ELECTRICAL SURGE PROTECTION: GROUNDING

From Computer-Aided Dispatching and digital radio equipment to 5G smart phones and 3D mapping, complex electronic systems and equipment are becoming absolutely essential to the ability of an Emergency Services Organization (ESO) to provide critical public safety services to their communities.

The backbone of contemporary E-911 communications is electronic and is extremely sensitive to electrical surges relative to analog devices from previous decades. "Digitizing" ESO operations absolutely requires robust lightning and lightning-related surge protection in order to prevent interruptions in the mission-critical services ESOs provide. As will be discussed below, whether surges are incurred as direct lightning strikes or enter the location from other outside sources, either path into an ESO is unacceptable and must be prevented to the extent possible.

Unfortunately, many ESOs overlook their lightning protection strategies when systems and equipment are enhanced or replaced. While the overall concept of electrical grounding is generally considered a rote exercise, such protective measures are essential in our electronic world. It is important to keep in mind that properly designed lightning protection and electrical grounding systems protect equipment and personnel from the destructive and potentially dangerous energy of lightning and lightning-related surges.

To help improve the understanding of lightning protection and grounding, this communiqué will briefly address three critical aspects of lightning protection:

1. The basics of highly effective exterior and interior electrical grounding techniques,
2. Understanding how and why your lightning protection system works (or doesn't), and
3. How to evaluate the performance of a protection system.

THE BASICS / EXTERIOR CONSIDERATIONS

The most important rule with respect to truly effective lightning protection is to prevent any surge from entering your structures. In other words, do everything you can to arrest and dissipate any excess current or voltage from any source while it is still outside the walls of your Emergency Communications Center, transmitter shelters or ESO. To do this, a network of highly robust grounding devices must be irreversibly connected to any conductor or path that a lightning-level surge may take to gain access to your structures and towers. That means, a single grounding network must be bonded to:

- the grounding leads of your commercial power supply and all other utilities,
- all "ground kit" grounding wires attached to every coaxial cable from any nearby antennas,
- all tower buss bars (if present),
- any bulkheads where coaxial cable passes through walls to the interior of your structures, and
- any buss bars or cables that aggregate grounding conductors running from any interior equipment or structural feature.

When all possible conductive paths into your structures are bonded using large wire gauge grounding conductors (at least 3/8-inch diameter or "AWG 2/0"), surge current from any source has an "exit ramp" to dissipation in the Earth—provided the actual grounding device is of sufficient capacity and resiliency. The goal at this point is to ensure that surge currents "see" exterior grounding devices as significantly more "attractive" in terms of flow and resistance, versus the valuable, expensive, mission-critical equipment housed in the ECC and associated structures. When this is accomplished, the probability of lightning and surge damage is dramatically reduced.

The essential step here is to ensure the devices used to dissipate surges are truly up to the task. More information will be supplied on this below.

THE BASICS / INTERIOR CONSIDERATIONS

Concerning interior measures for lightning protection and grounding, a similar highway metaphor applies as a must-do rule: if surge currents from any source somehow are able to enter your facility there MUST be a superhighway in place for these damaging charges to leave your buildings BEFORE they find your critical equipment—and this highway must be far more attractive as a path for fault currents than the circuitry of your essential electronics.

To do this, any equipment or location within your buildings that requires protection must be bonded* by wire to provide a low resistance route to grounding conductors that progressively improve the ability of fault currents to exit the affected structure. As the number of inputs to a grounding conductor grow, the conductor itself must have increased capacity to carry charge. Too often, an interior buss bar is the terminating point for a dozen or more grounding leads from equipment and their bonded racks—while the exit from this buss bar is a single, small gauge wire that is eventually connected to an insufficient grounding device somewhere outside the affected building. The electrical resistance generated by this arrangement nearly guarantees damage to equipment due to the inability of surge current to exit the building.

The last thing one wants when surge currents do manage to get inside is to make it difficult for these uninvited guests to leave. Better to give them an open door that they'll happily use.

Another very common strategy is the use of so-called "surge suppressors" to prevent entry. While this approach has some beneficial features, fully relying on such devices is not wise. Surge suppressors have serious limitations:

- When a surge reaches a suppressor, it is already inside your facility. Unless the suppressor can capture 100% of the surge and route it outside to an appropriate grounding device, your equipment, including the suppressor itself, is at risk. (Some suppressors are designed to be sacrificial, but this is also a cost that can be prevented with proper grounding.)

- In nearly all cases, surge suppressors offer no protection whatsoever to fault current that may be flowing on the neutral line of commercial power. A wide variety of electric utility companies now acknowledge that neutral-conductor faults are extremely common and damaging—and they have very little ability to control these faults, especially at the instant the fault surge occurs.
- Suppressors often do intercept lower energy, lower frequency faults, but by the time they do, high energy, high frequency current has already initiated a cascade of damage within your facility.

By combining these basics for exterior and interior lightning protection, a very simplified approach to effective risk management for surge events emerges. Make sure you have a great place for fault currents to go, and make sure their trip there is quick, easy and uneventful.

However, what many existing industry standards for grounding and lightning protection present as "sufficient" may not be that at all—particularly with respect to protection of electronic equipment. That's because many of these standards are derived directly from codes and rules for grounding developed well over fifty years ago—when electronic communications and management equipment were rare. Traditional grounding systems can reduce damage in some degree, but they are extremely limited in their ability to fully protect electronic equipment. w

* In terms of electrical wiring, "bonding" is defined as creating electrical continuity to ground of devices and metallic objects that may be exposed to an electrical fault or induced current to ensure an extremely low resistance path to ground.

HOW AND WHY YOUR LIGHTNING PROTECTION SYSTEM WORKS (OR DOESN'T)

At its most elementary level, lightning is nothing more than a massive balancing of electrical charge between the atmosphere and the Earth. In micro-seconds pathways are created to allow the discharge of more than 250,000 volts driving in excess of 30,000 amps of electricity, the power of which is truly dangerous. Ensuring this energy stays away from mission-critical equipment and humans is the job of lightning protection systems.

As mentioned above, electrical grounding is at the core of all lightning protection systems. And this grounding must be stout enough to conduct and completely dissipate tremendous energy.

The job of a lightning protection system is to ensure a massively-emitting, very low resistance path to Earth is available for very large discharges of current—thus preventing the "cooking" or electronic equipment or injury to humans.

Making sure your ESO has been designed with proper attention to lightning protection is a wise move for the entire Public Safety community.

While your lightning protection system is supposed to simply be that very low resistance path to the Earth for excessive electric current that may arrive in a variety of ways, in some cases, grounding systems and lightning protection at ESOs are very poorly designed or are not sufficiently maintained.

Problems may be on the horizon if:

- You notice grounding cables (typically green) in your equipment room are disconnected, missing or damaged.
- You see corrosion at or on any grounding points outside your buildings.
- Your main buss bars or those mounted on your towers and buildings have dozens of input lines and only one small gauge wire going to your grounding system, and/or
- You can't find more than one or two ground rods on your entire site.

These four observations may provide quick answers to why your operation is suffering regular equipment losses or has poor transmission signal quality.

HOW AND WHY YOUR LIGHTNING PROTECTION SYSTEM WORKS (OR DOESN'T)

Armed with a basic understanding of which aspects of lightning protection your site has and where it may have shortcomings is great "ammunition" to have when you go to the next step—and have your ESO undergo a complete grounding and lightning protection audit.

It is important to stress the understanding that effective lightning protection is changing. It is essential that your protection auditor is aware of these up-to-date methods. Standards based on half-century old techniques—that were written when fully-electronic communications and information management devices were rare—are now possibly obsolete. Even well-known vendor-written standards, as well as those published by large professional organizations are quickly being identified as outdated in key areas of protection.

Your VFIS agent can make helpful recommendations on companies that are on the front lines with respect to superior lightning protection and grounding—and are fully capable of communicating wise and financially prudent solutions for your facilities with minimal disruption to your operations or consumption of your time.