NUCO Controls

SURGE PROTECTIVE DEVICES 101

TECHNICAL TRAINING MODULE

Surge Protective Devices 101

This paper will explain what Surge Protective Devices are and why you should consider them for your facility. A brief summary of surge protection history will also be provided in order to help the reader become familiar with past terminology and how it has changed in recent years.

What are Surge Protective Devices?

A transient, or power surge, is an increase of voltage above expected system voltage. See Figure 1 for an example of a voltage transient. You often hear of the terms such as transients or spikes. Both are essentially the same thing and have the same detrimental effects on electrical systems. The primary difference between the two terms is simply the length of time the increase of voltage occurs. When an increase of voltage above nominal voltage occurs for 1 to 2 nanoseconds (that is 1 to 2 *billionths* of a second), the event is called a spike. When an increase of voltage lasts 3 nanoseconds or more, it is called a surge. Obviously, the longer an increased voltage exists on electrical equipment or insulating material, there is likely more chance for failure or degradation of the electrical devices.

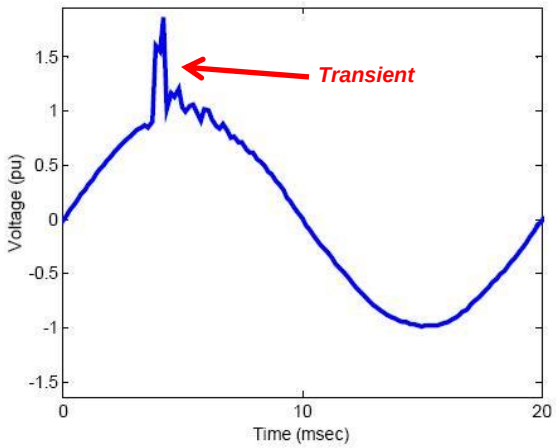


Figure 1 – Voltage Transient

A Surge Protective Device (SPD for short) exists to do one thing and one thing only – maximize equipment protection by diverting unwanted transients away from sensitive electrical or electronic equipment. When most people think about transients or surges, they think of lightning. Lightning can certainly cause transients but did you know that over 80% of transients come from internal sources or from utilities that switch power sources or other electrical equipment? Common sources internal to the factory or nearby neighbors include loose connections, motors switching on and off, production machines that have electronic controls, capacitor switching, welders, computers, and variable frequency drives. Switching some of these devices on *or* off can cause transients in the thousands of volts. When sensitive electrical equipment or insulating material are exposed to these very high transients, the equipment or

insulating material can fail immediately or can begin to prematurely degrade. An SPD is designed to minimize these effects.

Terminology

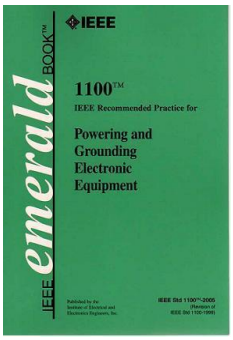
A brief background of transient voltage protection terminology is needed at this point in order to understand different terms you may encounter. Prior to the term Surge Protective Device, the most common terminology for surge protection equipment was Transient Voltage Surge Suppressor, or TVSS for short. TVSS is still often used today but there are very distinct differences between TVSS and SPD device designs because different standards and test methods are used for each one. This article will not detail the differences between the two standards. It is only important to know that the term SPD and the new electrical standards developed for SPD's were created in order to provide safer and more reliable surge protective devices. The old TVSS electrical standards left room for incorrect surge protective equipment comparisons and did not fully address proper testing to ensure equipment safety. Also, in the past, TVSS and Surge Arrestors were addressed under different electrical standards. Today, SPD's (previously TVSS) and Surge Arrestors are combined into one single UL standard, UL1449 3rd Edition. It is important to note the *3rd Edition*. UL 1449 has changed three times since its inception. Only equipment that complies and has been tested to the 3rd Edition should be considered for surge protection. The 3rd Edition addresses some of the short comings that the 1st and 2nd Editions did not address and it is the only valid UL listing for SPD's. It is also very important to know that there are some manufacturers that still sell SPD's and promote them as UL1449 but do not mention the edition. In some of these cases, the SPD's are either the 1st Edition or the 2nd Edition. Again, only the 3rd Edition is a safe and reliable product. When a manufacturer does not list the Edition number, the user should ask the manufacturer to provide the Edition number in writing. If doubt still exists, ask the manufacturer to provide a certified UL1449, 3rd Edition test certificate. If one cannot be provided, find another manufacturer who can. Remember, the 3rd Edition was created to improve safety and reliability over prior Editions.

One important design aspect of an SPD is Voltage Protection Rating (VPR for short). Other terms you may hear and essential mean the same thing as VPR are let-through voltage and measured limiting voltage. The VPR is defined as the amount of voltage that the SPD does not suppress and passes to the load. In general, better protection is provided at lower voltages.

Another important design aspect of an SPD is its peak surge current capability. Peak surge current is the amount of current the Metal Oxide Varistor (MOV for short) experiences as the MOV suppresses the transient voltage. In general, the higher the peak surge current capability *at the service entrance*, the better the SPD. There is no need to have SPD's with hundreds of thousands of volt peak surge current capability at or near the protected equipment because the service entrance SPD will remove a large portion of the surge and localized SPD's can absorb

the rest. This of course assumes that the user is providing full SPD protection from the service entrance to the protected load.

There is a point in which the level of surge current capability becomes excessive and provides little or no extra benefit. A device rated 250kA per phase can be expected to last 25 plus years. Some manufacturers are promoting ratings up to 600kA per phase. A higher rating does not really provide improved performance but instead increases life expectancy. Devices rated 600kA per phase will have life expectancies in the hundreds of years. The problem is cost versus benefit. A 600kA device will cost much more than a 250kA device. The 25 plus years that a 250kA/phase is expected to survive is much more than needed due to the very high probability the electrical system will change in that time period. When the electrical system changes, one needs to give consideration to reconfiguring existing SPD protection.



SPD equipment has different modes of protection. The maximum number of modes is 10 (wye systems). An SPD that protects all 10 modes provides the best possible protection when the proper equipment is selected and when the equipment is installed correctly. Modes are different protection configurations between phases, ground, and neutral. A ten mode device will provide effective protection between A-B, A-C, B-C, A-N, B-N, C-N, A-G, B-G, C-G, and N-G. A seven mode protection provides protection between A-N, B-N, C-N, A-G, B-G, C-G, and N-G. Try to obtain an SPD that protects the most number of modes for best protection. For three phase, 4-wire systems, the IEEE Emerald Book recommends to protect all 10 modes. A 10 mode system allows the SPD to take a larger surge without sacrificing itself and prevents less stress on a per mode basis than fewer modes (improving life expectancy).

How SPD's Work

SPD's are designed to shunt transients from the main power lines to ground before the transients can reach electrical equipment. There are many different types of electrical components that can be used in an SPD design such as MOV's, transient voltage suppression diodes, thyristor surge protection devices, and gas discharge tubes. There are others as well but MOV's are by far the most commonly used by today's mainstream manufacturers due to the balance between reaction time and let through voltage capability. In all cases, the basic premise is the same, remove the transient to ground as quickly as possible. See Figure 2 for SPD Block Diagram.

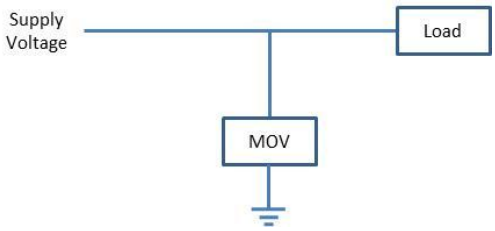


Figure 2 – SPD Block Diagram

Without getting into too much detail, MOV's are fairly simple and well understood electrical components. In simple terms, an MOV has a continuous operating voltage rating that it can operate within continuously without conducting. This operating voltage is referred to the Maximum Continuous Operating Voltage (MCOV for short). When the MOV is operating below its MCOV rating, it acts as a very high impedance and nothing happens. When a transient is present and the MCOV rating is exceeded, the MOV quickly changes to a low impedance and diverts as much of the transient as possible to ground. In other words, the MOV is essentially a variable resistor that changes with applied voltage.

The SPD works as follows,

1. A transient is generated internal or external to the facility and propagates toward the load.
2. As the transient reaches the SPD equipment, which is installed ahead of the load in parallel, the MOV's change to a low resistance path to divert the transient from the load to ground.
3. As soon as the transient is diverted from the main power source, the systems voltage returns to normal and the MOV returns back to a high impedance path, waiting for the next transient.

That's it in simple terms of operation. However, the best SPD in the world will not provide a great deal of proper protection if it is not installed correctly! The best installation is one in which the wire lengths to the SPD are minimized and do not have any bends. Wire adds impedance (or think of it as resistance). The longer the wire, the more impedance introduced. When impedance increases, it increases the amount of time the SPD has to react which essentially means the protected equipment is exposed to more voltage than wanted even with the SPD in the circuit. It has been documented that for every inch of wire added between the SPD and the

line, up to 25V of additional voltage is allowed to pass to the load. This means if 12" of wire is used to install the SPD and the SPD has a let-through voltage of 500V, the 12" of wire could allow an additional 300V to pass to the load, so a total of 800V. This is over 60% more voltage than intended. Installation is very important and the manufacturer should be consulted if straight, short wires cannot be installed for a specific installation.

Beware, not all SPD's are Created Equal!

This paper mentioned the importance of using equipment that complies with the 3rd Edition of UL1449. However, even within that specific standard, the guidelines allow manufacturers to test their equipment within recommended ranges specified by the standard. Some manufacturers may test to the higher range and some may test to the lower range. In either case, if the equipment passes the tests specified by the range the manufacturer selects, the manufacturer can market the product as UL1449, 3rd Edition. Both designs are safe because they comply with the same test methods but one device may provide much better protection than the other device due to differences in the test range selected. Let's look at some specifics for a better understanding.

UL 1449, 3rd Edition has established four SPD Types – Type 1, Type 2, Type 3, and Type 4. Type 1 devices have two recommended ratings, 10kA and 20kA and can be installed on the line side or load side of the primary overcurrent protective device, typically service entrance. Type 2 devices have four recommended ratings, 20kA, 10kA, 5kA, and 3kA and must be installed on the secondary side of the primary overcurrent protective device. Type 3 devices are installed at point of use of the protected equipment. Finally, Type 4 is 'manufacturer specific' related to components and can be tested to Type 1, 2 or 3.

The manufacturer selects one of the recommended ratings they desire to test to and if their device passes the test for the selected rating, it becomes UL1449, 3rd Edition compliant. If Manufacturer "A" decides to test a SPD to Type 2, 3kA and passes while Manufacturer "B" decides to test a SPD to Type 2, 20kA, they both can claim compliance to UL1499, 3rd Edition. However, you clearly would rather have a Type 2 device that has a 20kA rating versus one that only has a 3kA rating as long as there is not a significant price difference which is normally the case. The point here is that just because a manufacturer does have a UL1449, 3rd Edition product, it does not mean it has the best ratings since UL1449 allows flexibility in the recommended ratings and testing.

Conclusion

Surge Protective Devices are essential in protecting electrical components on your electrical network. They are more important today than ever due to the proliferation of sensitive electronic equipment installations. It is estimated that the average facility load will exceed 50% in sensitive electronic equipment in the coming years. The electrical test and safety standards have changed multiple times over the past decade. It is important that the user only use the latest electrical and safety standards to ensure proper facility and personnel protection. UL1449, 3rd Edition is the latest electrical standard. The user must understand that a manufacturer who claims their product complies with UL1449 does not necessarily mean their product is certified to the 3rd Edition. There are two prior Editions that are now obsoleted. The electrical and safety standards for the 1st and 2nd Editions contained loopholes and other deficiencies that could pose safety hazards to facilities and personnel. It is also important to understand that the 3rd Edition allows manufacturers to select from a recommended range of test values for Type 1 and Type 2 devices. The implication is that both manufacturers can claim their product is certified to UL1449, 3rd Edition but one product could still be superior to the other since one manufacturer could have tested their product to the upper range and the other manufacturer to the lower range. With all other things equal, including product cost, the user would rather select the product with the higher range.

NUCO Controls is well aware of the latest standards and associated nuances as mentioned above. We only use products that comply with the latest electrical and safety standards and know how to ensure you obtain the best product available at the right cost.