GE Energy
Digital Energy

Power Quality
Surge Protective Devices (SPDs)

FAQs

Q: What is a Surge Protective Device (SPD)?

A: A device composed of at least one non-linear component that is intended for limiting surge voltages on electrical equipment by diverting or limiting surge current and is capable of repeating these functions as specified. SPDs were previously known as Transient Voltage Surge Suppressors or Secondary Surge Arresters. UL 1449 Listed SPDs are now designated as either Type 1, Type 2 or Type 3 and are intended for use on AC power systems rated less than 1000vrms.

Q: Why do SPD manufacturers no longer describe their products as TVSS?

A: TVSS devices have always belonged to a larger family of surge suppression devices known as SPDs (Surge Protective Devices). Beginning with UL 1449 3rd Edition and the 2008 National Electrical Code, the term "SPD" has formally replaced the terms "TVSS" and "Secondary Surge Arrester". SPDs are now classified as Type 1, Type 2, Type 3 or Type 4 and are selected based on application and the location where they are to be used. With the recent changes in terminology by UL and the NEC, there are no longer any standards organizations that use the term TVSS, as IEEE®, IEC® and NEMA™ have been using the term "SPD" for many years.

Q: What are the UL SPD Type designators and what do they represent?

A: A Type 1 SPD is a permanently connected Surge Protective Device that is UL approved for installation at any location between the secondary of the utility service transformer and the service entrance primary overcurrent disconnect. Type 1 SPDs can also be installed anywhere on the load side of service entrance and are allowed to be installed anywhere on the low-voltage electrical system without requiring a dedicated fuse or breaker.

A Type 2 SPD is a permanently connected Surge Protective Device that is UL approved for installation on the load side of the service entrance primary overcurrent disconnect. Type 2 SPDs may, or may not require the use of a dedicated fuse or breaker.

A Type 3 SPD is a point of use Surge Protective Device, installed at a conductor length of 10 meters (30 feet) or greater from the electrical panel. These devices are typically cord connected, direct plug-in, receptacle type and SPDs installed at the load equipment being protected. The distance of 10 meters excludes conductors that are provided with, or used to attach the SPD.

A Type 4 SPD designation is for SPD components and assemblies that are considered to be incomplete in any aspect that would prevent them from obtaining a UL Listing classification. Examples of Type 4 SPDs range from Metal Oxide Varistor components to complete SPD system assemblies that are constructed without an outer enclosure.

Q: Does a Type 1 SPD perform better than a Type 2 SPD?

A: Not necessarily. A Type 1 SPD offers versatility by being able to be connected to either side of service entrance, however UL does not compare the surge clamping performance of a Type 1 SPD versus that of a Type 2 SPD. UL investigates clamping performance of all SPDs equally, without regard for SPD type. UL also evaluates all SPDs for safe operation within their intended installation location. Beginning with UL 1449 3rd Edition, Type 1 approved SPDs will include devices that were formerly known as Secondary Surge Arresters and will also include many devices that were formerly known as TVSS. It is important to understand that many Secondary Arresters type devices were designed with a higher MCOV (Maximum Continuous Operating Voltage) than were TVSS type devices. And since the MCOV rating of an SPD can have a direct impact on surge clamping performance, the best practice for SPD selection should include careful consideration for ratings such as maximum surge current, IEEE clamping voltage, UL VPR, and surge life ratings.

FAQs

Q: Why would I need to consider installing Surge Protection?

A: Whether it is an office copier, an industrial CNC punch press, or a residential appliance, preventative steps need to be taken in order to protect valuable electronic assets. Almost everyone is familiar with the adverse effects that lightning can have on sensitive electronics, but voltage disturbances can originate from sources of lesser energy as well. Everyday voltage "spikes" can occur when equipment such as HVAC compressors or other inductive loads are switched on and off. In addition, transients could also originate from sources such as a circuit breaker trip or equipment being used at a residence or business within your locality. These more common events might not result in problems that are immediately noticeable. In many cases the symptoms are gradual and will manifest as random upsets, data errors and reduced life expectancy of sensitive electronic circuits. Properly installed SPDs are regarded as a good first line of defense to help protect the sensitve circuitry contained within many of today's "smart" electronic devices.

Q: Will a SPD protect my equipment from direct Lightning Strikes?

A: The impulsive, high peak voltages that are produced by direct cloud-to-ground lightning strikes can produce currents that can exceed several hundred thousand amperes. SPDs are not well-suited to handle a direct lightning strike on a facility as a stand-alone means of protection. For the best defense against the direct effects of lightning, it is recommended to consider the installation of a UL96A or NFPA 780 certified Lightning Protection System. The majority of externally generated surge voltage damage is not caused by direct lightning. Instead it is the result of surge currents that are induced on AC power, telecom and other utility lines by the strong electromagnetic fields that can be created during a remote lightning strike, or from less severe sources such as power company switching nearby heavy loads, downed power lines, ground faults, etc. These surges can propagate for great distances on metallic conductors, arriving at your facility with enough residual energy to damage electronic devices. SPDs are designed for the specific purpose of mitigating these types of induced voltage disturbances.

Q: Will a SPD protect the electrical distribution system against power quality disturbances such as phase overvoltage, undervoltage or harmonics?

A: No. A common misconception about SPDs is that they are designed to protect against all power quality problems. SPDs are not designed to protect against occurrences of excessive voltage at the fundamental power frequency. Nor can they protect against low voltage (sags) or harmonics. In fact, multi-cycle overvoltage events, also known as TOV or voltage swell, can cause the suppression components within an SPD to fail if they reach potentials in excess of the rated operating voltage of the SPD.

Q: Will installing a SPD save money on my utility bills?

A: SPDs are designed to help protect sensitive electronics by helping to mitigate the potentially damaging effects of random surge events. Installing an SPD could conceivably save on the costs of downtime, premature repair or replacement of electronics that can be damaged by these surge events. However, there is no evidence to support SPD usage for the specific purpose of reducing electricity consumption by either direct or indirect means.

Q: What size SPDs should I choose for my facility?

A: The task of choosing surge protection for a given facility cannot be determined solely by the ratings or size of the electrical distribution system. Each facility should be assessed based upon factors such as the anticipated surge environment, type of facility, and exposure risk. IEEE C62.41 series standards identify the surge risk within a given facility based on proximity to service entrance. Locations are identified as Category C (Service Entrance), Category B (Secondary Distribution) and Category A (Branch and Point of Use).

At present, the majority of SPD manufacturers will recommend to install High Exposure SPDs rated between 100kA - 300kA per mode at Cat. C Locations, Medium Exposure SPDs rated 60kA - 100kA at Cat. B Locations, and Low Exposure SPDs rated 25kA - 50kA at Cat. A locations.

It is also important to understand that the suggested surge ampacity rating of the SPD should not be determined as an expected indicator of surge clamping performance, but rather should be considered based upon reliability, or more appropriately, SPD life expectancy. A service entrance suppressor can experience thousands of surges of various magnitudes. Based on historical data published in IEEE C62.41, we can roughly estimate the life expectancy of a suppressor. A well designed and constructed suppressor having a 150kA/mode surge current rating should have a theoretical life expectancy that is greater than 25 years even in the highest exposure locations.

In the absence of a facility site survey, GE's general recommendation for most SPD applications is a surge rating of 150kA per mode at service entrance locations (IEEE Cat. C), 80kA per mode at secondary locations (IEEE Cat B) and 25kA-65kA at branch/point of use locations (IEEE Cat. A).

Q: Are joule ratings important?

A: When speaking in terms of SPDs, the answer is no. Joule ratings are not considered a good indicator of SPD performance, nor are they endorsed by any standards organizations that have authority over surge protective devices. Joule ratings are typically promoted as a desirable spec parameter by SPD manufacturers that use Silicone Avalanche Diodes, or by manufacturers of plug-in power strip devices that include low energy surge protection components. Joule ratings are sometimes perceived as a means to confuse SPD users about the energy handling capability of such designs, by misdirecting consumers from the more reliable indicator of SPD robustness, which is the maximum single withstand surge current rating as defined in IEEE SPD Standard no. C62.62.

Q: What is the UL Nominal Discharge Current (In) rating?

A: The UL Nominal Discharge Current is defined as the peak value of 8/20µs surge current impressed through the SPD, where the SPD remains functional after 15 applied surges. The peak current ampacity for is first declared by the SPD manufacturer and subsequently tested for compliance by UL. The highest nominal discharge current rating currently allowed for assignment by UL is 20kA. It should also be noted that SPDs must carry a UL Listed Nominal Discharge Current rating of 20kA in order to qualify as the approved service entrance SPD for use on UL 96A Lightning Protection Systems.

Q: What is meant by the UL SCCR rating?

A: SCCR (Short Circuit Current Rating) is a required marking for all SPDs, mandated by both UL and the National Electrical Code. It is defined as the maximum allowable AC current that an SPD has been designed to interrupt in the event of SPD failure. SPDs are rated for SCCR based on testing that is conducted under the UL 1449 Standard compliance testing program. SPDs are allowed to be installed on AC power systems that are capable of delivering fault current up to the SCCR rating of the SPD. Per NEC, Article 285.6, a SPD is not allowed to be installed at a point on the electrical system where the available fault current is in excess of the SPD's assigned SCCR rating.

Q: What is SVR?

A: SVR (Suppressed Voltage Rating) was assigned to UL 1449 2nd Edition type TVSS devices based on clamping voltage performance data obtained during measured limiting voltage testing. Each TVSS mode was subjected to a 6kV / 500kA combination surge wave using 6" of lead length between the TVSS and surge generator. The average clamping value was rounded up to the nearest 100th volt increment to establish SVR for each mode. Effective in Sept. 2009, SVR values are no longer supported by the UL 1449 Standard's 3rd Edition release.

Q: What is VPR?

A: VPR (Voltage Protection Rating) is assigned to UL 1449 3rd Edition SPDs based on clamping performance data obtained during measured limiting voltage testing. Each SPD mode is subjected to a 6kV / 3kA combination surge wave using 6" of lead length between the SPD and surge generator. The average clamping value is rounded up to the nearest value based on table 63.1 from UL 1449 3rd Edition Standard. The rating of VPR has effectively replaced the UL rating previously known as SVR with the obsolescence of UL 1449 2nd Edition Standard.

Q: What are some of the pitfalls when comparing clamping voltage ratings between SPD manufacturers?

A: The task of comparing clamping (let-thru) voltage ratings between SPD manufacturers' published data, may initially be perceived as a routine process. However, clamping voltage can be one of the more ambiguous of all SPD ratings. In simplified terms, SPD clamping voltage can be defined as the peak let-through voltage the SPD will allow for a given surge test wave. Most SPD manufacturers will publish average clamping performance data for their various design types, and almost all will publish this data while referencing one or more of the surge test waves that are defined in IEEE Standard C62.41. While the reference to C62.41 is valid, it sometimes leads customers and specifiers to believe that IEEE 62.41 is a standard that provides a definitive testing methodology for the purpose of determining SPD performance ratings. Unfortunately, this is not the case, as IEEE C62.41 only defines the surge environment and suggested test waveforms for the various surge risk locations. The absence of a uniform, industry accepted test plan leads to a variety of testing methods that can be as unique as the manufacturers themselves. For instance, some manufacturers may measure the clamping voltage directly at the connecting terminals of the SPD, whereas others might measure with 6" or even longer leads. Others may omit critical components such as an integral disconnect or fusing. Any one of these practices can dramatically affect test results. When comparing clamping voltage data, it is always a good idea to request certified reports that describe the construction of the test samples and detailed testing methodologies. This will provide a better understanding of expected performance when comparing SPD types.

Q: What is Sinewave Tracking?

A: Sinewave Tracking is a term that some manufacturers use to describe SPDs that have capacitive circuitry for the purpose of EMI/RFI filtering. Sinewave Tracking does not represent an enhanced or otherwise advanced filter technology.

Q: What is the difference between "per-mode" and "per-phase" ratings?

A: A protected mode can be defined as a path that includes at least one non-linear surge suppression component located between any one of the possible Line-Neutral, Line-Ground, Line-Line or Neutral-Ground AC power circuit locations. All SPD designs should be tested and rated for maximum surge current handling capacity as "per mode" since the quantity and type of suppression components can vary between modes. In contrast, a protected phase is commonly defined as the aggregate total of protection located between the common L-N + L-G modes. SPD manufacturers that advertise "per phase" or "total unit" protection rating without providing the per mode rating, could easily conceal SPD design types that are built on an unbalanced suppression circuit platform, or hide calculation methods which may include values of N-G or L-L modes within their per phase rating.

Q: Do GE SPDs protect all modes of the electrical power system?

A: Yes. GE SPDs protect all possible modes of the electrical power system. For 3 Phase 4 Wire systems, GE SPDs protect L1-N, L2-N, L3-N, L1-G, L2-G, L3-G, L1-L2, L2-L3, L3-L1 and N-G for a total of 10 protected modes. For 3 Phase 3 Wire systems, the protected modes are L1-G, L2-G, L3-G, L1-L2, L2-L3, and L3-L1 for a total of 7 protected modes.

Q: Are SPD "Response Time" ratings important?

A: Manufacturers that publish Response Time ratings for SPD assemblies are actually providing data that is based on a single suppression component, such as an MOV or Diode, rather than providing a rating that is based on testing of the SPD assembly. Speed of response ratings are not supported by any authoritative standards organizations that oversee Surge Protective Devices. Additionally, IEEE C62.62 Standard Test Specification for SPDs states the following:

"The surge voltage response behavior of a surge-protective device to the front of a wave depends on the rate-of-rise of the incident wave, the impedance of the surge source, the effects of protective device internal reactance, and the response behavior of conduction mechanisms within active suppressor elements. In other words, response to front of wave can be affected more by the test circuit conditions, including connecting lead inductance, than by the speed of response of active elements."

IEEE C62.62 goes on to state: "Consequently, specification of response to front of wave is deemed to be potentially misleading and an unnecessary requirement for typical applications of devices within the scope of this standard. In the absence of specific requirements, it is recommended that no specification, test, measurement, calculation, or other recognition shall be given for response to front of wave."

Q: What is a modular SPD design?

A: A modular SPD consists of multiple components or sub-assemblies that can be replaced by the end-user in the event of SPD failure.

Q: What are the advantages and/or disadvantages of modular SPD designs?

A: Some SPD manufacturers aggressively promote modular design while creating a respectable aftermarket business for replacement components such as fuses and custom SPD module assemblies. The prospect of acquiring an SPD that is assembled on a modular platform would seem to make good sense initially. However, one should first take into consideration SPD designs, and what causes them to fail prematurely. In most SPD designs, the primary suppression components are usually Metal Oxide Varistors (MOVs). When an MOV fails, it is normally due to exposure to elevated phase potentials that exceed the voltage rating of the MOV components. Once MOVs are exposed to abnormal overvoltage, they will begin to rapidly heat up in a process known as "thermal runaway" and subsequently breakdown into a permanently shorted condition within just a few power frequency cycles. It is then the job of the SPD assembly to withstand the available system fault current until the SPD fusing or external circuit breaker interrupts the flow of current through the SPD. In some SPD designs, MOV's will fail in a violent manner that affects surrounding components as well as the surge path structure. And in many such designs, the only containment mechanism may be the SPD's outer enclosure.

GE typically recommends that in the event of SPD failure, all protected modes and all fusing integral to the SPD should be considered for replacement. This functionally equates to a total unit replacement and should be specified regardless of design type, modular or non-modular. To understand this rationale, one must look at how SPD units are evaluated by UL for safety. UL requires an abnormal overvoltage (AOV) test be conducted on all SPD design types during the UL 1449 safety testing program. The AOV exposure introduces a phase voltage potential that is intended to drive the SPD components into a failed state. Both during and after the conclusion of the test, the SPD is evaluated to ensure that no flames or molten metal have been ejected, nor any openings created in the outer SPD enclosure. But of equal significance regarding SPD modular designs, the AOV test does not serve to demostrate or evaluate the capability of any SPD design to be repaired and placed back into service.

Q: What does the term "Cascading" mean and why should it be considered in the application of SPDs?

A: As recommended by IEEE 1100 (Emerald Book), SPD units should be coordinated in a staged or cascaded approach. IEEE provides the following recommendations:

"...for large surge currents, (transient) diversion is best accomplished in two stages: the first diversion should be performed at the service entrance to the building. Then, any residual voltage resulting from the action (of the suppression device) can be dealt with by a second protective device at the power panel of the computer room (or other critical load). In this manner, the wiring inside the building is not required to carry the large surge current to and from the diverter at the end of a branch circuit."

"...proper attention must be given to coordination of cascaded surge protection devices."

While lightning is the most well-known and spectacular producer of externally generated surges, it is only one source of transient over-voltage. Other sources include the switching of power circuits, the operation of electrical equipment by neighboring industries, the operation of power factor correction devices, and the switching and clearing of faults on transmission lines. It is important to note that lightning does not need to directly strike a power line for such damage to occur; a strike several hundred meters away can induce large damaging transients, even to underground cables.

Additionally, it is estimated that 70 to 85% of all transients are generated internally within one's own facility by the switching of electrical loads such as lights, heating systems, motors and the operation of office equipment. Modern industry is highly reliant on electronic equipment and automation to increase productivity and safety. The economic benefits of such devices are well accepted. Computers are commonplace and microprocessor-based controllers are used in most manufacturing facilities. Microprocessors can also be found embedded in many industrial machines, security & fire alarms, time clocks and inventory tracking tools. Internally generated transients that originate from equipment loads on secondary and branch panel circuits and on separately derived power systems cannot be effectively mitigated by a single point SPD at service entrance. This further re-enforces the IEEE cascading recommendation of placing SPDs at secondary panels which serve the most critical and sensitive electronic loads.

Q: I have heard that SPD designs using Silicone Avalanche Diode technology will provide better performance than MOV based SPD designs due to their faster response...is this true?

A: It is well documented that manufacturers who design SPDs with Silicone Avalanche Diode (SAD) technology will often push speed of response as a critical performance parameter. However, the actual performance for an SAD based SPD design is no better than that of an MOV-only SPD. This is because the "response time" of any parallel-connected SPD is affected more by the internal/external wiring leads than the speed of the SAD (or MOV) components themselves. For example, a SAD component may be able to react the front of a voltage surge waveform with sub-microsecond speed, but the internal wiring and external connecting leads within the SPD add inductance (about 1 to 10 nanohenrys per inch). This inductive effect is by far the dominating factor in overall SPD performance - not the theoretical SAD or MOV "reaction time".

FAQs

Q: Does GE offer both UL 1449 2nd Edition and 3rd Edition SPD models?

A: GE only produces SPDs that are compliant and Listed per the requirements of UL 1449 3rd Edition Standard. As of Sept. 2009. UL no longer allows surge protective devices to be listed or evaluated under the now obsolete 1449 2nd Edition standard. Be cautious of manufacturers who cannot produce proof of their current listing status as a UL category VCZA type SPD.

Q: Are GE SPDs Listed to UL 96A?

A: UL 96A is the standard for Lightning Protection systems. SPD designs, regardless of manufacturer, are not allowed to be listed under UL 96A. Instead, they are referenced by UL 96A and are required to be included as a sub-component within a UL 96A system. UL 1449 is the only UL Standard for SPD evaluation. GE SPDs are UL 1449 Listed and available as either Type 1 or Type 2 SPDs with a Nominal Discharge Current rating of 20kA. This listing and performance criteria allows GE SPDs to qualify as the primary form of surge protection that is required by the UL 96A standard to be used in UL certified Lightning Protection Systems.

Q: Do SPDs that also carry a UL 1283 Listing provide better EMI/RFI Filtering performance than an SPD that does not?

A: No. UL 1283 is a standard for safety. There are no tests conducted under the UL 1283 compliance program that would serve to demonstrate the noise attenuation or filtering performance of an SPD.

Q: What is the maximum allowable length that the SPD connecting wires can be?

A: Within the SPD industry, it is a well-known and documented fact that the length of connecting wires can significantly affect the clamping performance of any parallel installed SPD, regardless of manufacturer or model type. However, there is not a well-defined answer to the question, "what is the maximum lead length that will still enable the SPD to perform without compromising the safety of protected loads?" For example, a SPD installed with 6 feet of connecting wire will still provide protection to loads, and can still clamp at a level that is lower than the sparkover clearance or surge immunity level of most electrical equipment, but at the same time, it will usually allow higher peak let-thru voltages to be realized at protected loads versus a SPD connected using only 3 feet connecting wire.

How this will affect the electronic loads depends on many things, including their sensitivity or surge immunity withstand ratings. In addition, if there are plans to add surge protective devices on secondary panels, a higher let-thru voltage at the primary panel might be less critical because of the cascading effect provided by using multiple SPDs as a suggested practice in IEEE 1100 –2005, Powering and Grounding Standard (Emerald Book).

If it is impossible to reduce the distance between the SPD and panel, there are a few practices that can mitigate the inherent inductive effects of cable. Weaving or twisting the connecting wires together will help reduce the inductive field. Ultimately, there is not a significant substitute for close proximity placement of the SPD to the panel. In most cases, SPD design has very little to do with this problem. Instead, it is the inductive effect of cable on fast rising transient surge voltages. The practice of using larger diameter cables is not a substitute for close installation either. The GE recommended practice is to mount the SPD in a position to allow for 3 feet of connecting wire or less. Ideally it would be suggested to maintain between 18" to 24", but we realize that this is not always practical for every installation.

Q: Which is better?...mounting the SPD integral to the electrical panel, or outside the panel as wall mounted?

A: The answer to this question should be based on the application. For new electrical distribution systems, installing the SPD integral to the panel or switchboard has a clear advantage over wall mounted. The reasons supporting this are:

1. Integral devices keep connection lead lengths to a minimum. This allows the device to give maximum protection. Longer lead length adds impedance to the SPD system, reducing the surge clamping effectiveness.
2. Integral devices reduce the overall amount of wall space required.
3. Integral devices reduce the risk of devices being installed incorrectly, possibly with long leads, incorrect voltage and incorrect device for the panel.
4. Integral devices reduce labor for the electrical contactor.
5. Integral devices reduce the number of shipments to the jobsite.

For existing installations or applications where there is not adequate room to add an SPD as integral, wall mounted SPDs might offer a better solution for the end-user.

Q: I have heard that integral SPDs can damage the electrical equipment or cause personal injury if they fail. Should I be concerned about this?

A: It is true that some SPDs manufactured prior to February 2007 were at risk for unsafe failure when exposed to abnormal phase over voltage on electrical systems with limited fault current availability. This potential for failure was due to both SPD design and the lack of regulatory safety testing at fault current levels lower than the SPD's short circuit interrupt rating. Updated in 2005 and becoming mandatory for all SPDs in 2007, UL 1449 Second Edition update (a.k.a. Feb, 2007 revision) introduced intermediate fault current testing requirements that cover the primary areas of concern about unsafe SPD failures at previously untested levels. Many within the SPD industry were required to take significant redesign measures in order to comply with the revised UL standard. As a result, SPD designs are safer today than ever.

Q: How was GE able to comply with the intermediate fault current revisions to the UL 1449 Standard?

A: In 2007, GE introduced a new line of SPDs that incorporate a unique thermal disconnect feature. Unlike traditional thermal cutoffs that are sometimes used in close proximity to a group of Metal Oxide Varistors, the thermal disconnect is attached directly to each MOV substrate via an eutectic bonding process. This design allows for a safe interruption of fault current at the component level by reacting quickly to the sudden heat rise generated by a failing MOV. The potential for catastrophic failure is greatly mitigated since the bonding alloy is designed to release during the initial stages of thermal runaway, allowing the MOV to be removed from the circuit before it has reached the critical point of expelling destructive material in the form of molten metal, fragments or fire. GE utilizes this enhanced thermal protection design on a complete product offering of integral, panelboard extension and wall mounted type SPDs.

imagination at work

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