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WATER *stewards*

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- Lightning Protection for Water and Wastewater Plants
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LIGHTNING PROTECTION FOR WATER & WASTEWATER PLANTS

BY BRUCE A. KAISER, CEO, LIGHTNING MASTER CORPORATION

Plant operator quiz: One south Florida wastewater plant suffered multiple, serial pump bearing failures in the same area of the plant. Operators soon noticed that the failures always occurred a few days after a suspected lightning strike. The causes of the pump failures were eventually determined to be:

A. Faulty bearings
B. Angry micro-organisms with tiny wrenches
C. Lightning

Although B. was strongly suspected by several operators, it was eventually determined that the cause was C. When lightning struck nearby, the secondary effect current flow through the bearings would cause pitting, leading to total bearing failure.

Although a direct lightning attachment is truly impressive, and will probably destroy most electronics, direct strikes are relatively less frequent than nearby strikes. If you look at the footprint of an entire plant plus its immediate surroundings versus the footprint of a single structure, lightning is obviously much more likely to strike nearby than directly.

Therefore, most of the damage caused by lightning is secondary effect damage, EMP damage, or damage caused by changes in ground reference potential. A nearby strike is much more likely to occur, and nearby strikes generate these indirect types of damage.

Secondary effect damage is caused by the motion of ground charge toward the point of a lightning strike. Immediately before a lightning strike, there is an area of ground charge underneath the storm cloud. When lightning strikes it changes the potential of the ground charge at the point of the strike, the surrounding charge rushes toward the point of the strike. This inrush of ground charge can cause arcing. If the arcing takes place within electronics, it can damage the electronics. If it takes place in a bearing, such as in a pump, it can scar the bearing and cause premature wear.

EMP damage is caused by transients induced into wiring by the electromagnetic pulse emanating from the current flowing in the lightning channel. The EMP, similar to that associated with the dreaded high-altitude nuclear blast, can damage microprocessor-based equipment. Actually, that equipment does not even need to be operating or connected. We have seen high-speed processors damaged in their shipping containers.

Damage caused by changes in ground reference potential is a close cousin of secondary effect damage. In many plant systems, a transmitter is located remote from the CPU. The transmitter is at the potential of the point on earth where it is located. The CPU is at the potential of the AC power service feeding it in the control room. If there is a lightning strike closer to one than the other, there will be an almost instantaneous and perhaps massive difference in potential between the two. Current divides and takes all paths. Some of that current will flow along data wires connecting the two. In effect, the equipment is wired in series with path-to-ground, so it will experience current flow, perhaps damaging that equipment.

The use of faster electronics translates to more lightning problems. Analog systems were relatively immune to the effects of lightning. Digital systems are more susceptible, and high speed digital systems even more so. If you want to make a device operate faster, you cannot make electricity go faster. Therefore, you have to make the distances it travels shorter. Shorter distances equal less breakdown voltage, therefore more susceptibility to lightning-caused arcing.

The solution to these indirect types of lightning damage is correct grounding and appropriate surge suppression. Add structural lightning protection, and you have the third leg of a complete lightning protection design solution.

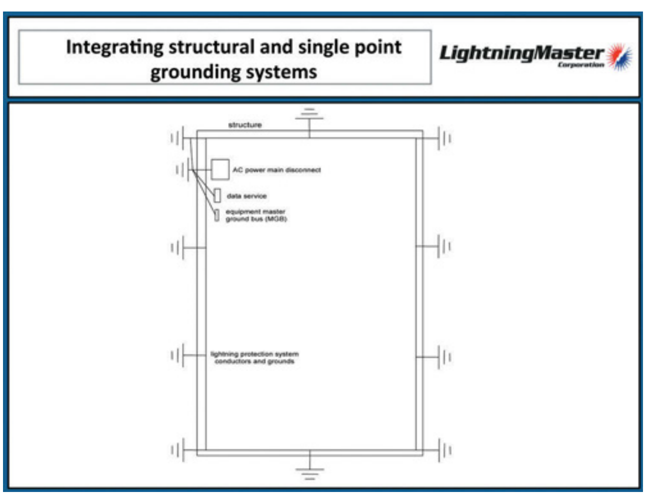
Three step solution — LightningMaster Corporation

1. Bonding and grounding
   A. Low-impedance structure grounding
   B. Single-point services and equipment grounding
2. Transient voltage surge suppression
   A. AC power
   B. DATA
   C. RF
3. Structural lightning protection
   Designed to meet the requirements of NFPA 780

When grounding a structure—that is anything likely to be directly struck by lightning—the idea is to get the lightning

energy off the structure and into earth as quickly as possible. This is best done by providing multiple, low impedance paths to ground: multiple paths to divide the current and low impedance routing to accommodate the nature of lightning. Although lightning is DC, it exhibits an extremely fast rise time, making it behave like high frequency AC. That means it wants to travel in straight paths. If you provide a path with tight bends or indirect routing, lightning may not want to cooperate.

Services and equipment grounding is different from structure grounding. When you ground the services into a structure and the equipment within that structure, you want to ground them in such a way that they all reference ground potential at one, and only one point. This is commonly referred to as "single-point grounding," although it is more accurately described as single-point ground potential referencing.



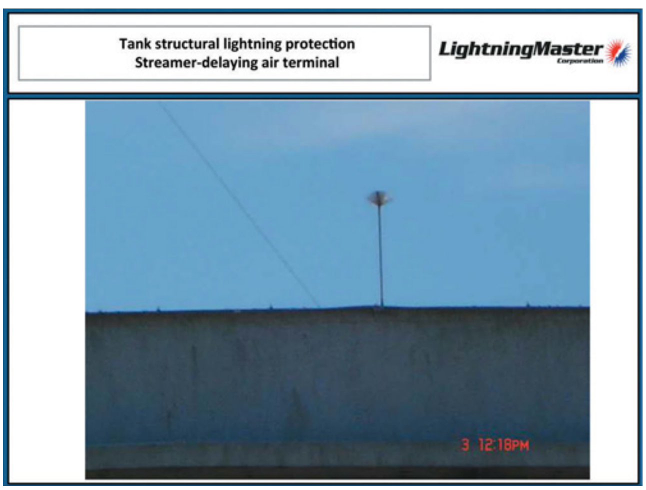
To accomplish this, all services should enter the structure at the same location, and the service grounds from the AC power, cable, data, RF and any other services should be unified before they actually are connected to ground. The services single-point ground should then be bonded to the structure ground. A close relative to single-point grounding is common grounding, where services are each grounded separately, then the different grounds are connected by conductors. This is not as effective as true single-point grounding, but, particularly with older or existing structures, may be the only option available. Single-point grounding will help mitigate secondary effect damage.

However, what about EMP and damage caused by changes in ground reference potential? These are best addressed with surge suppression. EMP will induce voltage onto wires. Surge suppression at both ends of those wires will help prevent damage to equipment connected at either end. Transients on conductors to remotely located transmitters may also be tamed by the use of surge suppressors. In both cases, the surge suppressors must be properly designed. They must equalize potential between all conductors within the affected cable, then equalize potential between all those conductors and ground, or the equipment chassis at both ends.

The final step to a complete lightning protection system design is structural lightning protection. Although the lightning rods may be the most visible part, it is only one part of the overall lightning protection system. All three steps must be taken in coordination.

When we think of structural lightning protection, we think of a lightning rod system on the roof of a structure. It is important to note that the primary purpose of a lightning rod system is to keep a structure from burning down. That is why it is included in the National Fire Protection Association standard, NFPA 780. NFPA 780 has, over the years, proven to be an acceptable standard for the design of a lightning rod system, and should be referenced in any specification. Underwriters Laboratories takes NFPA 780 and turns it into two installation guides. UL 96 addresses material and UL 96A addresses how that material is installed. These documents may also be reliably referenced.

The conventional lightning rod system was fine back in the days of wooden houses and barns. Lightning would attach to a lightning rod, be conveyed around the structure on a conductor system to ground, and the building would not catch fire. However, modern plants bear little resemblance to wood structures of old. That is why, when it comes to the actual lightning rods themselves, we recommend installing streamer-delaying air terminals in place of the conventional lightning rods. These look like conventional lightning rods, but are equipped with a multiplicity of very small radius electrodes extending upward and outward in a hemisphere from the tip of the rod. These electrodes enhance the electric field (dissipation) at the tip of the air terminal, thereby delaying streamer breakdown time. Streamers are the mechanism emanating upward from structures to meet the downward coursing stepped leaders, thereby completing the strike. Whatever object on the ground throws off the best streamer is the one likely to be struck.



As with any new technology, there is controversy about its efficacy, mostly originating from the makers of conventional lightning rods (think buggy whip manufacturers). However, they are in widespread use, mostly by large, sophisticated users who would certainly cease using any technology that did not provide them a clear and convincing return on investment.

The streamer delaying air terminals we supply are UL Listed air terminals, so you get the best of both worlds. If it works as a streamer delayer, you are less likely to suffer a direct strike. However, if it becomes saturated and takes a direct strike, you have all of the benefits of a conventional lightning rod.

After you have a lightning protection system installed, you may want to have the completed installation inspected. If so, Underwriters Laboratories offers an excellent inspection system. A system that passes muster may be eligible for a UL Master Label. This is a good program, but has become increasingly expensive to the point that many users elect to

forego the additional expense. There is another program offered by Lightning Protection Institute (LPI). LPI is an industry membership organization composed of conventional lightning rod salesmen. Unlike UL, LPI has no standing as a Nationally Recognized Testing Laboratory (NRTL – pronounced to rhyme with turtle), so its inspection sign-off does not carry the weight of a UL inspection. You and I and any two guys selected at random off the street have exactly the same standing and credibility as LPI.

Once you drive your shiny new lightning protection system off the lot, you obviously need to regularly inspect and maintain it. We are constantly amazed by the lack of inspection and maintenance in the real world. The biggest enemies of lightning rods are window cleaners (or hoses in plants). The biggest enemy of grounding systems is sprinkler system ditch diggers. The biggest enemy of surge suppressors is their successful operation. Please go out and inspect your system at least annually and after each big storm. It is easier to fix minor damage than wait for it to become major. If you make any changes, additions or other modifications to your plant, have your system inspected and expanded to reconfigured as necessary. We offer a periodic QA/QC program for the convenience of our customers. In our opinion, this is a most cost-effective approach, as it actually gets done on a regular basis.

The job of successfully operating and maintaining a water or wastewater treatment plant is difficult enough. You certainly do not need the kind ministrations of microorganisms with tiny wrenches or lightning working against you. The plan described above offers you a user-friendly leg up on reliability.

About the author: *Bruce Kaiser, founder and Chief Executive Officer of Lightning Master Corporation, is a leading international authority on the prevention of lightning and static damage at industrial, commercial, military and public facilities. Mr. Kaiser has authored numerous articles on static and lightning protection for domestic and international trade and professional publications and has spoken at many professional organization trade shows and seminars. He also holds multiple patents on various technologies relating to lightning and static protection.*