Lightning Protection Systems: Coordinating with the Building Enclosure

With early coordination, lightning protection systems can be safely and uniquely designed.

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IT HAPPENS ABOUT 100 times each second.[1] At this rate, lightning deserves our attention. A single lightning strike can have devastating consequences to a structure and the community. Over 22,000 times a year, fire departments respond to fires caused by lightning (**Fig. 1**).[2] We see the immediate impact of a lightning strike by the raging fire and structural damage.

What's not always talked about is the internal damage to computers, communication devices, security systems, and the entire electrical/electronic infrastructure. This damage results in loss of data, business downtime, and loss of personal and business productivity. When lightning strikes a critical building such as a fire station, police station, or hospital an entire community can lose the emergency services needed. Whether one is a homeowner, a business owner, or part of the design/build community, it is vital to understand the impact of a lightning strike and how to be prepared.

Our attention starts with that crackle and streak of light in the sky (**Fig. 2**). This single lightning strike is hotter than the surface of the sun and contains over 1 million volts of electricity. When this immense energy hits a structure, the power surges through the pipes, building structure, and electrical infrastructure. These damages can be avoided with the proper design and installation of a lightning protection system.

Figure 1. *Firefighters attend to an apartment fire that was started by a lightning strike.*

COORDINATING WITH THE BUILDING ENCLOSURE

Coordinating with the building enclosure involves outlining the appropriate process, materials, and people. From modern high-rises to historic buildings, the process remains the same. However, the variations in structural design and building materials require early planning and collaboration among the trades, so everyone's installation and project meets codes and expectations.

The process includes five main steps:

1. Assessment
2. Specification
3. Installation
4. Inspection/Certification
5. Maintenance

UNDERSTANDING A LIGHTNING PROTECTION SYSTEM FUNDAMENTALS

This basic knowledge is the starting point for proper assessment and considerations for the specification: building materials, special architectural features, rooftop equipment, and more.

Figure 2. *Lightning protection systems, when properly designed and installed, are scientifically proven to mitigate the risks of a lightning strike.*

Lightning protection systems (**Fig. 3**) are composed of five components that have precise materials, sizes, and installation measurements.

1. **Strike Termination Devices:** Air terminals (informally known as lightning rods) on high points of a building intercept lightning strikes.
2. **Conductors:** Heavy-duty metal cables connect the parts of a lightning protection system.
3. **Grounding Electrodes:** Most buildings can be grounded with 10-ft-long (3 m), copper-clad steel rods driven into the earth at multiple points around a building.
4. **Bonding:** Conductors are also used to equalize electrical potential throughout a building to prevent lightning from creating dangerous electrical arcing or side flashes.
5. **Surge Protection:** Special surge-protective devices must be installed wherever power or signal wires enter a building to prevent excessive electrical surges from causing damage. The surge protectors built into appliances and power strips do *not* protect against powerful lightning surges.

Although not part of the system, the final step in this process should always be inspection and certification by a third party to ensure that all standards for design and installation have been followed.

When these components are properly designed and installed, a lightning strike is intercepted by the strike termination device and directed to the ground without impact to the structure or the electronic infrastructure (**Fig. 4**).

IT'S A SYSTEM

There is a fairly common belief that lightning protection consists of one rod, one cable, and one ground rod. It is important to realize that *multiple paths* to ground are required.

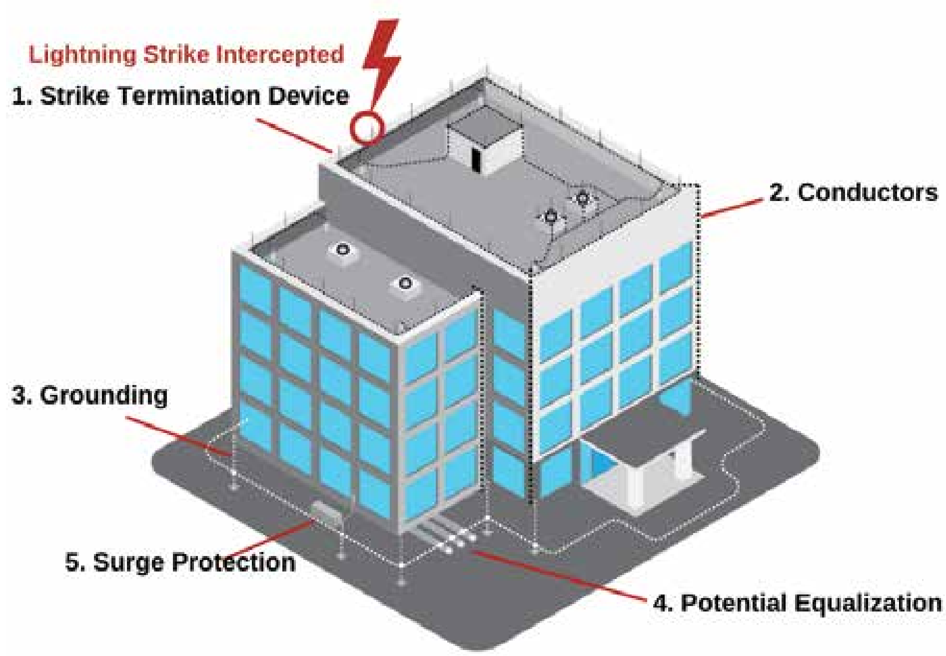


Figure 3. *This model shows the basic design of a lightning protection system; lightning is intercepted by a strike termination device.*

There are also nonconventional devices that claim to protect. Nonconventional devices include static charge dissipation devices, early-streamer emission devices, charge transfer systems, and lightning suppressors/eliminators. These mechanisms do not follow standards and are controversial.

Properly designed lightning protection systems follow strict guidelines from NFPA 780[3] and LPI 175[4] and are scientifically proven to intercept a lightning strike.

ASSESSMENT

The proper design and installation of this system requires the input of several individuals from the onset of a project: architects, engineers, building enclosure consultants, facility managers, and other specialty trades.

As we look to design a new facility or repair an existing structure, we evaluate the past, current, and future conditions to outline the appropriate materials and design. The same holds true for a lightning protection system.

NFPA 780, Annex L.1.3, outlines a simple assessment that encompasses gathering data points from the location of the structure to the use of a building's structure:

- **Location**
  - Flash Density Map/High-Risk Area (**Fig. 5**)
- **Type of Construction**
  - Structure Material Type
  - Roofing Material
- **Occupancy**
  - Occupied, Difficult to Evacuate

Figure 4. *Multiple paths are created with the use of properly placed strike termination devices and conductors.*

- **Contents**
  - Combustible
  - High Value, Electronic ≥ Infrastructure (**Fig. 6**)
- **Damage Impact of Lightning**
  - Continuity of Facility Services
  - Impact to Environment

During this assessment, asking questions from the various experts and building management can ensure a more thorough specification and decrease the chances of mistakes or delays in the entire building project:

- Are there certain design elements of the building that are important?
- Are there special materials being used for coping, flashing, or structural railings?
- Are there any past roofing or structure issues that should be considered?
- Do the building enclosure experts anticipate any challenges?

SPECIFICATION

The coordination of input and facts from the assessment creates a detailed outline of the proper processes, materials, and people to utilize throughout the process.

What Should a Specification Contain?

Process: Reference appropriate NFPA 780 and LPI 175 standards. Sizing and placement of materials are specifically outlined. Inspection and certification should be required. Maintenance and recertification protocols and timing should also be included.

Materials/Components: All materials shall be approved for the purpose of lightning protection systems by a nationally recognized testing laboratory. Specific metals and sizing should be considered and required.

People: Installation completed by Lightning Protection Institute (LPI)-certified lightning protection installers. Inspection by a third party to ensure the design and installation follow the standards; third-party inspection will ensure an objective and thorough certification of the system. All team members (architects to facility managers) who provided insight into assessment should be referenced to enable easy coordination of timing, materials, and labor throughout the process.

BRIEF CASE STUDIES

Historical to Modern Structures

Each building requires the same due diligence.

Historical Structure: Coordinating with Lightning Specialists and Architects

External design features may be of special concern with historic buildings, so the heritage of the building is maintained; the age of the building and materials used in the structure should also be considered.

The Capitol building in Austin, Texas (**Fig. 7**), is an iconic historic structure that was initially constructed more than 130 years ago. The building is the tallest structure in the immediate area and is in a region that experiences a significant amount of lightning activity.

Government and local municipalities wanted a detailed analysis of weather impact and expert design specialists for the installation of a lightning protection system. This analysis was coordinated by LPI members, Scientific Lightning Solutions LLC (SLS), architects, engineers, government, and facility managers.

SLS worked with Wiss, Janney, Elstner Associates Inc. (WJE) and facility managers from

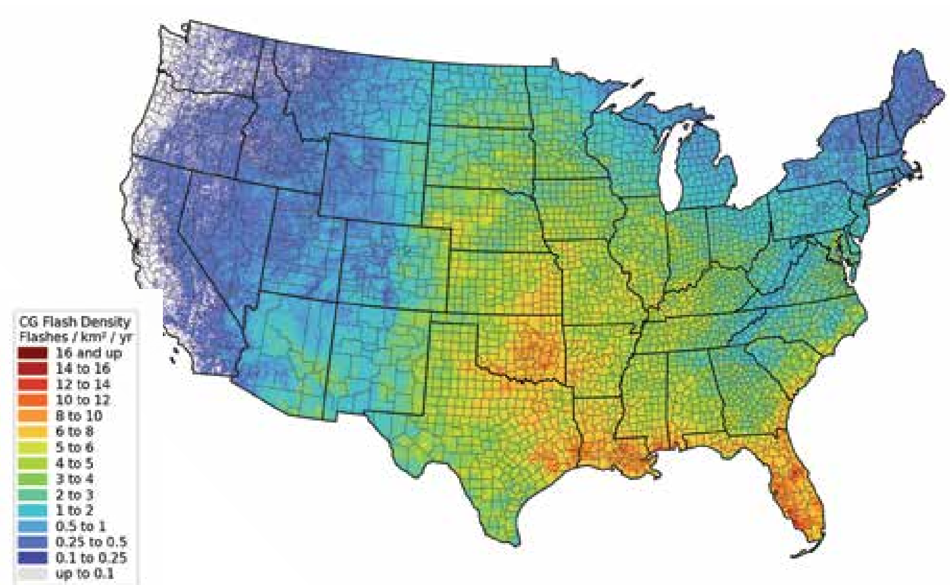


Figure 5. *Flash density maps provide data on the frequency of lightning strikes in a particular area, city, region, or state.*

Source: Vaisala

Figure 6. *Without proper protection, medical centers are vulnerable to lightning, which can strike and disable the electronic infrastructure that supports vital medical devices.*

Figure 7. *The Capitol building in Austin, Texas.*

Figure 8. *The Hard Rock Hotel and Casino in Hollywood, Florida.*

Source: Pixaby

the Texas Capitol to find innovative measures to improve the lightning resilience of the facility without compromising the ornate architecture and aesthetics. SLS performed both a thorough visual assessment and a series of bonding measurements to determine where nonintrusive improvements could be implemented.

Modern and Uniquely Shaped Buildings: Close Coordination with Curtainwall Fabricators

The signature guitar shape of the Hard Rock Hotel and Casino in Hollywood, Florida (**Fig. 8**), made the design and installation of its lightning protection system challenging. Due to the complex geometry of the building, coordination among the building's architect, engineers, curtainwall fabricator, curtainwall installer, general contractor, and lightning protection system contractor was needed with regard to details, schedule, and access.

A rolling sphere analysis was used to determine the zone of protection for this uniquely designed hotel. This analysis determined that the curved sidewalls had potential lightning attachment points, areas that would be more susceptible to a lightning strike. This required the installation of air terminals on the aluminum and glass curtainwall (**Fig. 9**).

Figure 9. *Early coordination enabled the lightning protection system to be concealed; conductors are internal to the structure.*

Close collaboration was required between the curtainwall fabricator and the curtainwall installer to provide mounting brackets on the curtainwall, especially because the inclination of air terminals varied depending on the curved wall's changing tangent (**Fig. 10**). Similarly, the size and construction of each floor plate varied, and each level required different details for attaching cables from the curtainwall to down conductors. At some locations, air terminals could be installed from the interior as glazing progressed.

Early Collaboration and Coordination

Starting the conversations early allows for thoughtful consideration of integrating the system into walls and/or utilizing architectural elements as part of the system. Functionality and aesthetics can play a role in material choices as well.

The Summit Visitor Center at Pikes Peak in Colorado (**Fig. 11**) is an excellent example of early coordination of people, processes, and materials. Input from several different fields and thorough assessment of the natural landscape, climate, and building usage led to a design that is architecturally stunning and safe from lightning.

Considering extreme climate and function, permanent metal fabrications—including railings and roof gutters made from steel plate—were used as strike termination devices and in lieu of conductor cables (**Fig. 12**).

Maintaining integrity can involve choosing visually appropriate materials: aluminum air terminals practically disappear when seen against the sky and copper components are used where they are adjacent to earth-toned materials (**Fig. 13)**.

Figure 10. *Strike termination device.*

The Summit Visitor Center is built on granite with a very low soil conductivity. This required aggressive measures to achieve satisfactory grounding (**Fig. 14**). Techniques employed included ground loops, ground-enhancing material, and welded connections.

Project Team

Table 1 lists the diverse group of experts utilized for the Pikes Peak project. The successful completion of this, or any of lightning protection system project, entails clear communication and coordination among the project team. Challenges can be understood and solved to maintain system integrity and project timelines.

Early Coordination Ensures Thorough Assessment and Design Options

With the frequency and potential of destruction, lightning deserves our attention. The damage of hurricanes, floods, and fires gains significant media exposure, so we can understand the impact and be prepared. Lightning is just as powerful and should be understood.

The design/build community continues to find ways to innovate design and materials to increase safety for individuals and

Figure 11. *The Summit Visitor Center at Pikes Peak in Colorado.*
Source: Mr. Lightning.

Figure 12. *Permanent metal fabrications—including railings and roof gutters made from steel plate—used as strike termination devices and in lieu of conductor cables at the Summit Visitor Center at Pikes Peak in Colorado.*
Source: Mr. Lightning.

Figure 13. *At the Summit Visitor Center at Pikes Peak in Colorado, copper components are used where they are adjacent to earth-toned materials—as seen in this boulder.*
Source: Mr. Lightning.

communities. Fire alarms are now standard practice to mitigate risks to individuals and minimize the structural damage caused by a fire. Buildings can be designed to tolerate earthquakes. And over the last decade, new materials and design methods have been utilized and tested to build hurricane-resilient homes. These life safety measures are due to the collaboration of trades.

All of us, as experts in our fields, have the opportunity to protect the welfare of the community with a clear understanding of lightning protection systems. The coordination of building enclosure people, processes, and materials will ensure the proper installation of a proven method to mitigate risks and destruction from lightning—lightning protection systems (**Fig. 15**).

REFERENCES

1. National Geographic Society. n.d. "Lightning Facts and Information." National Geographic, Washington, DC https://www.nationalgeographic.com/environment/article/lightning.
2. Ahrens, Marty. 2013. *Lightning Fires and Lightning Strikes*, National Fire Protection Association (NFPA) report. Quincy, MA: NFPA. https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/Fire-causes/oslightning.pdf.
3. NFPA. 2023. *Standard for the Installation of Lightning Protection Systems*. NFPA 780. Quincy, MA: NFPA. https://www.nfpa.org/codes-and-stan-

Table 1. Project team for the Summit Visitor Center at Pikes Peak in Colorado

Owners	Design	Construction
City of Colorado Springs, CO	**Architect of Record:** RTA Architects	**Contractor:** GE Johnson Construction Co.
High Altitude Research Laboratory	**Co-Design Architect:** GWWO Architects	**Electrical Contractor:** Encore Electric
US Army Corps of Engineers, Omaha District	**Electrical Engineer:** Branch Pattern	**Lightning Protection Contractor:** Mr. Lightning, Bret Pfeifer

Figure 14. *The soil density required a jackhammer to lay the proper grounding.*
Source: Mr. Lightning.

Figure 15. *Early coordination on the assessment and design of this rooftop terrace enabled architects and engineers to uniquely use metal elements as part of the lightning protection system.*
Source: HLP Systems.

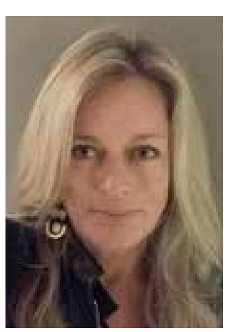
dards/all-codes-and-standards/list-of-codes-and-standards/detail?code=780.

4. Lightning Protection Institute (LPI). 2023. *Standard for the Design, Installation, and Inspection of Lightning Protection Systems*. LPI 175. Novi, MI: LPI.

ABOUT THE AUTHORS

TIM HARGER

Tim Harger *is an industry expert with an entrepreneurial spirit. For over 35 years, he has engaged in all aspects of the lightning protection industry: manufacturing, installation, and inspection. With these diverse experiences, he developed a vision of growth for the lightning protection industry that involves high standards, education, and partnerships. Harger's desire to maintain high standards comes from his involvement with ANSI accreditation and the ISO certification processes. Furthermore, he understands the value of partnerships to gain different perspectives and to learn best practices, which can be seen in his involvement in the NFPA 780 Committee and industry associations such as American Institute of Architects and IIBEC. Harger holds a bachelor of science in industrial technology from Iowa State University. He also is a certified LPI Master Installer Designer. He has served as the executive director of the Lightning Protection Institute (LPI) for just over two years and has been the program manager for the LPI-IP, which is the industry's third-party inspection program, for over 10 years.*



KELLEY COLLINS

Kelley Collins *has been immersed in the science and technology industries for over 25 years, with diverse roles such as executive management, marketing, sales, and consulting. She was intrigued with the science and the opportunity for growth in the lightning protection industry and joined LPI just over two years ago. Currently, Collins works with LPI developing strategy, partnerships, and communication to support the expansion and awareness of the lightning protection industry. She attended the University of Georgia's Terry School of Business and obtained a degree in management and marketing. She holds a master's in business management and organizational behavior from Benedictine University and two professional certificates: organizational development and management in a technical environment. She is also the co-developer and instructor for the science communication program for PhD students at Northwestern University.*

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