



UNDERSTANDING SPD CODES AND STANDARDS, AND TPMOV TECHNOLOGY

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Overview

- SPD Technology, and how a Mersen SPD product works
- Understanding today's codes and standards
- Important new terminology
- How the standards and codes may impact some specifiers

The most commonly used component in Surge Protective Devices (SPDs) are Metal Oxide Varistors (MOVs). MOVs have reliably provided protection against transient voltages for years. However, growing safety concerns about failures in the field have led to improved standards and protection schemes. To better understand these changes, it is helpful to review the operation of MOVs and their failure modes.

SPD Technology:

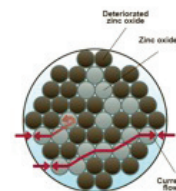
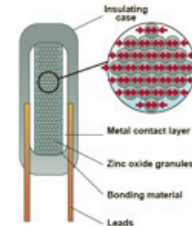
The key role of the MOV is to limit any overvoltage present in a circuit. This may lead one to ask, "how does an MOV do this?" An MOV is essentially a voltage dependent variable resistor. When the voltage in an electrical circuit exceeds a certain threshold, the resistance in the MOV drops sharply, and in turn diverts any excess voltage (and current) outside the circuit, resulting in overvoltage protection of downstream electrical equipment. Although the concept sounds quite simple, the actual operation of the MOV is a little more complex.

An MOV is a disc or rectangular-shaped device, which contains a ceramic mass of zinc oxide grains, in a matrix of other metal oxides (such as small amounts of bismuth, cobalt and manganese) sandwiched between two metal plates called electrodes.

MOVs are typically installed in parallel with the load (one lead to power and one to ground), so that when a surge occurs, the MOV shunts the excess energy away from the protected load. This allows the MOV to remain non-conductive during normal operation when voltage remains below the threshold level (also referred to as the Maximum Continuous Operating Voltage, MCOV) of the MOV.

One thing to keep in mind is that an MOV will degrade with every surge it encounters. When an MOV has been exposed to a large series of surges, or a high magnitude surge, the zinc oxide particles will begin to break down, reducing the resistance to electrical flow. When the particles begin to break down, the threshold value of the MOV will be reduced. This eventually results in failure of the MOV.

Overvoltage operation of an MOV is the fastest way to MOV failure. Under sustained overvoltages an MOV can fail due to thermal runaway. This



phenomenon occurs when the normal 60 Hz power system voltage becomes higher than the MCOV rating of the MOV and initiates flow of continuous 60 Hz current through the MOV. When the voltage is above the MCOV, the MOV enters its conductive state and current flows through the device until the voltage goes below this value. The magnitude of this current flow depends on the dynamic resistance of the MOV in its conductive state and the impedance of the power system.

For example, if you are using an MOV with a nominal voltage rating of 120V and a threshold (MCOV) value of 180V, and the MOV threshold has decreased to a value lower than that of the nominal voltage rating, the MOV will begin to conduct and overheat (thermal runaway). In most cases this will result in a short circuit and catastrophic failure.

In recent years, studies have focused on problems that arise from low and intermediate fault currents that would be below the fuse's protective ability. With risks in both cases (fault currents above and below the fuse's protective ability) some manufacturers have become leery of using MOVs in their equipment.

In the past, fuses were placed in series with the MOV. If the current through the MOV exceeded the current limiting threshold of the fuse, the failing MOV would be safely removed from the circuit. Although the equipment would be susceptible to future transient overvoltages, most SPDs in today's industry provide some type of indication as to when an MOV has reached the end of its life. This could be by means of an indicating light, a remote signal, or an audible alarm.

Understanding today's Standards:

Along with the changes to UL1449, the 2011 National Electrical Code has made some key changes, such as 285.5 which states the following:

"An SPD (surge arrester or TVSS) shall be a listed device."

The NEC has made it clear, when using an SPD it must be a listed device. This has in turn caused some SPD manufacturers' products to become obsolete due to the lack of UL certification.

Since 1985, Underwriters Laboratory (UL) 1449 standard has been providing safety guidelines for Surge Suppression, a topic found in the past to have very little structure or commonality across the standard. Originally titled "The Standard for Safety for Transient Voltage Surge Suppressor," this standard was initially created to provide structure to a rapidly developing and growing industry and was largely based on waveforms and testing methods from IEEE C62.41.

Over time, new developments and enhanced technology has driven the need for more rigorous standards. As a result of these advances, UL responded on September 29, 2009 by making significant revisions to standard 1449, updating it to the 3rd edition. This led many manufacturers to redesign their products in order to meet the new standard. Most notably impacted are the terminology, test program, and specifying requirements.

Some key facts about UL 1449 3rd edition which have an impact on specifiers and the supply chain:

- New performance tests use more surge current, resulting in increased clamping voltages
- New test results are numerically higher, thus not meeting old style specifications
- Lost time of electrical and general contractors and distributors trying to source SPDs that cannot meet an outdated specification
 - In frustration, old/obsolete TVSS product may be submitted, which may or may not be UL Listed, or supported in the future.
- Lost time of specifying engineers evaluating submittals that do not meet the new standard
- Specifying engineers may find significant industry confusion; unable to specify what is needed or receiving products with improper technology.

Important New Terminology for UL 1449 3rd edition:

In the past, most surge devices were referred to as transient voltage surge suppressors (TVSS). This old terminology has been replaced with Surge Protective Device (SPD), reflecting the changes made to the NEC and International standards terminology. Along with TVSS, the second edition secondary surge arrestors (SSAs) have been consolidated into the new third edition. Most third edition Type 1 devices will replace any obsolete secondary surge arrestors on the market. Having this new terminology creates an industry umbrella for all surge categories together under one common test criterion.

Location and or Type Designations:

UL 1449 3rd edition assigns type designations to SPDs (1,2,3,4) reflecting the expected surge magnitudes present in various locations within the electrical distribution system. These designations were adopted from IEEE categories A, B, & C.

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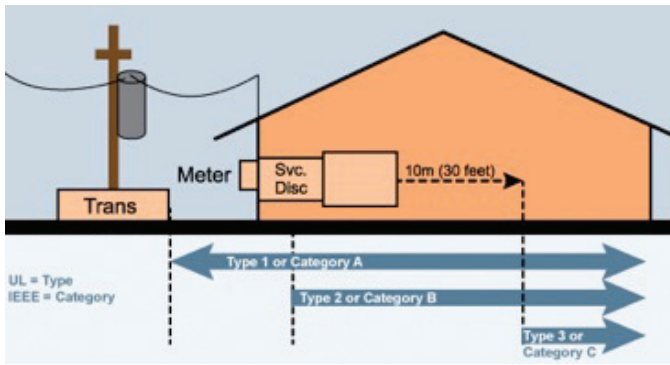


Figure 1: The above picture shows the locations within the electrical distribution and the associated Type device adopted by IEEE categories A, B, & C

Type 1 – Installed on line or load side of the main Overcurrent Protection (OCP), in the past this was referred to as SSA. The difference with UL 1449 3rd edition is the new, more rigorous safety testing which was not required in the previous editions.

Type 2 – Installed on the load side of the main OCP. In the past these devices may have been associated with, or referred to as hardwired TVSS, and in some cases may not require external OCP.

Type 3 – Point of utilization, direct plug-in-type devices. These components are similar to surge strips. They are required to be installed 10 meters from the panel (rational based on IEEE Cat. A location)

Type 4 – Surge suppression components, which could be a basic component or a complete module. Type 4 components can be tested to Type 1, Type 2, or Type 3 applications.

New Impact on UL96A:

Prior to UL 1449 3rd edition, UL96A required surge suppressors to be evaluated as secondary surge arrestors. However, with new revisions made to 1449, secondary arrestors are now classified as a Type 1 SPD. This means that UL96A will now accept Type 1 or Type 2 SPDs having 20kA I_n ratings, explained later in this paper.

More Rigorous Test Requirements in UL 1449 3rd Edition:

When specifying a surge product in today's industry, there is often confusion with the significant number of previously used terminologies to address overvoltage protection. However, there are a few critical concepts to understand to sort through the values of importance when selecting an SPD. Previously, UL 1449 2nd edition referred to the clamp voltage test as the suppressed voltage rating (SVR), which consisted of a 500A, 6000V surge. Updated in UL 1449 3rd edition, the clamp voltage test is referred to as the voltage protection rating (VPR) and

consists of a 3,000A, 6000V surge – more than six times the surge current needed than that of the previous 2nd edition test requirements. This means the VPR for an SPD will be higher than the SVR of an identical SPD. Higher current levels equal higher clamp voltages.

Standard	UL 1449	
	3rd Edition	2nd Edition
Test	3kA/6kV	0.5kA/6kV
Title	Voltage Protection Rating	Suppressed Voltage Rating
Reference	VPR	SVR

Table 1: The above table shows the comparison between VPR and SVR test requirements

The change from SVR to VPR is the single most important change in the UL 1449 3rd edition relating to specifiers. The SVR listed in current specifications will be obsolete, since comparing a VPR rating to a SVR rating would provide no valuable information. To be sure there is an accurate performance comparison, the VPR of one device must be compared with the VPR of another device.

New Test Requirement Added to UL1449 3rd Edition:

New to UL 1449 3rd edition standard is the nominal discharge current test (I_n). This new requirement originates from the International Electrical Code (IEC) surge testing criteria, mandating that a SPD must remain functional after being subjected to 15 repetitive impulses of a specific value. During the I_n test, every mode of protection is tested, including any required overcurrent protection device. The unit is tested at its rated voltage or what is referred to in UL 1449 as the maximum continuous operating voltage (MCOV). The I_n testing is performed in conjunction with the VPR test, so it is crucial to understand the testing conditions for the SPD. The I_n values which a device must be tested at are as follows:

Type 1 device: 10kA or 20kA.

Type 2 device: 3kA, 5kA, 10kA, or 20kA.

Important to note is that the manufacturer has the ability to chose which I_n value the device is tested at, which means that SPD products need to be investigated in detail to understand the published ratings. In the event a device can not pass at any given value, it is permitted by UL that the SPD manufacturer can re-test at a lower level until a stable value is obtained to pass the test. This means that a manufacturer has a number of I_n values they are able to test to achieve compliance.

UL 1449 Limited Current Abnormal Overvoltage Test

One of the most significant changes occurred with a revision to the 2nd edition (2007). This change consisted of adding the limited current abnormal overvoltage test. This test was added

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to address the issues with the safe removal of an SPD under low fault current conditions, and it led a lot of manufacturers to redesign their products.

This area of concern addresses the situation where low level fault currents could exist for a short period of time. If it is below the current limiting threshold of the fuse, the MOV could heat to the point of causing fires or a subsequent catastrophic failure of the MOV and equipment. This led specifiers to question the integrity of some SPD manufacturers.

What do the changes to UL 1449 mean?

Since the effective date of September 29, 2009 all surge products which do not meet UL 1449 3rd edition are considered obsolete. UL updated the standard to drive consistency and commonality to the SPD market, recognizing that it can be confusing to determine the published values of importance. One must understand that there are many SPDs on the market that no longer meet the standard but are still offered for sale. The simplest way to know if a SPD product is in compliance is to look for a UL holographic label on the device. If it has a UL "SPD" holographic label, it is in compliance. If not, it does not meet the new UL 1449 3rd edition standard.

Keep in mind, some second edition products did incorporate a UL "TVSS" holographic label. The below pictures illustrate the difference between obsolete and acceptable labels seen on products in today's industry.



Figure 2: A picture of a holographic label from an obsolete 2nd edition device. Please note the obsolete TVSS wording.



Figure 3: A picture of a holographic label from a UL 1449 3rd edition device. Please note the SPD wording, which is accepted in today's industry.

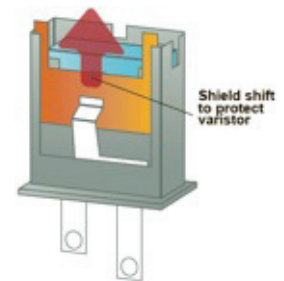
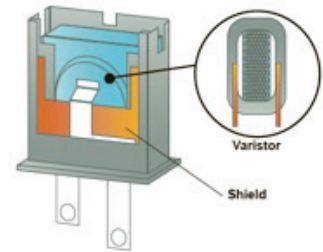
Mersen SPD Technology:

Mersen TPMOV[®] technology is a viable solution to prevent catastrophic failure. Mersen is the sole manufacturer of the TPMOV[®] (thermally protected MOV) technology. This patented technology provides solutions to all of the issues previously discussed and places them into one compact device. The TPMOV[®] product is constructed of four basic components: an MOV, thermally protected contact, arc-shield, and plastic housing. Within these four basic components, the TPMOV[®] is

able to achieve what other ordinary MOVs can not, an all-in-one solution.

So how does the Mersen TPMOV[®] technology work?

As previously mentioned, during a surge event the MOV will act as a momentary short to ground, sending any excess voltage and current away from the device in which the SPD is protecting. In the event the magnitude and/or duration of the surge is above and beyond the SPD capabilities the TPMOV[®] will react to the surge in the same manner as a MOV/fuse combination would. When the MOV reaches a specific temperature, the solder between the thermally protected contact and MOV will begin to melt. Once the solder has melted, the thermally protected contact will disengage itself and break away from the MOV body. When the thermally protected contact has completely disengaged, the arc shield will be driven upward (the arc shield is spring loaded and held in place via the thermally protected contact) and will separate the thermally protected contact from the MOV body to prevent re-strikes. With the MOV disconnected from the circuit, an indicator has informed the customer the MOV is no longer protecting the device from an overvoltage condition.



Conclusion:

While MOVs have reliably protected electrical equipment from surges and transient spikes for years, growing safety concerns about failures in the field have led to improved standards and protection schemes.

With the rise of more stringent testing and safety regulations, many large SPD manufacturers are using Mersen's TPMOV[®] technology within their products. The TPMOV[®] has proven to be a reliable, cost-saving measure and a space-saving component. Additionally, the TPMOV[®] has successfully passed and exceeded all testing identified by the UL.

Simple, basic components (an MOV, thermally protected contact, arc-shield, and plastic housing) enable the TPMOV[®] to achieve what other ordinary MOVs can not: an all-in-one solution.

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