads that are present
- the activities and operations conducted within a facility

Because of variability in site conditions, it is difficult to know exactly when SPDs may reach the end of their service life. In order to monitor SPD condition, users can select SPDs with various indicators that can signal when components may be in sub-optimal condition or may be providing sub-optimal performance. (For information regarding the available forms of indicators, see our paper entitled Monitoring SPD Condition.) In addition, selecting SPDs with high surge current ratings, or kiloamp (kA) values, can increase service life in a given application.

SUMMARY

Surge protective devices routinely provide effective protection against transient overvoltages. Nevertheless, repeated exposure to electrical surges can degrade SPD components and their performance. Specifiers can use the following strategies to account for these effects:

- Specify SPDs with large kA ratings at service entrances, distribution panels, and sensitive load equipment
- Consider SPDs that feature arrays of redundant MOVs
- Specify SPDs with suitable indicators for operability and condition
- If unexplained SPD malfunctions occur, investigate whether sustained overvoltage conditions could be the cause and adjust the surge protection strategy as necessary