



Seven Compelling Reasons Why Integrated Surge Protective Devices are the Best Choice in Surge Protection

Application Note

Introduction

This document is designed to point out the many performance and functional advantages that integrated surge protective devices (SPDs) offer. Choosing integrated units will provide you with the best and most effective method of surge protection. This fact will be demonstrated throughout this document by pointing out seven compelling reasons why integrated SPDs are the best choice in surge protection.

What is an integrated SPD?

An integrated SPD is one that is mounted inside a piece of electrical distribution equipment (panelboard, switchboard, switchgear, motor control center, or other device). These units are most often installed when the electrical panel is manufactured, along with circuit breakers and other items. The SPD becomes part of the UL listed panelboard, switchboard, switchgear, motor control center, or other distribution equipment. Although the practice is very rare, integrated units can also be installed within existing panels if ample space is available and if covered by the UL listing of the distribution equipment.

There are two methods of connecting an integrated SPD to an electrical panel:

- 1) Connected directly to the bus – In this installation, the SPD is bolted directly to the electrical panel's bus bar.
- 2) Connected through a circuit breaker – In this installation, the SPD is interfaced to the electrical bus through a circuit breaker.

Why choose an integrated SPD?

Before making a case for the superiority of integrated SPDs, let's first discuss the other option when choosing a surge protective device. The alternative to an integrated SPD is a sidemount unit. Sidemount

units are also called retrofit units and are mounted external to the electrical panel and interfaced to it via wires and conduit or other conductors. Sidemount SPDs can provide good surge protection if correctly installed. However, electrical performance is almost always better with integrated SPDs.

Why should application and specifying engineers, facility managers, and users choose integrated SPDs over sidemount versions? Below are seven compelling reasons that support the decision.

Reason #1- Integrated SPDs provide the greatest possible performance by providing the shortest possible lead length

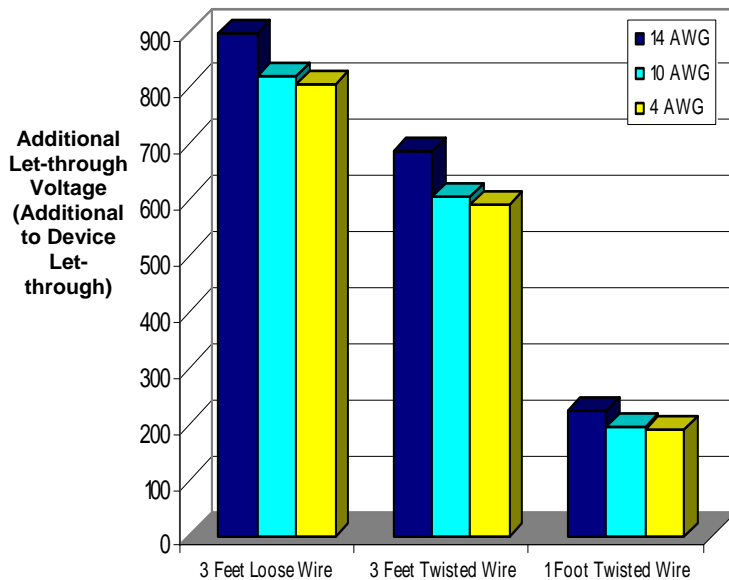
The single most important installation criteria determining the performance of an SPD is conductor lead length. Lead length refers to the length of the wires used to interface the SPD to the electrical panel's bus bars. Lead length and SPD performance are inversely proportional; as lead length increases, SPD performance decreases and vice versa.

An integrated SPD that is connected directly to the electrical panel's bus bars provides the shortest possible lead length. The effective lead length in such installations is approximately 3 inches. Notice that lead length was quantified in units of inches. Tests have shown that for every additional inch of lead length, an additional 15 to 25 volts of let-through voltage may be passed through the system.

Sidemount SPD installations typically utilize a minimum lead length of 18 to 24 inches. It is important to point out that 18 to 24 inches of lead length is a minimum number. In many sidemount installations, lead lengths of greater than 24 inches are utilized. Adding 24 inches of lead length to an

installation can result in additional let-through voltage of 400V when a high energy surge event occurs.

Why do inches matter? Refer to the graph below for independent test data showing the effect that additional lead length has on SPD performance. The performance effect realized by twisting the wires together was also tested. An IEEE defined standard waveform of 6000 Volts, 3000 Amps (C1 waveform) was utilized for all tests.



Three very important conclusions can be drawn based on the tests that were performed:

- 1) Three different wire gauges were utilized during the test. Lower wire gauge = lower impedance = slightly lower let-through voltage. As the graphs demonstrate, **wire gauge has a very small effect on the let-through voltage.**
- 2) Refer to the results of the 3 feet of loose wire versus 3 feet of twisted wire. Twisting the wires together decreases the mutual inductance between them, resulting in lower impedance. This practice resulted in let-through voltages that were decreased by approximately 25% as compared to untwisted wire of the same gauge and length. As the graphs demonstrate, **twisting the wires together lowers the let-through voltage but does not provide the greatest possible means of increasing SPD performance.**
- 3) Refer to the results of the 3 feet of twisted wire versus 1 foot of twisted wire. This practice resulted in the largest SPD performance increase. A decrease in let-through voltage of approximately 70% was realized. This data proves that lead length

has the greatest effect on SPD performance. **Shorter lead length = lower let-through voltage = greatest possible improvement in SPD performance.**

All in all, what did the tests prove? They prove that **integrated SPDs provide the greatest possible performance by providing the shortest possible lead length.**

Reason #2- The IEEE points out the performance advantages that integrated SPDs offer

The IEEE (formally known as the Institute of Electrical and Electronic Engineers, now known simply as "IEEE") is a non-profit organization that is the world's leading professional association for the advancement of technology. This organization publishes journals, magazines, articles, textbooks, and standards that provide guidelines for industry recommended best practices.

IEEE Standard 1100-2005, also known more commonly as *'The Emerald Book'*, provides references to the advantages that integrated SPDs provide. Section 8.4.2.5 contains the following statement: **"These devices (referring to SPDs) may be installed externally or internally to the switchboard or panelboard. Panelboards are available that contain integrally-mounted SPDs that minimize the lead length of the SPD conductors, thus optimizing the effectiveness of the device."**

The statement by the IEEE further solidifies the fact that integrated SPDs provide the most effective means of surge protection. There is no mention in *'The Emerald Book'* or any other IEEE publication that states anything contrary.

IEEE Standard C62.72 titled *'IEEE Guide for the Application of Surge-Protective Devices for Low-Voltage (1000V or Less) AC Power Circuits'* does not specifically point out any performance advantages that integrated SPDs offer but does contain a statement concerning lead length. The following text is found in section 16.2: **"Connecting conductors of SPDs should be as short as possible to achieve optimal SPD performance. Long lead lengths will add to the measured limiting voltage of the SPDs, and it could be necessary to select an SPD with a lower measured limiting voltage for use in that location."**

Recall the independent test data that was presented on lead length. The tests determined that lead length was the single most important factor related to the performance of an SPD and match the IEEE recommended practice of keeping the lead lengths as short as possible in order to achieve optimal performance. How is the shortest possible lead length achieved? It's by using an integrated SPD.

Reason #3- Integrated SPDs ensure the proper unit is selected and installed

SPD return statistics show that a sidemount SPD most commonly fails immediately after being energized for the first time. Why does this occur to a brand-new unit? The most common reason is the wrong SPD was selected for the application. If the proper voltage and configuration is not selected, the SPD can and will fail immediately. Selecting the proper voltage and configuration seems like an elementary task but misapplication occurs more often than one would think. Failures such as this are often not covered under warranty and the replacement costs must be incurred by the purchaser.

Purchasing an integrated SPD eliminates the chance of this situation occurring. Integrated SPDs are installed and tested by factory-trained professionals. This ensures the correct unit is selected, installed, and will work seamlessly when the electrical panel is energized.

Reason #4 - Integrated SPDs ensure the unit is installed properly

When a sidemount SPD is chosen, reliance is placed on the electrical contractor for the installation. Many electrical contractors probably do not install SPDs on a daily basis. If the installation instructions related to installing the SPD with the minimum possible conductor length are not followed, a sidemount SPD will have very high let-through voltage. This could be as ineffective as having no surge protection installed at all. It is important to note that even if proper installation practices are followed, in almost all cases an integrated unit will outperform a sidemount version.

Often the SPD is installed after the major electrical distribution equipment is installed. This often means that it is difficult to mount the SPD close to the panelboard or other distribution equipment. There may not be sufficient space between panels, or electrical conduit might be in the way, making it difficult or impossible to mount the SPD close to the electrical equipment it is designed to protect.

Reason #5- Integrated units have a lower installed cost – no additional installation or material costs are incurred

Integrated SPDs are installed when the electrical panel is manufactured, along with circuit breakers and other items internal to the panel. No additional installation costs are incurred. The unit is resident within the electrical panel and is ready to provide protection when the electrical panel is energized. No user or installer intervention is required.

Sidemount SPDs incur both installation and material costs. Installation costs are incurred when the electrical contractor installs the unit. Material costs are also incurred, as wires and conduit must be

purchased and utilized in the installation. Field installation costs can also be significant. Per hour labor rate charged by an electrical contractor can be up to \$75 to \$100 per hour.

Reason #6- High quality integrated SPDs require no user intervention or service

Some SPD manufacturers that do not offer integrated SPDs falsely claim that users are forced to work on and service integrated units while the panel is in a live, powered condition. High-quality integrated SPDs, including Cutler-Hammer® units from Eaton®, require no user intervention after the electrical panel they are installed within is energized. They contain no replaceable parts such as fuses, batteries for alarms and surge counters, or surge modules. When the panel is energized, they are ready to provide surge protection for their entire life, with no user intervention or service required.

Reason #7- Integrated SPDs take up less space within a facility

Integrated units are installed within the electrical panel and utilize no more space than the panel itself. Sidemount units are mounted external to the electrical panel and utilize extra wall space external to the panel. The extra wall space they take up can be utilized for other equipment if an integrated SPD is used.

Summary

There are many compelling reasons why integrated SPDs are the best choice in surge protection. First and foremost, they provide the greatest possible performance by providing the shortest possible lead length. Independent tests have proven this fact. This is also pointed out by the IEEE in the Emerald Book.

Application and specifying engineers, facility managers, and users should take the reasons highlighted within this document into consideration and choose integrated SPDs in order to ensure facilities are being protected from harmful surge events by the best possible choice in surge protection.

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