The risk of lightning damage and disruption to US industry and property is continually rising. Costs of lightning related damage are currently estimated at $8 billion to $10 billion annually (1), and are growing by 20% per year. Besides physical degradation, a large part of the total cost is due to the downtime of facilities and interruption of business operations.

The fact that lightning can destroy both external structures and internal systems is often ignored until it is too late. However, the implementation of a comprehensive facility lightning protection system (FLPS) can mitigate the risk of damage and disruption in both cases. An effective FLPS not only protects roofs, walls, and other structural components from direct lightning strikes, but also shields electrical circuits, communications, process control systems, and other elements that are vulnerable to indirect strikes.

Neutralizing Direct Lightning Strikes

Direct lightning strikes can be neutralized by a structural lightning protection system (a structural LPS). The main components of this system are air terminals (otherwise known as lightning rods), conductors linking the air terminals, and down conductors, which connect the air terminals to earth. In accordance with the basic principles of physics, a structural LPS generates an electrical “streamer” that intercepts a downward electrical “leader” from the storm cloud.

This interception establishes a circuit, allowing the structural LPS to conduct the lightning current to the earth, bypassing the building structure while equalizing the potential between the cloud and the earth.

Photo: Upward Streamer and Downward Leader Activity in a Lightning Strike

A structural LPS does not attract lightning, and a lightning strike in a location does not depend on whether protection has been installed. Instead, the structural LPS simply provides a preferential path for the lightning current to flow to the earth. This form of grounding is different from the common electrical ground installed for everyday safe working of electrical systems, which is not designed to handle the extremely high levels of instantaneous voltage and current (100 million volts, 30,000 amps, or more) that are typical of a lightning strike.

Find out more about lightning formation at the website of the National Oceanic and Atmospheric Administration NOAA(2).

A single path to the earth is not enough to guarantee that lightning will be properly conducted away from the structure of a building. Multiple conductor paths must be installed at correctly distanced intervals on the building to be protected.

Standards for these lightning protection systems include NFPA 780 and UL 96A for the US, and IEC-62305 internationally. The UL Master Label Certificate program covers the inspection and certification of these systems.

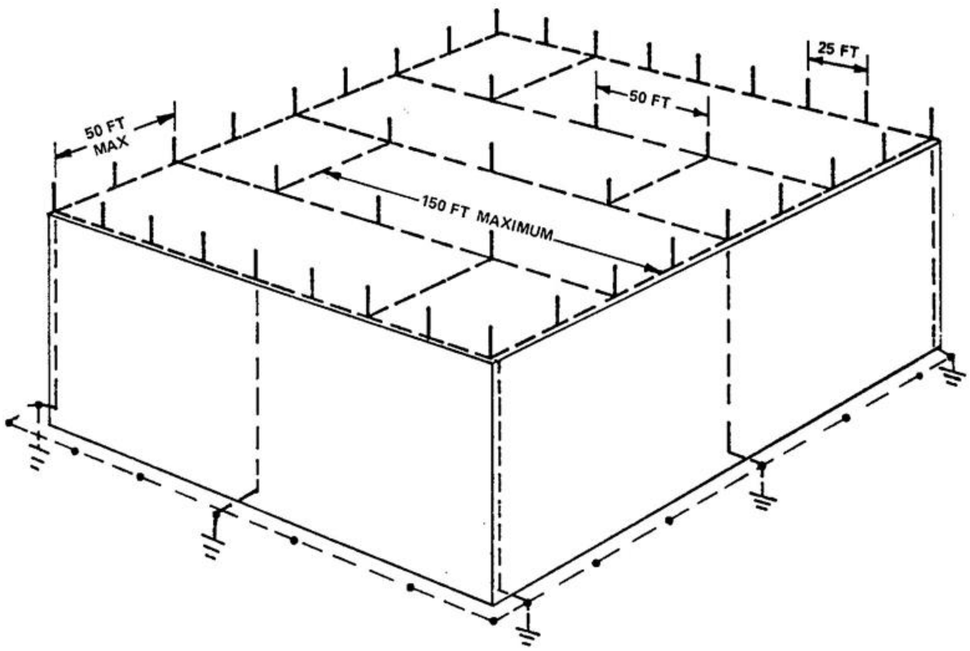


Figure 1-18. Air Terminal Placement on Flat-Roofed Structures

Diagram: Air Terminal, Conductor, and Down Conductor Spacing for an LPS

Current Induction and Indirect Damage

Lightning also produces an electromagnetic pulse (EMP) that induces current in any ferrous materials in the building. Nearby lightning strikes, strikes to power or communications systems, or even cloud to cloud strikes may induce harmful current in a facility and its systems. The current may cause conductors and equipment to burn. It may also cause electrical, communications, and process control equipment failure to occur internally, even if there is no externally visible damage.

The notion that lightning must strike a building directly to do damage or cause losses is therefore a myth. Induced current that damages process control systems in a facility for instance can cause as much downtime as physical damage to the overall building structure. In addition, a building and its equipment are more likely to be damaged by ancillary current induction than by a direct strike.

The Need for Both Structural and System Lightning Protection Systems

A structural LPS alone will not protect a facility from the risk of induction. While a structural lightning protection system is critical for the protection of the physical structure and the equalization of potential that it provides can reduce induced currents, internal systems require additional measures of protection.

Fortunately, other technologies allow facility systems, electrical components, communications, and process controls to be as effectively protected as the structure itself. This protection is provided by:

- Low resistance grounding systems (low transient impedance)
- Potential equalization
- Surge protection devices (SPDs)

Low Resistance Grounding Systems (Low Transient Impedance)

Standards for complete lightning protection systems are based on the principle of providing a direct or quasi-direct, low resistance, low impedance path for lightning current to follow safely to the earth. Achieving low impedance requires suitable handling of both the resistance and reactance (capacitance and inductance) of the system.

Inattention or unjustified assumptions about the effectiveness of the grounding system can contribute to lightning related damage and business interruption. Practical rules to prevent this risk include the following:

- Grounding systems must be designed and tested for a reasonably low resistance to earth, generally less than 25 ohms, for each grounding connection. Where an especially low impedance earth ground is needed, for example for communication facilities, or if the soil itself is highly resistive, an electrolytic ground rod or other ground enhancement can be used
- Existing systems must be regularly tested to ensure they are operational and intact: for example, ground rods installed several years ago, may now be corroded or otherwise damaged.
- New systems must be designed to last. For example, a low resistance grounding system that only works for three years is not a suitable solution, however good its performance during that time.

Potential Equalization

Lightning can travel through soil and can therefore be picked up by underground conduits entering a building. Incorrect potential equalization between electrical and service lines (water, gas, telco, CATV) and the building they serve can expose people to high levels of touch potentials and leave a facility vulnerable to indirect lightning damage. Consequently:

- All the systems in the facility as well as the physical structure must be properly bonded together and connected to the same grounding system for potential equalization (equipotential bonding). These systems include AC power, telecommunications, gas, water, CATV, control systems, and antennas.
- A service that must remain isolated, that cannot be directly bonded to the building's grounding system, must use a gas discharge tube (GDT) arrester installed between the service and the building's grounding system. The GDT will provide a discharge path to earth for potential equalization.

Equipotential bonding does not substitute conduits or service lines for the lightning protection system ground. Neither does it put these systems at any greater risk. Instead, it allows charges to be routed away from the systems via a common ground potential, which also reduces the risk of side-flash, arcing, and exposure of people to lethal touch potentials resulting from a lightning strike.

Surge Protection Devices (SPDs)

An SPD (surge protection device) is designed to protect electrical equipment from voltage spikes. It limits the voltage supplied to equipment to a safe level by blocking or diverting excess voltages to ground, including those transmitted into a structure by an electrical, communications, or data line circuit. An SPD may also be called a surge suppressor, surge diverter, or transient voltage surge suppressor (TVSS).

Faulty use of SPDs is common and improper implementation can provide a false sense of protection. Common errors include:

- **Improperly located or installed SPDs**
  The proper installation and placement of an SPD is a critical factor in the protection provided. Utility service line entry points are key locations for installing SPDs, because of the extensive systems that the service lines form for the indirect transmission of lightning. Other building service conductors

like antenna systems should also be equipped with SPDs at their entry points for the same reason.

- **Incorrect let-through voltage**
  An SPD is designed to let voltage pass through up to a defined limit, known as the let-through voltage. Minimization of the let-through voltage is important for the protection of connected equipment. SPDs for AC power are often installed at the service entrance, but depending on the SPDs used and their installation, the let-through voltage may not be low enough to properly protect all equipment downstream. Additional SPDs may be required at branching points and next to equipment to further reduce let-through voltage.

- **Missing SPDs**
  SPDs are also important on low voltage communication conductors that enter a facility or process control panel. Although they are often the most vulnerable systems, they are frequently overlooked when deploying SPDs. More generally, no single surge protection device can protect an entire structure and SPDs must always be deployed in multiple locations to properly protect equipment.

Conclusion

Increasingly, today's facilities must be continuously operational, making downtime unacceptable. Fortunately, lightning related disruptions and damage can be prevented by using technologies now available. A properly designed and integrated system of low resistance/low impedance facility grounding, potential equalization, and SPDs can effectively protect today's digital systems, while a structural lightning protection system protects the building that houses them.

A complete facility lightning protection system is also essential to achieve safe and effective protection. Partial systems leave facilities vulnerable to transient voltages and currents, and to side-flash to non-protected conductive components, and therefore to damage, loss, and business interruption. Only through full integration of protection against both direct and indirect lightning damage can US facilities expect to reduce or even eliminate the $8 billion to $10 billion of lightning related damage and disruption that occurs each year.

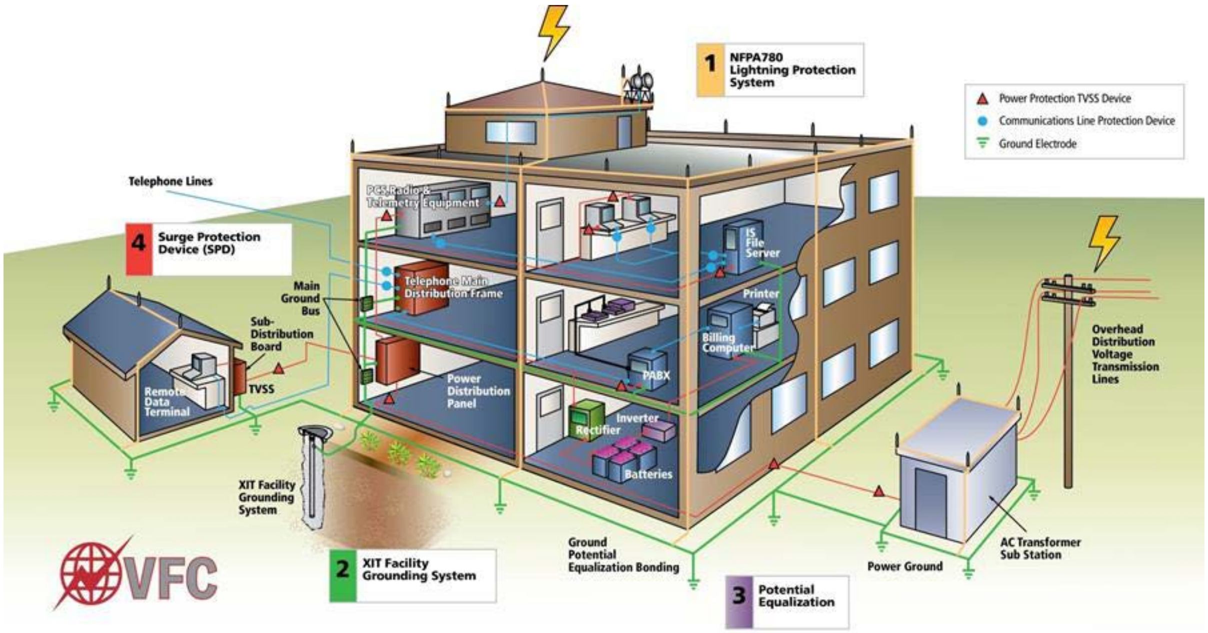
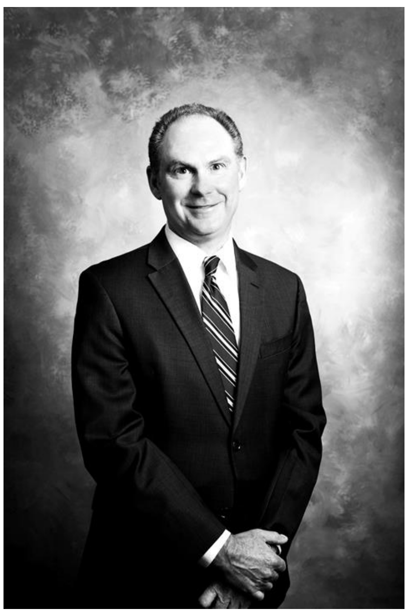


Diagram: Structural LPS, Grounding, Potential Equalization, and Surge Protection (SPD/TVSS)



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LINK:

1) http://lightningsafety.com/nlsi_lls/ListofLosses14.pdf

2) http://www.lightningsafety.noaa.gov/science/scienceintro.shtml

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