Choosing the Right Level of Protection

Peak Ampere Surge Current Ratings of SPDs

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One of the difficult tasks encountered when specifying a Surge Protective Device (SPD) is identifying and understanding the ratings associated with its application. There are many performance values and ratings associated with an SPD, such as Maximum Continuous Operating Voltage (MCOV), Voltage Protection Rating (VPR), Nominal Discharge Current (I_n), and Short Circuit Current Rating (SCCR). The most commonly misunderstood rating is the Surge Current Rating, typically quantified in kilo-Ampere (kA).

In today's market there are numerous SPDs with surge current ratings ranging from 10 kA through 1000 kA. How is the right surge current rating determined? Are there advantages with higher-rated devices? Does location matter? Are properly sized SPDs specified at the right locations?

The purpose of this document is to provide a clear understanding of what the surge current rating of an SPD represents and to answer questions through industry standards, Schneider Electric's power expertise, and over 30 years of experience providing surge protection. Ultimately, this understanding provides the framework to make an informed decision and ease the burden of properly specifying an SPD.

Surge Current Ratings: No industry definition

The peak ampere surge current ratings of an SPD are generally based on the summation of the capacities of the peak ampere rating of the individual suppression components used within a particular protection mode. Both line-neutral (L-N) and line-ground (L-G) modes are added together to represent a peak ampere rating per phase. (I.e. L-N 100 kA, L-G 100 kA provides 200 kA/phase).

Unlike the other SPD performance values such as MCOV, VPR, I_n and SCCR that have clearly defined test criteria, there is no industry consensus, nor an approved industry-standard definition or test procedures for peak ampere ratings.

In the past, NEMA LS-1 1992 had been commonly referenced for peak surge current performance. However, this document has been rescinded as of August 2009 and is no longer valid. This is due to a majority of the NEMA members (SPD industry manufacturers) not coming to consensus on testing and test procedures that would provide meaningful peak surge current performance data of an SPD.

The absence of an industry-defined procedure has provided opportunities for different SPD manufacturers to create their own definitions of peak ampere surge current ratings.

Higher Surge Current Ratings Don't Always Equal Better Protection

There are instances where a higher surge current rating does provide better protection. For instance, placing a 10 kA surge current rated SPD at a service entrance where it will be exposed to large surge currents can prove to be too much for such a device, and it may fail prematurely.

Using a higher-rated device, with its increased capacity and greater ability to withstand the large surges common to a service entrance environment, can provide better protection for the system.

However, when you get above a certain surge current (kA) level, the higher kA does not provide better protection, only a longer life expectancy for the SPD itself. (Higher kA devices use more surge components; more components sharing the surge load means less stress on each component).

IEEE states:

> "The selection of a surge current rating for an SPD should be matched to the expected surge environment and the expected or desired useful life of the device."[1]

Choosing the Right Level of Protection

Comparing two different automotive tires that have identical specifications except for their mileage ratings could be similar to comparing two SPDs with identical specifications except for their high kA ratings. One tire may be rated for 25,000 miles while another tire is rated for 50,000 miles. Both tires provide the same traction (performance) in different weather conditions and provide maximum control of the vehicle. The only difference is that under normal driving conditions it is expected that the higher rated tire will get twice as many miles of service. It is largely the same with SPDs, a larger surge current (kA) rated device is expected to have a longer active life.

Transient Size: What can you expect?

The size of any single internal or external transient will vary depending on its source and location within the electrical distribution system.

Per IEEE C62.41.2-2002, the levels of exposure within a particular surge environment based on location within the electrical system are:

Category C	Service Entrance	10 kV, 10 kA
Category B	Distribution	6 kV, 3 kA
Category A	Point of use	6 kV, 0.5 kA

When asked, "What is the number one cause of transients?" lightning is the most common answer. However, studies show that the majority of all transients (80%) are being generated inside a facility while only 20% are coming externally from the utility side.

While the externally sourced transients are definitely the more destructive type (Category C), the more common internally generated transients (Categories B and A) are slowly wearing down the systems integrity, and affecting the performance and life expectancy of the down stream equipment. When looking at a complete solution, both internal and external transients must be addressed.

IEEE identifies possible scenarios whereby external transient voltage and currents can be introduced into a system. In addition, it identifies the associated current that could be seen at the utility secondary distribution system feeding the service entrance of a facility.

Annex A.2.1 of IEEE C62.41.1-2002 (Figure 1) describes the scenario of a direct lightning strike terminating on the conductors of an overhead secondary distribution system. In this scenario, a 100 kA stroke at a utility pole will divide and take multiple directions seeking a path to ground. One should not expect the entire transient to be focused directly at one building.

The example shows that a 100 kA lightning stroke could result in 30 kA of surge current at the service entrance to a facility (30% of original current).

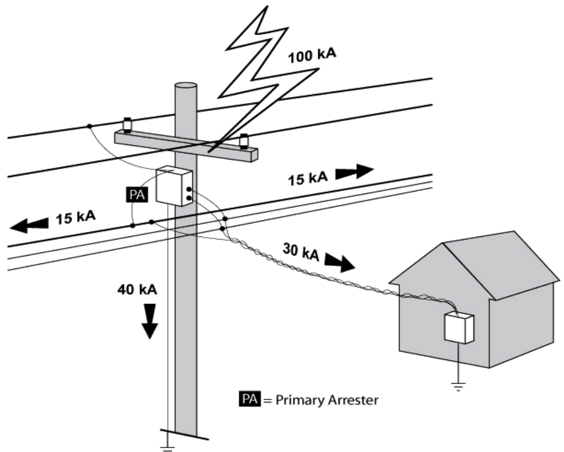

Figure 1: IEEE C62.41.1-2002, Annex A.2.1

How frequent are these lightning strokes that contain large amounts of current? Data from IEEE shows that only 5% of all strikes would reach or exceed peak currents of 100 kA. The majority of lightning strikes vary from a few kilo amperes through the median values of 20 kA.

Schneider Electric's own Lightning Study[2] supports the findings within the IEEE data.

Large transient surge currents typically associated with a lightning stroke are very rare. They are so rare that IEEE indicates that the probability of 100 kA or greater impulse striking any particular utility distribution line or pole would be 1 per 8,000 years.[3]

Annex A of IEEE C62.41.1-2002 also provides information demonstrating the physical impossibilities for high surge currents making it to the point of the SPD or into a building. Since the basic insulation level (BIL) of a typical electrical system is approximately 6,000 volts, the high voltages that accompany high surge currents will flash over prior to reaching the SPD.[4]

From these scenarios it is clear that higher-rated surge current (kA) devices offer no real benefit over lower-rated devices when comparing their abilities

Choosing the Right Level of Protection

to shunt large amounts of current. This is due to limiting factors within the distribution system that keep the SPD from experiencing extreme currents. The advantage of the higher-rated device is the ability to handle more transient surge events over time, not necessarily larger individual transient surge events.

How to Properly Size SPDs

There is very little published data or even recommendations on what level of surge current (kA) rating should be used in the different categories or locations. IEEE has provided some input on what surge ratings are, and how to interpret them, but does not publish recommendations. Also, there is not a proven equation or calculator available to input system requirements and receive a solution. Any information a manufacturer provides, via calculators or other means is merely their recommendation.

As a result of its many years of knowledge, experience and expertise in the energy solutions industry, Schneider Electric has generated an SPD Application Guideline; a strait forward, simple approach to applying surge current ratings (Table 1).

To optimize the level of suppression throughout a system, SPDs should be installed at all levels of the distribution system. This is known in the SPD industry as cascading (or layering).

Choosing the appropriate Surge Rating for an SPD comes down to two things:

1) The location of the SPD within the electrical distribution, and;
2) The location of the facility (environmental surroundings)

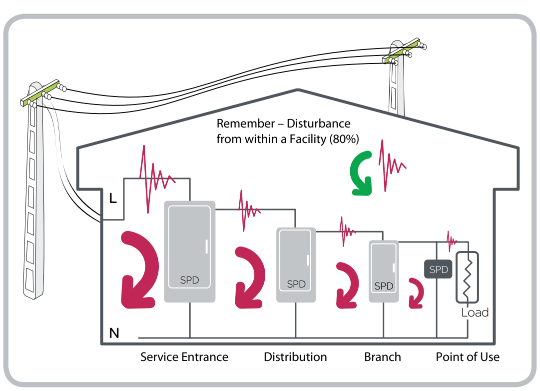

Figure 2: Cascaded Surge Suppression

Cascaded surge protection provides additional suppression from large transients that step their way through from the service entrance by reducing the let-through voltages even more. It also provides suppression from the more frequently generated internal transients.

The surge environments for these cascaded SPDs are not as harsh (Cat B and A) as if located on the service entrance (Cat C), therefore, the surge ratings of these downstream SPDs should be reduced (refer to Table 1).

To summarize the information in Table 1, Schneider Electric recommends the following surge current ratings based on SPD location within the electrical distribution.

Service Entrance Locations	**240 kA**
Distribution Locations	**120-160 kA**
Branch Locations	**50-120 kA**

Earlier discussions highlight the fact that larger more destructive surge currents are mostly found at the facility service entrance. On very rare occasions, for example if the exposure level is 'Extreme' (e.g. rural Florida), it might be wise to increase surge current ratings. Not that the SPD will be exposed to larger surge current events, but the SPD can be exposed to more surge events before it needs to be replaced.

Schneider Electric's experience shows that a device carrying a surge current rating of 240-250 kA provides many years of service in the 'High to medium' exposure locations.

Conclusion

The primary purpose of an SPD is to shunt and suppress the transient voltages that are being introduced into an electrical system from either an external or internal source. Selecting the proper surge current (kA) rated SPDs throughout the electrical distribution system provides the best performance life for equipment.

Keep in mind:

- Providing proper surge suppression to a facility and the equipment within requires more than a single SPD located at the service entrance. Schneider Electric recommends cascaded SPDs and a proper surge current rating for each location. This will provide superior suppression. A single SPD, no matter

Choosing the Right Level of Protection

how big or expensive, will not provide the same level of system protection.

- Over-sizing an SPD for its application cannot hurt a system, yet under-sizing the SPD can result in premature failure of the SPD, leaving systems exposed to transients and their effects.
- For direct lightning strikes, SPDs alone are not a replacement for a comprehensive lightning protection system (required for UL96A Master Lightning Certification).

Following the Schneider Electric Application Guidelines for sizing and placing SPDs throughout an electrical distribution system (Table 1) takes the guess work out of selecting the appropriate SPDs for the appropriate locations and maximizes your surge suppression at every point. Remember, bigger isn't always better.

References

1. IEEE C62.72-2007, Sec 16.5
2. SE Lightning Study – 1300DB1101
3. IEEE C62.41.1-2002, Annex A.2.1.1
4. IEEE C62.41.1-2002, Annex A.2.1.3

Table 1: Application Guidelines

Exposure Level	Surge Rating	Environment	Internal Mount	External Mount
Extreme	480 kA 320 kA	• Larger ampacity service entrance • Extreme lightning area • Other large industries in area • Large facility in rural locations	• Switchboard • Switchgear	• Modular (EMA)
High to medium	240 kA 160 kA	• High lightning areas • High to medium ampacity service entrance • Service entrance switchboards • Service entrance panelboards	• Switchboard • Switchgear • MCC • I-Line™/QMB Panel	• Modular (EMA) • Brick (EBA)
Medium	160 kA	• Distribution switchboards • Branch circuits not protected by a SPD at service entrance • Panels feeding heavy industrial motors • Branch circuits feeding loads outside the facility	• Switchboard • MCC • I-Line/QMB Panel • NQ/NF Panel • Busway	• Modular (EMA) • Brick (EBA)
Medium to low	160 kA 120 kA	• Computer equipment loads • Branch circuits with no upstream surge suppression	• Switchboard • MCC • I-Line/QMB Panel • NQ/NF Panel • Busway	• Modular (EMA) • Brick (EBA)
Low	120 kA 100 kA 80 kA 50 kA	• Branch circuits well inside the facility • Branch circuits with very sensitive loads and upstream surge suppression	• NQ/NF Panel	• Modular (EMA) • Brick (EBA) • Nipple Mount (HWA)

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