

*Approximately 90 million lightning bolts strike the United States each year and cause approximately 30,000 building fires, over 400 personal injuries and 30 percent of all power outages. Lightning is estimated to produce in excess of \$2 billion in property damage annually. Lightning is also responsible for more deaths and property losses than tornados and hurricanes.*

### Principles of Lightning Protection

According to Ernest Freeman and Matthew Glennon, P.E., from the Hartford Steam Boiler Inspection and Insurance Company, a lightning protection system has the single purpose of protecting a building and its occupants and contents from the thermal, mechanical and electrical effects of lightning. The fundamental principle of such a system is to provide a means by which a lightning discharge can be safely diverted to the earth without causing damage to the equipment or property being protected. To do this successfully, the system must intercept the lightning flash before it strikes the structure, lead the current safely downward, prevent the occurrence of side flashes and conduct the current to a ground system which is able to instantly accept the heavy flow of current and dissipate it harmlessly.

### Exterior Building Structure Protection

When properly located and installed, lightning protection systems consist of three basic components that provide a low impedance metal path to assure that a lightning discharge will be conducted harmlessly between air terminals and the ground. These three components are described below.

- **Air Terminals**—Also known as lightning rods, air terminals are pointed metal rods or tubes made of copper, bronze or aluminum which are installed at the high points of a building. Their function is to intercept any lightning in the immediate area. Terminals less than 24 inches high should be spaced along roof ridges and railings not more than 20 feet apart. Terminals from 24 to 60 inches high should be spaced not more than 25 feet apart. There should be a terminal within 2 feet of each gable end of a roof. All chimneys, dormers, ventilators, flagpoles, towers, water tanks and other projections should have at least one terminal. In some cases,

the metal building structure may be used as part of the lightning protection system if the structural metal framing has sufficient cross-sectional area to equal the conductivity of the main lightning conductor and the framing is electrically continuous.



- **Conductors**—Conductors are cables made of copper or aluminum that connect air terminals to one another and to the ground, forming a conductor network. The metal path must be continuous from the ground terminal to the air terminal. When selecting metal conductors, care should be taken to assure the integrity of the lightning conductor for an extended period. Down conductors should not be painted, since this will increase impedance. Gradual bends (minimum 8-inch radius) should be included to avoid flashover problems.

The conductor network consists of three parts: the perimeter roof conductor, cross-run conductors and down conductors. Roof conductors are installed along ridges and around the roof perimeter. Cross-run conductors interconnect air terminals on flat roofs over 50 feet wide and connect to the main perimeter cable at least every 150 feet. Down conductors run vertically between the roof conductor network and the ground terminals and should be spaced as far apart as possible. At least two down conductors are needed for any kind of structure. For buildings over 250 feet in perimeter, an additional down conductor is required for each additional 100 feet.

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- **Grounding**—Grounding is the key to any lightning protection system. Galvanized steel and copper are suitable ground rod material, but aluminum should not be used. Each down conductor should terminate at a ground terminal dedicated to the lightning protection system. Welded connectors are highly recommended in all circumstances. Ground rods should be at least 1/2 inch in diameter, 8 feet long and should be vertically driven at least 10 feet deep. If the soil is sandy or rocky, additional ground rods may be required to improve the ground resistance. These additional rods should be spaced horizontally at least 10 feet from each other.

After grounding rods have been bonded to the rest of the system, the electrical ground resistance should be checked to see if it meets the National Electric Code® requirement of 25 ohms. Ensure that the lightning ground system is connected to all other grounding systems associated with the structure being protected. This means interconnecting the lightning protection system with the electrical system ground, as well as telephone, cable TV, antennas or any underground metallic piping system. If the electric, telephone or other systems are bonded to a metallic water pipe, only one connection from the lightning protection system to the water pipe system is required.

### Interior Building Systems Protection

The inclusion of electrical Surge Protection Devices (SPDs) should be considered in any comprehensive lightning protection plan if a building contains important electrical or electronic systems or equipment. Proper selection and installation of SPDs can protect electrical and electronic equipment from lightning and other surges that can enter a building through the electric, telephone, data or other wires that enter the building from the outside.

### Inspection of Lightning Protection Systems

- Frequency of inspections varies. Systems should be inspected following installation. Existing systems should receive inspections at intervals determined by such factors as classification of structure or area protected, expected level of protection, immediate environment (corrosive atmosphere) and component materials and the surface type to which they are attached. In addition, a lightning protection system should be inspected whenever alterations or repairs are made to a protected structure, as well as after any known lightning discharge to the system.
- Visual Inspections of components should determine the following:
  - ▶ No loose connections that might result in high-resistance joints.
  - ▶ No part of the system has been weakened by corrosion or vibration.
  - ▶ All down conductors and ground terminals are intact.
  - ▶ All conductors and system components are securely fastened to their mounting surfaces.
  - ▶ No additions or alterations to the existing structure that would require additional protection.
  - ▶ No indication of damage to surge suppression devices.
  - ▶ The system complies in all aspects with the current edition of the NFPA® Code 780.
- Testing is needed to verify the continuity of the system and the proper operation of components not possible through visual inspection. Perform resistance tests of the ground termination system and compare the results with previous or initial results. Investigate all results with significant differences.
- Records should be kept for general condition of air terminals, conductors, other components and corrosion measures; stability of attached conductors and components; resistance measurements of the ground terminal system; and any variations from the requirements in the standards.

### For Additional Information

**National Lightning Safety Institute:**

[www.lightningsafety.com](http://www.lightningsafety.com)

**National Fire Protection Association:**

[www.nfpa.org](http://www.nfpa.org)

- Code 780 Installation of Lightning Protection Systems

**EMC Insurance Companies:** [www.emcins.com](http://www.emcins.com)

- Tech Sheets: Electrical Surge Protection