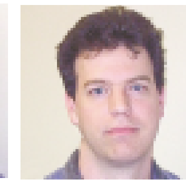
Specifying the Right Ratings for Surge Suppressors

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The Key to Specifying the Right Suppressor is Understanding that the Amplitude of a Lightning Strike is Unrelated to a Power Line Surge.

Let's jump to the bottom line: specifying surge suppressors with ratings above 250 kA per phase is overengineering that needlessly increases your clients' investment in electrical protection. It is analogous to specifying a 4/0 cable to feed a 20-amp outlet, or a 64-circuit loadcenter to supply a one-bedroom apartment.

Yet, and despite the obvious folly of such overengineering, some manufacturers of surge suppressors are recommending it, insisting that ratings of 500 kA, 800 kA, even one thousand kA are needed. They have ratcheted up the ratings during the past few years, arguing its validity by pointing out that lightning strikes of up to a thousand kA can, and do, impose those same amperages on facility wiring (untrue).

The continuous ratcheting raises other important questions: are lightning strikes carrying more energy now than in the past? (not that we know of), and at what rating will the ratcheting end? (when consultants and other specifiers say so).

The Plain Truth About Lightning Strikes

Lightning strikes are the flashes that jump between clouds and earth; their currents vary widely. Virtually all–99.98 percent by the best estimates–carry an initial current of less than 220 kA; about fifty percent of all strikes carry a current of less than 18 kA.

According to the IEEE, the amplitude of lightning strikes varies from a few kA, through the medium values of 20 kA, to the exceptional values (only 5 percent of all strikes) in excess of 100 kA (see Figure 1).

Regardless, the magnitude of strike currents is irrelevant when specifying surge suppressors. Why? Because when a strike hits a power line, service entrance, or building it follows the paths of least resistance. Most of its energy is shunted to ground through the power provider's arresters installed on distribution poles, other arresters installed at the facility's service entrance, the building's structural and plumbing systems, and lightning rods. (see Figure 2) The remaining energy, by now a small fraction of the energy in the initial lightning strike, enters the facility's power system by inductance or capacitance. Several major conclusions can be drawn from these facts:

1. The induced or capacitive current creates a transient impulse (Fig.3) that lasts less than one-half cycle with a maximum amplitude of 20kV, 10kA (8x20 µs surge as recognized by IEEE 62.41.
2. BIL limitations prevent higher currents from traveling down conductors to valuable equipment, causing arcing. In fact, low voltage wiring (defined as fewer than 1000 volts by the IEEE) would have trouble carrying a combination wave of 20 kV, 10kA without exceeding 6000 V BIL ratings. Therefore it is impossible for the high current (ie > 500 kA) claimed by some surge suppression manufacturers to travel into a facility.

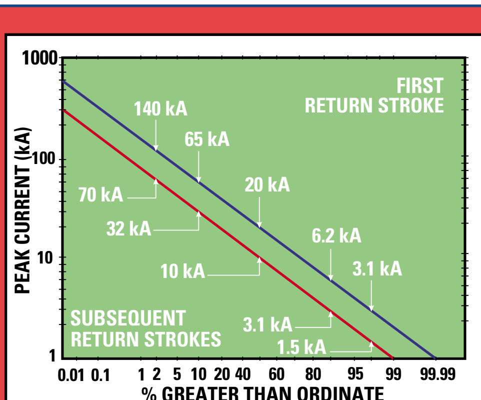

Figure 1: Distribution of Lightning Strike Current. Only .02 percent of all lightning strikes carry currents of 225 kA. The median amplitude is less than 20 kA.

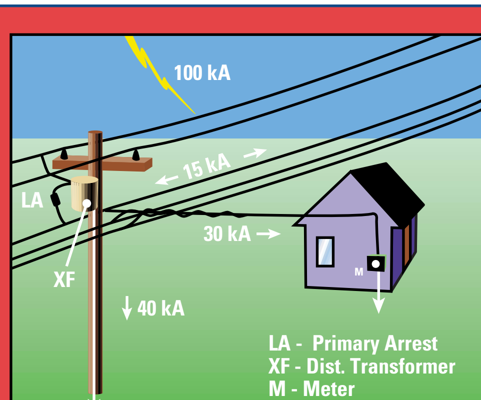

Figure 2: A lightning strike will seek paths to ground according to the impedance of paths to ground according to the impedance of each path of parallel combination. The relative values shown on the diagram are arbitrary, selected to illustrate the concept.

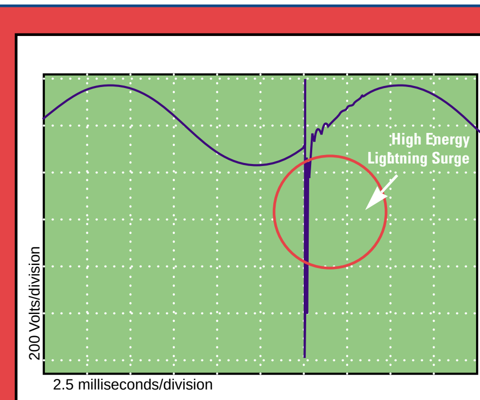

Figure 3: Lightning can produce surges with high voltages and currents, but the duration of the surges is short, typically fewer than 100 µs.

A Prudent Design Approach

A rational, deliberate approach to the design of a practical surge protection system must balance, simultaneously, at least four variables:

1. The frequency of lightning strikes (or, the degree of environmental hostility), depends heavily on geography, and is generally expressed as strikes/square km/year (see Figures 4a and 4b).
2. The amplitude of lightning strikes, which has already been addressed.
3. The degree of protection desired based on the integrity and sensitivities of the equipment to be protected, the characteristics of the electrical system, and the performance of surge protective devices, including…
4. The life expectancy of arresters/suppressors, which is directly related to the rating of the device and the frequency and amplitude of strikes.

UL requires that facility surge suppressors in service entrance applications be tested to 10 kA per phase to assure safety and reliability. Yet, Cutler-Hammer recommends actual ratings from 50 kA up to 250 kA per phase. The reason is life expectancy, not added protection.

A service entrance suppressor will be subjected to thousands of surges of various magnitudes; each will shorten the life of the suppressor by various degrees. Statistical data indicate that suppressors installed in, say, Florida, the lightening capital of North America, and rated 250 kA per phase, can be expected to remain in service for 25 years or more, even longer in areas where lightning strikes are less frequent.

Failure of a suppressor is extremely rare, and is generally caused by a swell or temporary overvoltage (TOV) on the utility's power line, i.e., when the voltage on a 120 V line rises to 170 V or higher for short periods of time. Therefore, it's apparent that no engineering or other value is derived from ratings of suppressors that exceed 250 kA/phase.

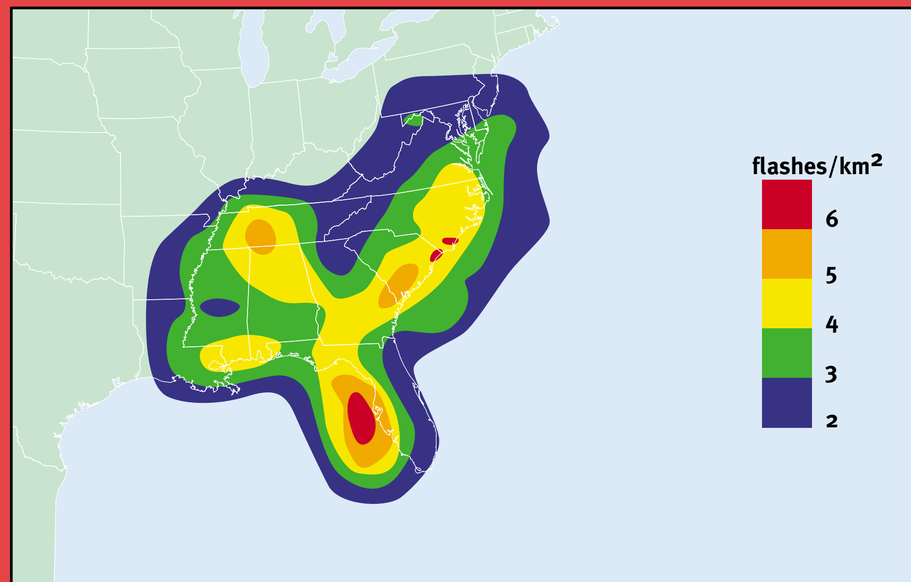

Figure 4a: The density of lightning strikes in the Eastern and Midwestern states varies widely from 6 km^2/year in Central Florida, Coastal South Carolina, and South Central Tennessee to only 1 km^2/year throughout most of the Midwest and Northeast.

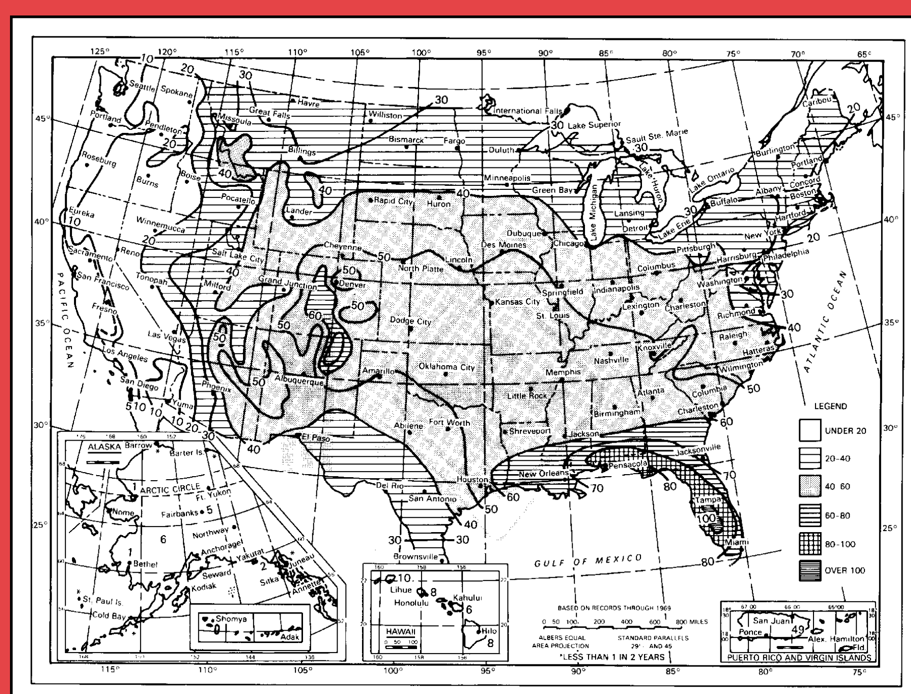

Figure 4b: Exposure to lightning can be related to the number of thunderstorm days/year in a geographic area. The area just south of Tampa, Florida, is highest, at more than 100 thunderstorms/year, followed by the rest of Florida and a good part of the Southeaster United States. Suppressors of higher ratings should be specified in areas of higher densities, not because they offer greater protection, but because their service lives will be longer.

Conclusion: Specify Up To 250kA/Phase

There is absolutely no direct relationship between the amplitude of lightning strikes and the amplitude of surges—also called transient impulses—on power lines.

Surges can enter the facility's incoming electrical, telephone, and coaxial conductors, requiring that prudent design protect all three paths. Surge suppressors rated 250 kA per phase will protect AC power lines against all recorded lightning strikes, and will remain in service for 25 years or longer even where lightning strikes are most frequent. Protection is not increased by specifying suppressors rated higher than 250 kA, but cost is, and facility owners will pay for protection that is unwarranted.

1 IEEE 62.41-1991. Reaffirmed 1996.   2 IEEE 62.41-1991, Appendix B, paragraph B1.   3 Surge and Temporary Over Voltage Protection Considerations for Remote and Wireless Telecommunications Sites, by Russell Barss and James Funke, Cutler-Hammer.   4 Orvill, R. E., Henderson, R.W., and Pyle, R. B. Lightning Flash Characteristics: 1987. Interim Report el-6413, August 1989, Electric Power Institute.