Fuse Confusion

White Paper

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Fuses react very differently to transient surge current as opposed to sustained overload current conditions. Fuses and fusing concerns become complex when contained within surge suppression equipment. Utilizing current limiting fusing in any SPD can quickly become counterproductive because the device's overall performance is hindered. These fuses greatly limit the total surge current capacity of a SPD to their own individual capacity. The causes of the hindrances are related to the various current ratings and the operational characteristics of specific types of fuses. While there are legitimate ways to compensate for this troublesome drawback, many suppressor manufacturers choose to misrepresent the facts and further complicate the issue.

What it all boils down to is simply summarized as fuse confusion. It is important to emphasize that the following paragraphs refer to current limiting fusing that is installed in series with entire suppression circuits. That is not to say that individual suppression components need not be fused; that is altogether different consideration.

Parallel SPDs

Modern surge suppressors typically utilize multiple suppression components attached internally and arranged into individual circuits that parallel the AC power source. Each suppression circuit conducts a design specified amount of transient surge current. These individual suppression circuits must operate identically, simultaneously, and in conjunction with each other. It is assumed that these circuits work together by conducting like current values during suppression operations to share suppression responsibilities. With this configuration, a surge suppressor's total rated surge current capacity is the sum of each suppression circuit's individual surge current capacity added together. If the suppressor utilizes 10 parallel-attached suppression circuits, each individually rated to conduct 10,000 amps of surge current, the product's total surge current capacity would be 100,000 amps.

It is desirable to fuse individual suppression circuits appropriately to maintain human safety considerations. Individual fuses should open if the suppression circuit draws current inappropriately. However, it is equally advantageous for the suppression circuits in the previous example to continue to pass repeated momentary 10,000 amp surge current pulses without sacrificing during the process. The problem at hand stems from the surge suppressor industry's practice of using surge current ratings as a yardstick to measure their products' transient surge current handling capacity. It is not uncommon to find surge suppressor specifications from various manufacturers boasting surge current capacities upward to a million amps. Even the low-end suppressor models carry surge current ratings of 100,000 amps or more. These figures are impressive and look good on paper, but, they present an important question: Can the surge suppressor truly withstand its full rated surge current capacity?

Current Limiting Fusing

The answer is no when the suppressor utilizes current limiting fuses to meet UL fire and safety requirements. Any suppressor that is labeled by the UL as being recognized or listed to the revised Second Edition UL 1449 has been subjected to sustained current limited overvoltage stress testing for a seven hour time period. Those suppressor products have also been tested to safely withstand fault currents ranging from 5,000 to 25,000 amps (depending on the level they are intended to protect). While inherently safe suppressor design parameters preclude the need for incorporating this type of fusing in their product's to pass these UL tests, many competing manufacturers are not as fortunate. They install fuses in series with their suppression circuits in order to comply with UL's safety requirements. While these fuses may be rated to handle appropriate fault current values, they cannot be relied upon to pass adequate levels of momentary surge current. The fuse, necessary to maintain a margin of suppressor safety, effectively defeats the poorly designed suppressor's purpose. A suppressor that is specified to suppress 100,000 amps or more surge current may be limited to a small fraction of its reported total surge current rating. The fuse opens before it can pass the suppressors rated values of momentary surge current. (Fuses are current sensitive components that are designed to be the weakest links in electrical circuits. It is intended that they open these circuits during overload current conditions.)

Load Current Amperage

There are additional fusing concerns associated with various fusing applications. The most familiar is the fuse's load current amperage ratings. For instance, a fuse rated at 10 amps is intended to open the circuit if it is called upon to pass more than 10 amps of current to its loads. Another common fuse selection consideration regards its AIC rating. Fuses rated for 10 amps may easily open as anticipated when called upon to pass a sustained 100 or even 1000 amps. However, when the demand is to withstand 25,000 amps of fault current, they may not be able to safely interrupt the circuit or they may allow too much current to pass before opening. They might not open or take too much time to react. In these instances, human safety is compromised. Unless, of course, the fuses are appropriately AIC rated.

Load current amperage and AIC fuse ratings are used hand in hand with each other. A 10 amp fuse with a 25,000 AIC rating tells the user it will open the circuit when called upon to pass overload current values in excess of 10 amps and it will safely interrupt the circuit when called upon to react to a 25,000 amp fault current overload. In any event, these various fuse values are all in reference to time durations lasting at least into millisecond ranges. Transient surge currents, on the other hand, refer to momentary current bursts that typically do not extend beyond low to high microsecond time periods. Fuses react very differently to transient surge current as opposed to sustained overload current conditions.

Surge Current Capacity

Fuses can be designed and tested to operate appropriately when subjected to very high fault current values. Fuses may also be legitimately labeled with very high AIC ratings. It is here where fuse confusion compounds. This is because there is an important third fusing selection criteria regarding surge current capacity. Surge current capacity ratings differ dramatically from AIC ratings and pose equally critical concerns for surge suppressor users. This rating refers to the amount of transient surge current that the fuse can safely pass without opening. Surge current occurs as a momentary burst at values many times greater than its load current amperage rating. Not all fuses are surge current rated. However, some suppressor manufacturers don't make that fact clear to their customers. They reference the fuse's AIC rating and use it interchangeably with surge current ratings. This practice is inappropriate and misleading at best. In a worst case scenario it is fraudulent. A fuse specification boasting a 100,000 amp AIC rating does not mean that it can conduct 100,000 amps surge current. The fact is that it may open long before coming anywhere close to passing those preferred levels of surge current.

Some manufacturers of surge suppressors attempt to circumvent the problem by utilizing surge rated fuses that are constructed with elements of silver as opposed to lead alloys. These fuses are readily available with reported surge current ratings up to 40,000 amps. Newer versions of these fuses are surge rated up to 100,000 amps. However, the theoretical performance characteristics of these fuses do not always jive with their actual measured performance characteristics. A great difference is recorded when they are repeatedly subjected to actual test pulses conducted under controlled laboratory conditions.

Conclusion

Surge rated fuses cannot be relied upon to allow surge suppressors to conduct very high levels of momentary surge repeatedly and still open appropriately under sustained overload conditions (as required in real world environments). Their internal elements deteriorate with use and over time as they are stressed by repeated suppression activities or short duration, lower intensity overloads. Their original performance characteristics become corrupted in real word applications. These fuses readily fail to render surge suppressors useless.