The growing need for lightning resilient facilities in 2021 and beyond

Executive summary

The risk of lightning strikes on people, structures, and businesses is increasing. Two major factors are driving this trend: bigger cities and global climate change. In the US alone, total lightning-related damage and disruption currently cost $8 to $10 billion annually, rising at nearly 20% per year. Yet for risk mitigation and damage avoidance, cost-effective lightning protection systems are readily available. Truly lightning resilient facilities can protect people and save industry and the public sector billions of dollars each year.

VFC has been protecting and inspecting facilities across the US and the world for more than 40 years. In this white paper, Todd Vought reviews what VFC has learned about practical lightning protection application, as well as the effective design and implementation of lightning resilient buildings and operations.

Increasing rates of lightning strikes

Every second, there are on average 40 or more lightning flashes over the world[1]. At this rate in 2021, there will be approximately 1.2 billion flashes. Their distribution across the planet depends on diverse factors like climate and time of year. However, hotter, more humid conditions lead to higher concentrations of lightning flashes. In the US, the state of Florida is especially prone to lightning for these reasons. It is essentially a peninsula with a warm climate surrounded by water.

Lightning is also more prevalent in cities compared to countryside. A 17-year study from 1997 to 2013 [2] showed that certain large cities gave rise to more lightning strikes compared to surrounding rural land. The study used data collected on thunderstorms in a southeast region of the US including Atlanta.

Cities are also getting larger. It is estimated that 55% of the world's population (more than 4 billion people) live in cities today. The proportion is expected to grow to nearly two-thirds by 2050. As cities expand and urban sectors replace rural areas, asphalt and concrete replace vegetation. Vehicle use and density increase, causing pollution. As a result, cities continue to heat up and receive even more lightning. For example, increasing urbanization has already been linked to higher lightning strikes in Rio de Janeiro.

Climate change is also producing more lightning. Globally rising temperatures compound the problem in cities. They also lead to other surprises. In 2019 for instance, lightning strikes within just 300 miles of the North Pole were reported for the first time [3].

Risks on the rise

A lightning strike on a high-rise building, a manufacturing facility, or another large structure is practically inevitable. The only uncertainties are when, how often, and with what consequences. Meanwhile, levels of risk are rising. A major factor is our increasing dependence on electronics and electrical infrastructure. Besides direct hits, lightning strikes can generate indirect (induced) transient currents, power surges, and electromagnetic pulses (EMP) that can destroy modern systems if they have insufficient protection.

To mitigate risk, there is increasing adoption worldwide of facility protection systems (FPS) in building codes. Florida leads the US in the requirements for FPS. In the US and internationally there are three dominant standards that govern the risk assessment, design, and implementation of these systems.

- NFPA 780-2020 (NFPA 780 updated for 2020) is a US standard for traditional lightning protection system installation for diverse structures. It specifies passive systems with simple risk assessment. It does not cover electrical power infrastructure.

- IEC 62305 used in Europe and much of South America and Asia is for passive systems with advanced risk assessment including physical damage to structures and life hazard. It defines protection levels and electronic systems protection.

- NFC 17-102 used in Europe and much of Asia is for active systems (Early Streamer Emission Air Terminals or ESEAT) using IEC 62305 for risk assessment and protection levels.

Comprehension, communication, and construction

Most of the damage and disruption from lightning is preventable. Yet building owners often spend tens or even hundreds of thousands of dollars on lightning protection systems without comprehending if they are adequately protected.

Sales and marketing communication on facility protection systems has been limited. These systems are not a standard part of major disciplines like architecture or engineering. They started with Benjamin Franklin and remained largely unchanged until the 1980s. Considerable efforts then went into developing technologies for protecting modern, digital facilities. However, there has been little promotion of the improvements to businesses.

For a modern digital facility, an effective facility protection system includes not only structural lightning protection, but also grounding, potential equalization, and surge protective devices. The additional features help turn basic structural protection into overall lightning resilience. At the same time, they add complexity, making understanding and communication more challenging.

Ideally, the facility lightning protection system should be fully integrated into the facility at the time of construction. Like other major systems, it can then provide maximum benefit with little outward sign of its existence. If the facility has already been built, this becomes more difficult to achieve.

For this reason, VFC actively supports the proper design and implementation of lightning protection technology as an increasingly important part of the Resilient Facilities Initiative.

Effective lightning protection in 2021 and beyond

VFC and its Lyncole Division have been inspecting and analyzing existing facilities for lightning resilience for over 40 years, across the US and in many international locations. Through this work we have identified the key systems that must be integrated into the facility lightning protection to make a facility or operation truly lightning resilient.

Structural lightning protection

A well designed, installed, and maintained structural lightning protection system is required to protect the physical structure from damaging effects of a direct lightning strike. The system consists of air terminals, conductors, and grounding electrodes. An annual visual inspection is recommended on all lightning protection systems to identify degradation due to the elements. A more thorough inspection and certification should be performed every five years to ensure the lightning protection system still protects all the roof mounted equipment and complies with current standards.

Utility service entrances

These utilities may include electrical, telephone, data network, natural gas, water, cable/satellite TV, and RF/radio frequency circuits. It is critical that these circuits be inspected for the presence of surge protection, a low resistance grounding electrode system and proper bonding. These are fundamental components of any site protection system inspection or audit.

Stand-by generators and automatic transfer switches

In a facility for businesses requiring uninterrupted services, a stand-by electrical generator is a must. These generators require a fuel supply, automatic transfer switch (ATS), and an uninterruptable power supply (UPS). These items must all work together to ensure that critical equipment does not lose its power if the utility-provided electricity fails. They are also either volatile or controlled by sensitive electrical components that need surge protection, grounding and bonding.

Process Control Systems

These systems are ubiquitous in today's modern operations and are tied back to a central control panel. They generally represent the number one issue our damage assessment teams see when visiting a disrupted facility. Their wires traverse miles of conduits and chases. These wires are susceptible to direct and indirect (induced) currents as they run from the individual pieces of equipment. A small amount of induced current can result in a complete failure of these systems resulting in a complete shut down or disruption in the facility's operations.

Elevator controls

Multiple-story buildings have at least one elevator. Typically, the elevator motors, electrical panels, and controls are in a rooftop penthouse. The connecting metallic cables, cylinders, control wires, and communication lines are routed through the elevator chase. All these conductors are prone to same direct and indirect (induced) current and voltages as mentioned above. The National Electrical Code (NFPA-70) requires all apparatus to have a ground fault current path. However, this path is often a relatively small green wire with an extraordinarily high impedance at higher frequencies produced by lightning.

Building alarm and security systems

These systems run throughout the entire facility and are all tied back to a central monitoring/control area. The monitoring/control area is powered by one electrical branch circuit. The individual cameras, keypads, maglocks, and smoke/carbon monoxide sensors are all powered by different branch circuits. Their video/data/electrical wires traverse miles of conduits and chases that are susceptible to both direct and indirect currents as they run from the individual units to the monitoring/control area.

Wi-Fi and cellular signal boosters/range extenders

As technology advances, the frequency range of wireless communications increases. 5G in the 24 GHz range or above uses higher frequencies than 4G. As a result, some 5G signals are not capable of traveling large distances (over a few hundred meters), or traveling through multiple walls, unlike 4G or lower frequency 5G signals (sub 6 GHz). The boosters and range extenders for higher frequency 5G signals will have both power and signal conductors that require surge protection, bonding, and grounding.

Return on investment

While figures vary from one case to another, a comprehensive facility lightning protection system may cost as little as $100 per month, calculated over an expected solution lifetime of 30 years. By comparison, unscheduled facility downtime due to lightning strikes can reach as much as $100,000 per hour. Another priceless benefit is the safeguarding of employee and site visitor safety.

Conclusion

Connectivity between industry, commerce, and the electronic infrastructure will continue to grow in 2021 and beyond. The systems powering businesses are highly vulnerable to damage from lightning and transient currents. Lightning strikes are also rising owing to urbanization and climate change.

Structural lightning protection alone does not offer lightning resilience, even though it is often all that is specified for facilities and operations. As a result, many businesses operate with a false sense of security. They have not inspected their lightning protection since it was installed or considered the vulnerability of their modern digital systems.

Fortunately, cost-effective solutions are available for protection against lightning and transient currents. Current technologies in grounding, potential equalization, surge protective devices, and structural lightning protection can make for a lightning resilient facility if deployed and integrated correctly. US industry can achieve savings of billions of dollars per year if the use of these solutions increases.

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