Prevention is the Best Defense Against Lightning-Related Threats

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Best Practices for Lightning Defense

Lightning strikes present a serious threat to critical facilities, leading to costly downtime, hazardous working conditions, and potentially irreversible damage to operations and stakeholder relationships. Effective lightning protection requires proactive measures that go beyond addressing direct strikes to also mitigate the broader range of lightning-related hazards, including induced surges and ground potential rise.

Broadly speaking, **Lightning Defense** encompasses two key approaches: **Lightning Protection** and **Lightning Avoidance** (such as Charge Transfer technologies). This paper examines the nature of lightning-related risks, strategies for mitigating these threats, the unique advantages offered by LEC solutions, and best practices for designing, installing, and maintaining a comprehensive and effective Lightning Defense system.

Traditional Lightning Protection

Franklin Rods, commonly known as "lightning rods," have been the standard method of lightning protection for over 250 years. These devices function by creating a "preferred collection point" on a structure to attract a lightning strike and channel its energy—ideally—safely to the ground through a conductive wire.

However, this approach is not without flaws. Historically, one significant risk arose from the physical attachment of lightning rods to structures. In many cases, the immense energy from a lightning strike

ignited fires or caused severe structural damage. While advancements in techniques have reduced this risk over time, other critical vulnerabilities have emerged.

A fundamental issue lies in the very purpose of lightning rods: to attract lightning. This design means lightning rods can sometimes draw strikes into areas that might have otherwise remained unaffected. Paradoxically, in attempting to protect a structure, a lightning rod can create a risk where none previously existed, introducing lightning into the very zone it is intended to safeguard. Fortunately, Lightning Defense technology has advanced since the introduction of the Franklin Rod.

Lightning Risks and Scenarios

Modern operations and processes depend heavily on electronic equipment and telecommunications systems. Traditional lightning "protection" methods, such as lightning rods, can inadvertently bring dangerous lightning energy uncomfortably close to critically sensitive environments—often involving explosive materials—and the electronic systems responsible for monitoring and controlling these operations.

An equally significant, but frequently overlooked risk, lies in the **secondary effects of lightning**. Even when a direct strike is avoided, the residual effects—such as earth currents, atmospheric transients, secondary arcing, electromagnetic pulses (EMP), and ground potential rise (GPR)—can severely degrade system components. These secondary effects can result in equipment failure, operational downtime, or even false and erroneous system behavior, compromising safety and reliability.

A wide range of facilities and operations face risks from both direct lightning strikes and their secondary effects. These risks may stem from the nature of the materials or commodities involved—such as flammable or explosive substances—or the critical missions they support, including essential services and infrastructure.

Industries particularly vulnerable to lightning-related threats

Oil and Gas
Petrochemical plants, refineries, produced water facilities, and upstream/midstream operations are vulnerable to fires, explosions, and operational disruptions caused by lightning.

Telecommunications
Data centers, cell towers, and network facilities depend on uninterrupted service and are at risk of lightning strikes or secondary power surges.

Broadcasting and Media
Lightning can disrupt television and radio communication, leading to significant operational interruptions, loss of revenue, as well as expensive and time-consuming repairs.

Energy and Utilities
Power plants, transmission, and distribution infrastructure face risks of outages and equipment damage.

Transportation
Airports, railways, shipping ports, and logistics hubs require robust infrastructure to avoid disruptions.

Manufacturing
Industries such as electronics, paper mills, and pharmaceuticals face operational and financial losses from lightning-related shutdowns.

Time-Sensitive Critical Processes
Industries like overnight delivery require systems that prevent operational downtime.

Process Industries
Wastewater treatment plants and pulp mills must protect against environmental and operational risks.

Healthcare
Hospitals and clinics rely on continuous power for critical medical equipment.

Public Services
Emergency response agencies and military installations need uninterrupted functionality to maintain public safety.

The Importance of Lightning Defense for Mitigating Risk

Lightning Defense is crucial for safeguarding assets, maintaining operational continuity, and ensuring personnel safety. An effective Lightning Defense strategy mitigates risks and ensures the sustainability of critical operations.

Business Risks of Lightning Events

1. **Operational Downtime**
   - Equipment Damage: Lightning can physically damage machinery, servers, and production lines.
   - Power Outages: Disruptions halt productivity and lead to revenue losses.
   - Communication Disruptions: Damaged networks and systems impair coordination.
2. **Safety Hazards**
   - Personnel Injuries: Direct strikes or secondary effects jeopardize onsite safety.
   - Liability Issues: Legal consequences arise from injuries to workers or visitors.
3. **Financial Loss**
   - Repair and Replacement Costs: Infrastructure repairs are costly.
   - Insurance Premiums: Inadequate protection systems may result in higher premiums or claims denial.
   - Revenue Loss: Operational halts affect customer satisfaction and profitability.
4. **Reputational Damage**
   - Customer Trust: Frequent disruptions erode client confidence.
   - Brand Impact: Negative coverage damages public perception.
5. **Environmental Impact**
   - Fires and Explosions: Lightning-induced incidents harm ecosystems and cause regulatory challenges.
   - Compliance Issues: Violations due to environmental damage result in fines.

6. **Regulatory and Legal Risks**
   - Code Violations: Non-compliance with standards like NFPA 780 incurs penalties.
   - Legal Exposure: Claims of negligence arise from insufficient protection.
7. **Data and Intellectual Property Loss**
   - Data Corruption: Surges damage data storage systems.
   - IP Loss: Compromised proprietary information affects competitiveness.
8. **Supply Chain Disruptions**
   - Vendor Delays: Strikes at one facility can cascade through supply chains.
   - Inventory Loss: Damaged storage areas result in significant losses.
9. **Long-Term Infrastructure Damage**
   - Structural Weakening: Repeated lightning strikes degrade infrastructure.

Lightning Defense System Design Considerations

There are several interrelated factors that contribute to a facility's unique lightning risk profile. Primary considerations include:

1. **Site-Specific Factors**
   - Geographic location, storm frequency, and soil resistivity influence system design.
   - Topographic features and environmental conditions must be accounted for.

2. **Structural and Operational Considerations**
   - Facility type, material composition, and layout determine the level of protection required.
3. **Electrical and System Characteristics**
   - Proper grounding and surge protection are critical.
   - Integration with existing systems ensures operational continuity.
4. **Operational Requirements**
   - Facilities with critical functions require advanced prevention systems.
   - Personnel safety is a key priority in all designs.
5. **Regulatory and Industry Guidelines**
   - Compliance with NFPA 780 and other industry-specific requirements are essential (e.g., API 545 for the oil and gas industry).
6. **Environmental and Sustainability Concerns**
   - Reducing environmental impact and using durable materials promote sustainability.
7. **Maintenance and Monitoring**
   - Regular testing and real-time monitoring ensure system reliability.

The Dissipation Array System (DAS®) prevents direct lightning strikes by reducing the electric field to below lightning-collection levels.

Solutions for Minimizing Lightning Risk

Lightning Defense risk mitigation strategies fall into two primary categories: **Lightning Protection** and **Lightning Avoidance**, briefly summarized below.

Lightning Protection

Lightning Protection refers to strategies designed to minimize the damage caused by a lightning strike after it occurs. The primary objective is to protect structures, equipment, and personnel from the destructive effects of lightning. One of the most widely recognized technologies is the lightning rod (or Franklin Rod), which attracts lightning strikes and channels their energy safely to the ground. As previously mentioned, however, **because lightning rods are designed to attract lightning they can inadvertently imperil the very areas they are intended to protect.**

Less understood is the fact that lightning can cause significant damage even if a strike occurs some distance away—sometimes up to a mile. Under certain ground and soil conditions, the electrical charge from a strike can travel considerable distances underground, posing a threat to nearby facilities and systems.

When lightning strikes a structure equipped with a Lightning Protection system, the system provides a controlled pathway for the electrical current to disperse into the ground. This minimizes risks such as fires, structural damage, operational disruptions, and other hazards.

Common Lightning Protection solutions include Franklin Rods, surge protection devices, grounding systems, mesh and Faraday cage systems, and air terminals. Each plays a critical role in managing the energy of a strike and reducing its impact.

Paragon Arrays and Chem Rods protect cooling towers at a power plant from lightning strikes.

Lightning Avoidance

In contrast to Lightning Protection, **Lightning Avoidance technologies (i.e., Charge Transfer Systems or CTS) aim to reduce the likelihood of a lightning strike altogether.** The primary goal of Lightning Avoidance is to alter atmospheric or ground (static) conditions, discouraging or diverting lightning strikes away from vulnerable areas such as critical infrastructure (e.g., mail sorting hub, crude oil storage facilities, etc.) or densely populated regions or venues (e.g., sports stadiums, schools, etc.).

Lightning Avoidance technologies focus on charge transfer, which lowers the electric field within the protected area to below lightning-collection thresholds. For example, the Dissipation Array® System (DAS®) from LEC works by reducing the static field in the protected zone, encouraging lightning to terminate outside the area.

By proactively preventing strikes in this manner, DAS systems help to minimize downtime, preserve valuable assets, and enhance safety for personnel working in lightning-prone environments.

Best Practices for Lightning Defense

In this section, we cover the recommended practices for assessing lightning risk and developing an effective Lightning Defense strategy for your operations.

Assess Your Lightning Risk

Now that we have covered the types of lightning risks and lightning prevention strategies, in this section we pivot to the best practices planners and operators can use to develop an effective risk mitigation strategy for their specific risk profile and needs.

Engage an Expert. Lightning Defense is a specialized body of knowledge that has accumulated over 200 years, making it critical to secure an experienced and knowledgeable expert in lightning protection. A qualified lightning expert can help you assess your specific risk profile and develop a comprehensive protection strategy aligned with your budget.

Perform a Site Survey. A qualified Lightning Defense consultant can help survey your operations to identify likely physical risk factors. A site survey should include a detailed review of the structure(s) requiring protection, including materials, location, and other physical properties (i.e., height, depth, shape, etc.), environmental surroundings, soil composition and other factors.

Identify Critical Assets and Vulnerabilities. Identifying equipment that is vulnerable to lightning, either because of its location, connection to power systems, and/or reliance on power is an essential element of developing an effective Lightning Defense strategy. Particular attention should be given to equipment that may be time-consuming to replace. In most cases, insurance can cover

the cost of replacement, but in the case of specialized equipment or assets customized to a particular facility, extra protection is warranted.

Risk Mapping. Based on a site survey, create a visual representation of risk zones, highlighting areas of high strike probability, zones requiring surge protection, and paths for potential lightning-induced currents.

Operational Assessment. Make a critical analysis of the impact of a lightning-related interruption to your business. This includes downtime, loss of revenue and profits, time required to re-start a process, potential environmental impacts of a spill or overflow scenario along with associated fines, loss of business to competitors, and other operational factors.

Compliance Standards and Guidelines. Adherence to industry standards and guidelines (e.g., NFPA 780, API 545) is important, but these standards often represent only the baseline for protection. In our view, relying solely on compliance may expose your operations to a higher level of lightning risk than your business can afford.

Cost/Benefit Analysis. We recommend conducting an analysis of both the quantitative and qualitative costs of a lightning-related business interruption, given different scenarios ranging from a short period of downtime all the way up to extended periods for more catastrophic situations. Handicap each scenario based on an assessment of each scenario's probability of occurrence, and then determine the appropriate level of budget to mitigate the risks.

In our experience, one of the most common errors is underestimating your risk by confusing compliance with an objective Lightning Defense strategy tailored to your structure's unique risk profile. For example, can you afford to lose your largest customer to a competitor? A system that is compliant may not offer the most protection for your critical processes and operations.

Take A Comprehensive Approach

Once you have assessed the lightning risk profile of the facility under evaluation and the costs of a lightning-related business or process interruption, we recommend taking a comprehensive approach to developing a Lightning Defense strategy. Consider both Lightning Protection and Lightning Avoidance technologies in your defense initiative to minimize the risks and costs.

Meeting compliance objectives is important, but compliance generally means achieving only a minimum level of lightning defense. **In many cases, the risk and cost of a process upset, or lengthy downtime can be significantly reduced by using Lightning Avoidance solutions that go above and beyond compulsory compliance.**

The LEC Advantage

With over 80,750 system-years of field operation and proven success in Lightning Defense, LEC is the smart risk reduction expert for your critical systems lightning protection. **Our patented Dissipation Array System (DAS®) is a Charge Transfer System (CTS) that uniquely positions LEC as the company with the expertise and technologies best able to provide you with the most comprehensive lightning defense solution and keep you running through the storm.**

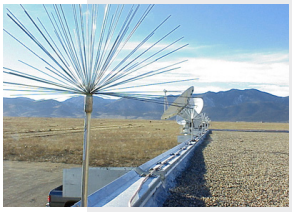
LEC has arguably the longest track record in Lightning Defense solutions, offering patented lightning avoidance technology and proven lightning protection.

Lightning Avoidance Offerings from LEC

Dissipation Array System® (DAS). Prevents direct lightning strikes by lowering the electric field within the protected area to below lightning-collection thresholds. This innovative approach helps to minimize downtime, protect valuable assets, and enhance safety for personnel in lightning-prone environments.

Streamer Delaying Air Terminal® (SDAT®). A cost-effective alternative to traditional air terminals for both new and existing lightning protection systems. Unlike conventional lightning rods and grounding rods, which are designed solely to collect strikes, the SDAT delays upward streamer generation, significantly reducing the risk of lightning damage. Additionally, it serves as a highly efficient air terminal, enhancing overall lightning protection and safety.

Lightning Protection Offerings from LEC



Spline Ball Terminal (SBT®). A superior alternative to traditional air terminals for both new and existing lightning protection systems. Unlike conventional lightning rods, which are designed solely to collect strikes, the SBT is engineered to reduce the risk of direct lightning strikes while serving as a highly efficient air terminal. The SBI device is listed under UL 96 standard, and is typically installed under UL design standard UL96A.

Spline Ball Ionizer (SBI®). A lightning protection design that utilizes a modular component to enhance Dissipation Array installations. It serves as the first line of defense for structures that require lightweight protection with a low wind profile. Like the Dissipation Array System (DAS), our patented SBI lightning protection technology significantly reduces the risk of direct lightning damage at the protected site. The SBT device is listed under UL 96 standard, and is typically installed under UL design standard UL96A.

Retractable Grounding Assembly® (RGA®750) Generation 2. Floating roof tanks are particularly vulnerable to fires caused by lightning strikes. The award-winning lightning protection design of the Retractable Grounding Assembly (RGA) reduces the risk of lightning damage and fires by establishing a low-impedance bond between the roof and shell. The RGA 750 offers a cost-effective, easy-to-install solution that requires minimal maintenance, making it an ideal choice for protecting these tanks.

In-Tank Potential Equalizer® (IPE®). Specifically engineered for non-metallic and lined tanks to address the issue of internal electrical discharges and the associated risk of vapor ignition. Its no-point lightning protection design enhances safety, reduces costs, and provides excellent resistance to corrosion.

Surge Protectors. We offer a comprehensive range of UL 1449 Listed Type 1 SPDs designed specifically for critical panels in the harshest environments. These Surge Protection Devices (SPDs) achieve the highest UL performance ratings for Nominal Discharge Current (In) and Short Circuit Current Rating (SCCR) tests, while maintaining a low Voltage Protection Rating (VPR).

Grounding/Earthing

Smart Ground® Testing Service. An advanced lightning protection solution offering a state-of-the-art ground audit system that delivers precise results, even on energized systems. It combines computer modeling with a comprehensive professional analysis based on IEEE/IEC standards, providing actionable recommendations to enhance your grounding and earthing system for optimal performance.

LECWELD®. A simple and efficient field welding solution for lightning protection installations, eliminating the need for external power sources or equipment. This process creates a solid copper molecular bond that remains secure and resistant to corrosion for the lifetime of the host structure.

Grounding Augmentation Fill (GAF®). A specially formulated substance designed to establish a low-resistance earth interface. This innovative product simplifies and reduces the cost of preventing lightning damage, providing effective and reliable protection.

Chem-Rod® Low-Impedance Chemical Grounding Electrode. Addresses the limitations of conventional grounding systems by requiring less area and fewer electrodes to achieve the desired resistance. Each Chem-Rod provides an optimal electrical connection to the earth, offering a larger conductive surface for superior lightning protection.

Professional Services

With LEC's unique combination of experienced consultants, engineers, and integrated services, you can rely on expert advice backed by over five decades of industry experience. LEC's comprehensive services provide tailored lightning protection, grounding, and surge protection solutions across multiple industries, enhancing lightning safety, efficiency, and cost savings through our proprietary risk reduction approach. Our services are customized to meet your company's specific lightning safety requirements—ranging from a simple technical review to an extensive site survey.

Summary

In summary, Lightning Eliminators is uniquely equipped to design, develop, install, and maintain the most advanced Lightning Defense solutions available. Our patented Dissipation Array System® (DAS®) Lightning Avoidance technology combined with our comprehensive lineup of Lightning Protection products, enable us to create a customized solution tailored to your operation's unique needs—ensuring uninterrupted performance to **Keep You Running Through the Storm.**

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We Don't Just Protect, We Prevent Lightning

About Lightning Eliminators

Since 1971, Lightning Eliminators & Consultants (LEC) has been empowering customers to **Keep You Running Through the Storm** with industry-leading Lightning Defense solutions and expertise. As the premier provider of advanced Lightning Avoidance systems, LEC is dedicated to safeguarding critical infrastructure and operations, ensuring uninterrupted functionality and safety.

LEC was founded in 1971 by Roy B. Carpenter, Jr., a visionary engineer who previously served as a Chief Engineer for NASA's Apollo Moon Landing Missions and Space Shuttle design teams. Leveraging his expertise in engineering and physics, Carpenter established LEC to address lightning strike challenges through the science of point-discharge. His groundbreaking research led to the development of our flagship product, the patented Dissipation Array® System (DAS®), and a suite of other innovative solutions.

Today, LEC's solutions protect critical operations and structures for some of the world's most recognized companies, including Federal Express, UPS, CSX Railroad, Chevron, ExxonMobil, Telluride Ski Resort, and thousands more.

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