LIGHTNING MASTER® ULTRA-SHARP POINT ENHANCEMENT TO FRANKLIN LIGHTNING ROD TECHNOLOGY

When Ben Franklin invented the lightning rod in 1752, he first theorized that a lightning strike might be preventable by using an elevated iron rod connected to earth to empty static electricity from a cloud. As he pondered the usefulness of a lightning rod, he posited, "May not the knowledge of this power of points be of use to mankind, in preserving houses, churches, ships, etc., from the stroke of lightning, by directing us to fix, on the highest parts of those edifices, upright rods of iron made sharp as a needle. Would not these pointed rods probably draw the electrical fire silently out of a cloud before it came nigh enough to strike, and thereby secure us from that most sudden and terrible mischief!"

Thus, Franklin began to advocate lightning rods with sharp points. Conversely, his English colleagues favored blunt-tipped lightning rods, reasoning that sharp ones attracted lightning and increased the risk of strikes; they thought blunt rods were less likely to be struck. King George III had his palace equipped with blunt lightning rods. When it came time to protect the buildings in the English American colonies' buildings with lightning rods, the decision became a political statement. The pointed lightning rod expressed support for Franklin's theories of protecting public buildings and the rejection of theories of blunt iron rods supported by the King. The English thought this was just another example of the flourishing American colonies being disobedient to the British crown.

While the king got everything exactly backwards, Franklin was on the correct track. However, he was wrong in two respects. One, based on manufacturing technology then available it was not possible to create an electrically sharp point on a metal rod. A blacksmith could create a mechanically sharp point, but it was not sufficiently small radius and it would erode down quickly. Two, a ground-based a lightning rod could not possibly influence cloud charge. What he actually needed to accomplish was to affect the ground charge.

Hence, the Lightning Master Ultra-Sharp Point (USP) air terminal. What is the difference between a USP air terminal and Franklin lightning rod technology? Well, not much and a whole lot.

Physically, the only difference is the addition of one thousand or so small radius electrodes (wires, or "needles" as Franklin desired) inserted into the tip of a blunt elevation conductor of the air terminal. The USP air terminal uses a multiplicity of ultra-sharp points, hence the nickname Fuzzy Ball™ lightning rods. Everything else in the system is identical, including the grounding system, main and down conductors, clips, clamps, bases, etc. In addition, all components are Underwriters Laboratories UL 96 listed, and the completed system is eligible for a UL Master Label, Letter of Findings, or Engineering Inspection Report, as appropriate. In fact, virtually any Franklin lightning rod system may be converted to a Lightning Master system by simply unscrewing the lightning rods and screwing in Lightning Master air terminals.

POINT RADIUS EFFECT

If the differences are so small, then why the Lightning Master approach? The small wire electrodes greatly enhance dissipation of ground charge to the atmosphere by virtue of their small radius (sharpness).

Lightning attachment is determined by streamer formation. Whichever object on the surface of the earth emits the best streamer becomes the lightning attachment point. These small radius points break down into corona under a much lower potential (voltage) than a rounded or even pointed Franklin lightning rod, making it more difficult for a sufficient amount of ground charge to accumulate to form a streamer from the protected structure. As the air terminal breaks down into corona sooner, it dissipates the charge over a longer period of time.

Imagine the corner of a structure. The charge on the base of the storm cloud pulls the ground charge surrounding the structure up and onto the corner of the structure. As the storm builds in intensity, the difference in potential between the cloud base charge and the corner of the structure builds. When the difference in potential overcomes the dielectric (resistance) of the intervening air, the difference in potential is equalized by the lightning strike. In order for the corner of the structure to emit a streamer, the ground charge must accumulate to the level at which it may form a mature streamer. The ground charge leaking off the small radius points interferes with that accumulation.

In its primary mode, the USP air terminal dissipates the ground charge that would otherwise form a lightning-completing streamer, reducing the likelihood of direct lightning attachment. If the ground charge rises too quickly or builds too high, the dissipation ability of the air terminal may be exceeded. In that event, the air terminal reverts to its secondary mode of a Franklin lightning rod. Since the USP air terminal is located at the top of the structure as required by both NFPA 780 and UL 96A, and it is already saturated with streamer constituting ground charge, it then emits a streamer, reliably collecting any strike and conveying it to ground over the lightning protection system. A USP air terminal provides a zone of protection exactly the same as any other lightning rod and is designed and intended to be used as a component in a NFPA 780 or UL 96A system.

GENESIS OF THE TECHNOLOGY

Lightning Master's original exposure to structural lightning protection for buildings was at the Veterans Administration Hospital in Bay Pines, Florida. The building had suffered a direct lightning strike to the roof between lightning rods. The strike punctured the roof, melting the roofing material. Building maintenance had heard about Lightning Master and asked us to see if we could develop a solution to their problem. At that time, Lightning Master provided lightning protection mostly for broadcast and communications facilities. In response, we developed an air terminal employing streamer-retarding technology that slipped over and crimped on to a Franklin lightning rod. In order to obtain a UL Listing, we later modified the product so it no longer slipped over, but replaced a Franklin lightning rod.

Several years later, a Franklin lightning rod system was installed on a data center in Lake Mary, Florida. This system was designed by a well-known and influential engineering company specializing in the design of lightning rod systems. Because the data center was considered critical, the system was designed and installed with decreased spacing between lightning rods to enhance its level of protection. Sometime after the installation was completed, the structure suffered a direct lightning strike to its roof near, but not to, a Franklin lightning rod. After an investigation, no one could explain why it occurred or how to keep it from happening again. The installer of the original system suggested replacing the Franklin lightning rods with Lightning Master streamer-retarding air terminals. The customer did so, and there have been no incidents since.

MEETING INDUSTRY STANDARDS

Both the Franklin lightning rod system and the Lightning Master Ultra Sharp Point™ air terminal enhancement meet the requirements of NFPA 780 and are Underwriters Laboratories Listed to UL 96. The USP air terminal provides a zone of protection exactly the same as any other lightning rod, and is designed and intended to be used as components in a NFPA 780 or UL 96A system. As such, a completed installation is eligible for a UL Master Label or Letter of Findings, the gold standard in lightning protection. In oilfield applications, grounding requirements of American Petroleum Institute API 2003 and API 545 are applied.

To enhance personnel safety, the elevation conductor (shaft) of the air terminal terminates in a blunt upper end. A plurality of small radius dissipation electrodes is inserted into that blunt tip. These electrodes greatly enhance dissipation of ground charge to the atmosphere by virtue of their small radius (sharpness).

EXPLANATORY MODELS AND EXAMPLES

To explain this phenomenon, we sometimes use one or more of the following examples or models. Sometimes it helps to envision taking the protected structure, turning it upside down and dipping it in syrup. When the inverted structure is lifted from the syrup, the syrup tends to drip off the outside edges, corners, and any protrusions. These points are analogous to the charge accumulation and streamer formation points of that structure and can help make it clear why those points are most likely to be struck by lightning. It also explains why NFPA 780 and UL 96A locate lightning rods at those locations. The USP air terminals dissipate ground charge off, and delay streamer formation from, the locations most likely to be struck by lightning.

When talking with engineers, it is sometimes helpful to use a variation of Coulomb's law showing that the smaller the radius of a point, the greater the electric field intensity surrounding it. This explains the greater dissipation current from a USP air terminal than from a Franklin lightning rod.

At trade shows, we sometimes use a Van de Graaff generator to show the difference in dissipation between objects of various shapes. Where the point of a car key or Franklin lightning rod may arc 1/2" to 1" or so to a 200,000 volt Van de Graaff, a Lightning Master air terminal may be brought much closer to the generator ball without arcing. We also use the Van de Graaff to show the ability of an electrical field to induce current in a piece of metal. That piece of metal then arcs to any other piece of metal brought into proximity to it, demonstrating a common cause of ignition, particularly at oilfield facilities.

COMMON MISCONCEPTIONS

We have been asked how it is possible for a USP air terminal system to dissipate the millions of volts and thousands of amps of a lightning strike. It is not necessary to do so. Actually, only a small percentage of that energy need be dissipated to lower the streamer emitting threshold of the protected structure. As in the case of a dam holding back a reservoir, it is not necessary to drain the entire reservoir to prevent the dam from overflowing. It is only necessary to drain a very small percentage of the reservoir.

Neither is it necessary to discharge the storm cloud. A USP system has no effect on the storm cloud. It only affects one small area of the surface of the earth.

Further, the USP air terminal does not protect only itself, thus allowing nearby strikes to the protected structure. In our experience, this is actually more of a problem with Franklin lightning rods than with Lightning Master USP air terminals, as recounted above.

ADVANTAGES FOR INDUSTRIAL FACILITIES

According to both NFPA 780 and UL 96A, certain conductive metal components of a structure may be substituted for lightning protection system components. An industrial facility normally consists of metal process vessels supported by steel frames. The I-beams and frames that comprise the top of the structures are greater than 3/16" thick. Therefore, they may be substituted for lightning rods. The horizontal and vertical framing is also greater than 3/16" (or arguably 0.064") thick, so it may be substituted for the main and down conductor system. The frames are grounded to the plant grounding system at their bases, meeting the requirements for lightning protection system grounding. Therefore, these structures are considered self-protecting under both NFPA 780 and UL 96A. According to those standards, no lightning protection is required so there is no point in installing a lightning rod system.

However, based on experience with lightning damage, these plants are obviously not self-protecting. Fire is not the issue. A lightning strike is highly unlikely to burn down a steel structure. These plants run on microprocessor-based communications and control systems, and suffer damage, interruptions and outages during electrical storms. In addition to equipment damage, other problems occur ranging from momentary data interruptions to a plant emergency shut down (ESD). These problems are generally the result of secondary or electromagnetic pulse (EMP) effects of direct or nearby lightning strikes. The solution is to install SRAT's atop the plant. Using UL Listed stainless steel bases, the air terminals simply attach to the I-beams or frames, and use the existing plant structure as the conductor and grounding system. The effect of the SRAT system is two-fold. First, they act as simple static wicks, similar to those on an airplane, to reduce static charge accumulation on the structures. Second, they act to delay the formation of streamers from the protected structure, thereby lowering the likelihood of a direct lightning strike. Less strikes, less secondary or EMP effects, so less damage and down time.

The effectiveness and reliability of this approach has been documented by numerous, experienced and sophisticated users over the past 30+ years this system has been available.