Tech Byte 22: Why Surge Protection Awareness Must Increase

Surge Protection And Its Importance In Today's Electronic Environment

The surge protection device (SPD) industry has been met with significant change over the past couple of years. These changes range from new industry terminology, to revised standards and product classifications, to new focus on design strategies for tomorrow's SmartGrid. What has not changed, however, is the increasing need for quality surge protection devices and the increased costs of improper application in power distribution systems. In this paper, we will review important topics relative to the selection, specification, and application of Surge Protection Devices, as well as the cost impact of ignoring surge protection.

To begin our discussion, let us review some important industry data that pertains to how power quality anomalies are affecting today's businesses. This data will identify why properly applied surge protection is necessary for facilities of all sizes and types.

First, let us look at the SPD industry from a world-wide view. Frost & Sullivan released their latest report titled *World Transient Surge Suppressor Market* in August of 2010. In this document, they provide research data pertaining to the SPD industry, collected from industry participants, industry experts, end users, regulatory organizations, financial and investment communities, and other related sources. The data was compiled and used to illustrate trends in the market place, demand for SPD devices, and to forecast the future of the industry. Here are some intriguing findings from this report:

- *"Every year, billions of dollars in revenues are lost due to power-related problems. It is estimated that 50% of the data loss at computer installations is attributed to power quality problems. About 40% is due to transient voltage spikes and the remaining 10% is caused by other factors. More than 60% of transient voltages and surges originate within the facility and the remaining 40% occur outside the facility because of harsh weather conditions and utility grid switching."*

- *"The demand for transient voltage surge suppressors (TVSS) is likely to increase as power quality becomes a major issue for businesses and consumers using electrical power.* ***Failure to protect equipment and facilities from power line disturbances can result in production and revenue losses****."*

- *"With advancements in electronic equipment and increased use of microprocessors, transients and surges have become a common issue. Microprocessor-based equipment is more susceptible to damage due to greater sophistication and sensitivity of components."*

- *"As semiconductors continue to shrink in size while increasing in power density, the possibility of surge damage increases. This can lead to minor errors, deterioration, and gradual destruction of electronic appliances."*

- ***"Transients can be a perennial problem unless addressed, and the issue has gained significance as many industries are moving toward automating information and reporting systems."***

The study also projects that from 2010—2016, the expected increased proliferation of microprocessor-based equipment and continued reliance on personal computer use will impact the growth of the SPD industry on a high level. These findings should not be surprising. As technology continues to advance, electronic devices continue to shrink in size, but yet also become more powerful. This combination of smaller components and increased power leads to devices that are much more sensitive to power quality anomalies. Sensitive electronic devices can be found in PLCs, CNCs, industrial robots, soft start control systems, variable frequency drives, assembly process computers, industrial air conditioners, commercial refrigerators, motors, x-ray machines, MRI machines, CAT scanners, and water and oil well pumps, just to name a few. Ensuring the proper protection of these devices

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against power anomalies will be a focus of design engineers and facility managers for the foreseeable future. So how does the story look on a local level? Are we experiencing significant power quality problems here in the Midwest that are costing our local businesses revenue? How can we quantify this?

State	Aggregate Annual PQ Costs for Sectors Surveyed ($millions)	Estimated Annual PQ Costs for All Sectors	
		Low Estimate ($millions)	High Estimate ($millions)
CA	$766	$1,659	$2,630
NY	470	1,066	1,710
TX	431	986	1,587
PA	321	741	1,196
FL	318	710	1,135
IL	298	649	1,029
OH	269	598	954
MI	235	552	895
NJ	228	527	852
NC	224	498	794

Figure 1: Top 10 States With Highest Power Quality Anomaly Costs ($millions) (EPRI—*The Cost of Power Disturbances to Industrial & Digital Economy Companies*)

To take this discussion to a more local level, we can reference a study by The Electric Power Research Institute (EPRI), titled *The Cost of Power Disturbances to Industrial & Digital Economy Companies*. This study not only identifies the potential for power quality anomalies to cause outages, disruption, and loss of revenue, but it also provides this information relative to location within the United States. For example, Figure #1 shows EPRI's data relevant to power quality anomaly costs. These are costs attributed to anomalies ***OTHER than outages***, and are state-specific. What is interesting to see is the high power anomaly costs for the local Midwest area. Illinois, Ohio, and Michigan rank #6, #7, and #8 respectively for states suffering the highest business costs due to power quality anomalies ***across the entire nation***.

What these two reports show us is that power quality anomalies are currently causing a significant amount of revenue loss for local businesses. Based on Frost & Sullivan's findings, the expectation amongst industry experts is that this trend will only intensify moving into the future. As facility managers and design engineers, the best approach to attacking this problem would be to identify what power quality anomalies are most prevalent in our facilities. Once identified, industry best practices could be applied to address them, and reduce their potential for introducing downtime and losses.

The good news is that resources already exist that can offer insight as to what these problematic power anomalies are. The Frost & Sullivan *World Transient Surge Suppressor Market* report estimates, based on industry expert research, that 40% of all computer equipment damage or data loss is attributed to surge activity.

EPRI also provides similar data on the issue in a white paper titled *Equipment Damage Caused By Power Surges*, 2003. In this report, EPRI provides a break down of power quality anomalies that have contributed to equipment failures. This data was gathered through actual investigation of end users and insurance companies. Figure 2 on the following pages shows the typical power anomaly reported for an event causing damage, and the frequency that each was claimed. Lighting and surge activity constitute ***nearly half*** of all damaging events.

A contributing factor to their conclusion was data acquired from an insurance company, regarding claims made due to equipment damage over a given time period. The report states:

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- "*Between 1998 and 2001, this insurance company recorded 2017 payments to policyholders with claims of damaged equipment. Of those 2017 payments, 889 - or 44% - were made to claimants based upon damage attributed to either "lightning" or "surge," for an average of $2,700 per claim. Over those four years, the company paid out over 2.4 million dollars because of electrical excursions, an average of $600,000 per year.*"

Many other whitepapers and research documents exist that provide the same type of data with the same conclusions. Surge activity, whether internally or externally generated, is the most significant cause of damage or data loss of all power quality anomalies. It stands to reason then that a more focused effort on the design and implementation of an effective surge protection network in all power distribution systems will provide a significant return on investment in the form of reduced downtime and damage related costs.

The SPD Industry - What You Need To Know

Now that we know the importance of a properly designed surge protection network, it is important to have an understanding of the technologies that exist, standards that categorize them, and best practices for applying them. Let us now review some highlights of the SPD industry:

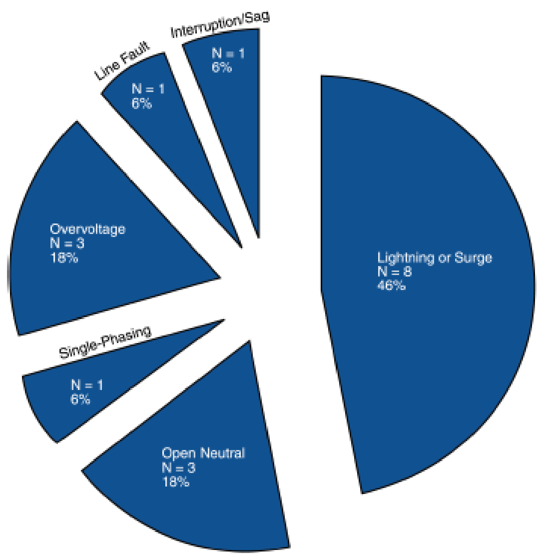

Figure #2: EPRI Data from *Equipment Damage Caused By Power Surges*

Highlight #1 - Surge Protection Beyond The Service Entrance:

An effective surge protection network only ***begins*** with a service entrance installed SPD. It does not ***end*** there. There are two realities that enforce the use of cascaded SPD devices throughout a facility. The first is the fact that 60% of all surges and transients are generated ***internally to a facility*** *(*Frost & Sullivan *- World Transient Surge Suppressor Market)*, beyond the protection of the service entrance SPD. None of this internal transient activity will be addressed without cascaded devices. Second, an SPD device can never become a zero impedance path to dissipate surge energy. It is not possible. Therefore, during those large, external surge events (lightning, grid switching), the service entrance device will still allow residual surge energy to travel downstream. Without cascaded devices, the residual energy can cause damage or operational problems. With cascaded devices, the surge energy will be reduced at sub panel levels. Figure 3 on the following page illustrates cascaded SPD protection.

Highlight #2 - SPD Technology Is Not Created Equally:

As with every industry, a variety of products and technologies exist for solving the same problem. How does one go about making an informed decision on what to specify? To begin with, an SPD product must be selected based on where its intended application will be within the electrical distribution. The new UL 1449 3rd edition standard created a classification matrix for SPDs, requiring that a given device pass certain tests in order for it to be used in a specific environment, such as service entrance or subpanel use only. Within each of UL 1449's classification categories, however, there are different levels to which the SPD can be tested and approved to. It is not adequate to simply specify an application category. This complicates one's efforts in trying to compare individual SPD device performance. For example, device "A", certified for type 1 categories, may show a lower voltage clamping performance than device "B" in its UL performance summary. However, it may have been tested with a much lower surge test current than device "B", which was also tested for type 1 category use. Which device has the better performance? The key is to ensure that when specifying or comparing SPD devices, ensure that each device is certified to the same SPD category, AND is also tested using the same testing parameters within that category.

Although the UL 1449 3rd edition standard has required additional testing requirements for SPD devices, it still remains a safety related standard only. It accomplishes very little in comparing the actual performance of SPD devices. For example, the UL 1449 3rd edition standard only requires service entrance SPDs to be tested to a 10kA or a 20kA surge current. However, most service entrance devices will be specified at over 80kA. There is no ***mandatory*** performance testing requirement in the SPD industry. SPD manufacturers are not required to actually test their entire device to meet the performance specifications that they publish in their documentation. This fact has, and still does, open the door for questionable SPD rating tactics. Manufacturers are free to publish surge current capability of their SPD device based solely upon the performance of the internal MOV components, not including the NEC required fusing elements. Once these particular devices are fully assembled, most of them can only perform to a fraction of their published rating. This is because the required fusing limits the surge current diversion capability of the device. The fuses will blow before the MOV components can complete their job. That is not how an SPD device should operate, because it will only protect itself, not the loads it was installed to protect.

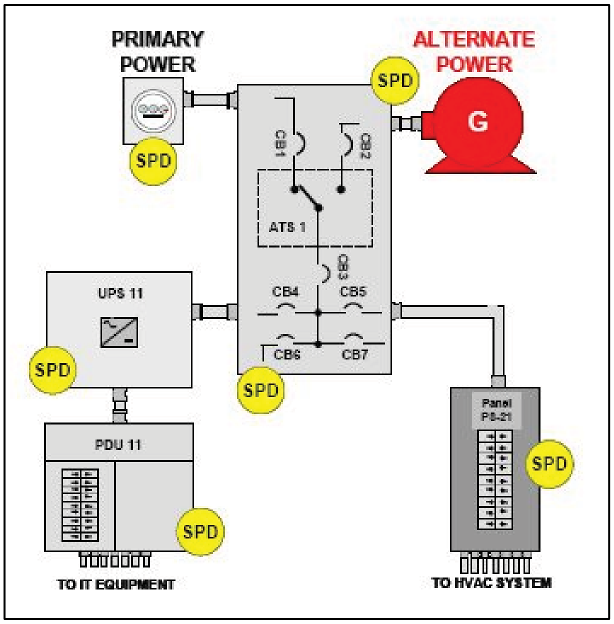

Figure #3: Cascaded SPD Protection

To protect against this situation, it is recommended that third party testing data be requested for any SPD device that is being specified. This test data should show, at a minimum, that the SPD was tested as a complete device and met its published maximum surge current rating. If a manufacturer is unwilling to provide such data, it should instantly raise some concerns over the actual capability of the device to perform to published data.

Highlight #3 - Integrating Surge Protection Devices Into Switchboards And Panelboards:

The case has been firmly made for cascaded SPD devices to be installed throughout various locations within a facility. However, the question of how these devices should be installed is a frequent topic of conversation. The two options for installation include switchboard or panelboard integrated SPDs or SPDs mounted externally to the switchboard or panelboard.

The case for integral SPD installation is typically supported with statements such as "cleaner, more simplistic, reduces installation errors, and shorter lead lengths." While there may be some potential truth to some of these claims in theory, ***integral installation does not guarantee any of them***. On top of this, many of these supporting claims offer justification in the way of simply making things easier for designers or installers. These are not claims that lead to a more safe and effective surge protection design.   There are three important considerations that ***fail to be mentioned*** when individuals speak in support of integral installation. These considerations are as follows:

- **Downtime / Safety Risk**: When an integral SPD requires service or replacement, the panelboard in most cases must be powered down and locked out, as the interior of the panel must be accessed. This is downtime that a customer would otherwise not have to experience with an externally mounted SPD device. Accessing the integrally installed SPD without shutting down the panel would introduce a risk to personnel safety in the form of exposure to lethal voltage. Again, this risk is not present with an externally installed SPD.
- **Collateral Damage Potential**: Of significant concern, per IEEE, is the collateral damage potential that exists in a TVSS failure event. IEEE describes this as follows:

  "When metal oxide varistors reach and end-of-life condition, they lose their ability to block normal system voltage and begin to conduct current continuously. The continuous current condition creates heat. The metal oxide varistor (MOV) initiates a conductive condition identified as thermal runaway that inevitably results in the destruction of the MOV. The resulting destruction of the MOV might expel hot metal fragments, conductive ionized gases, and dense conductive smoke and soot. In addition to immediate hazards, the introduction of such materials into the interior of electrical distribution equipment can damage or compromise an insulation system and result in a cascading effect and serious equipment damage. Resulting damage from cascading effects can be substantial when the electrical equipment, affected by the damaged MOV, is the service entrance equipment..."

Switchgear Collateral Damage Due to Failed, Integral SPD Device

- **Limitation of SPD Offering**: Almost all switchgear manufacturers offer a line of SPD products, designed for installation in their respective gear. What this means is that for a project specification that includes switchgear and integral SPD protection, the customer will end up with the SPD product that the winning switchgear provider offers. This is the nature of the bid-specification process for switchgear and integral SPD protection. Other approved SPD products are unable to compete in this scenario. This limits the customer's access to a vast offering of SPD products and technologies. On top of this, SPDs provided by switchgear manufacturers for integral installation are in nearly all cases those of the type that are not third party tested and proven to perform to their published data. With a specification requiring external installation, many different technologies and quality offerings become available to the consultant and end user.

External SPD installation offers a higher degree of personnel safety, a greater selection of technology offerings, and a reduction of downtime risk. Furthermore, IEEE recommends the practice.

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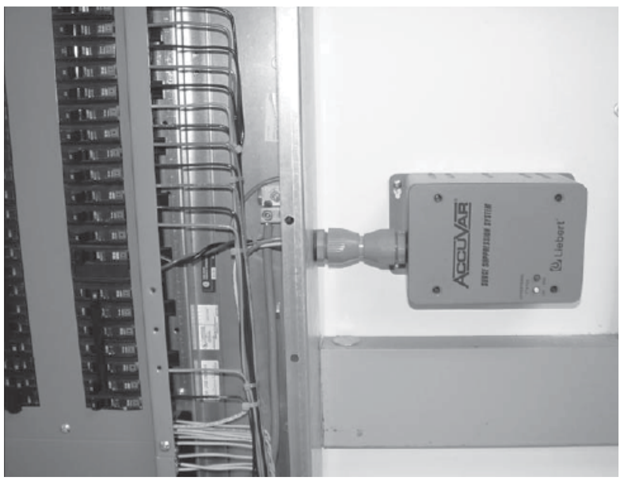
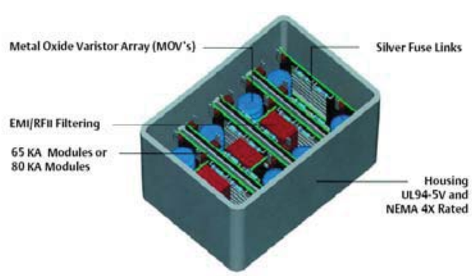
In summary, all facilities can gain from a properly designed surge protection network. Industry data supports the claim that addressing surge events in facilities will make a major impact in reduction of operational costs and downtime. Consideration should be made in the selection and design process to ensure incorporation of products that meet their published performance data, and that the design considers the impact of location and installation practice with downtime and personnel safety risk potential.



Externally Installed SPD Device On A Distribution Panelboard—Fed From Panelboard Branch Breaker

Liebert SI Interceptor II
Category Type 1 - Service Entrance Rated



Liebert ACCUVAR
Category Type 1 - Service Entrance Rated

Liebert TVSS Products: http://www.liebert.com/product_pages/SecondaryCategory.aspx?id=6&hz=60