THREE ESSENTIALS OF LIGHTNING PROTECTION: BONDING, GROUNDING AND SURGE PROTECTION

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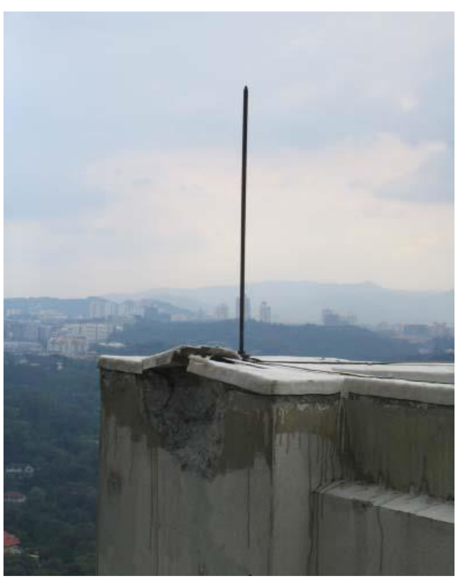
1.0 Summary. Lightning protection for facility operational continuity requires attention to combinations of defenses. The IEC, NFPA and other codes and standards generally describe lightning protection systems (LPS) as consisting of several components:

1.1 Air Terminals which may or may not "collect" the lightning.
1.2 Downconductors which direct all or some or none of the lightning.
1.3 Bonding which unifies all conductors.
1.4 Grounding which provides a low impedance earth destination.
1.5 Surge Protection Devices (SPD) to defend critical circuits/operations.
1.6 Inspection, Maintenance and Testing.

Air Terminals whether rods, masts or overhead static wires, including Conventional as well as Unconventional designs, play a limited, even exaggerated role in overall lightning protection of contemporary assests, facilities, and the continuity of electrical/electronic operations.



1. Franklin Rod Performance

2. LEC/DAS Performance

The concept of topological application of Bonding, Grounding and Surge Protection zones must be applied. This first was proposed by EF Vance of Stanford Research Institute in 1977. P. Hasse and J. Wiesinger appropriated the idea where it migrated into today's IEC 62305. Without this application protection from the effects of lightning may not be assured.
This Paper provides insights and rationale into zoning details.

2.0 Bonding. Detailed bonding of all conductors confirms that unrelated or adjacent metallic objects are at the same electrical potential. Without such equi-potential connectivity lightning protection cannot be reliable. Voltage rise mis-matches will ocurr which may cause dangerous arcing. This may cause interruptions to circuit regularity. And sparking in the presence of combustible objects may lead to fires.
All metallic conductors at structures such as AC power circuits, racks and cabinets, cable trays, gas and water piping, data and signal sources, HVAC ducting, metal conduits, piping and ladders, railroad tracks, overhead bridge cranes, roll up doors, metal door frames, hand railings, etc. etc. should be electrically connected to the same single ground potential. Each facility or structure is unique and different. Connector bonding should be exothermal and not mechanical (bolted) wherever possible, especially at below-grade locations. Mechanical and bolted bonds are subject to corrosion, physical damage and looseness due to temperature differentials. Regular inspection and measurement of cross-joint connections to assure continuity is recommended. Air Force AFI 32-1065 section 14.2 provides guidance: "Adequate bonding is more important than grounding." A measured minimum one ohm bond usually is satisfactory.

3. Inadequate Bonding Connector

4. Tight Bend – Ohmic Heating

3.0 Grounding. Lightning will follow all conductors to ground according to their respective impedances. The grounding Earth Electrode System (EES) must address low earth impedance as well as low resistance. Low resistance values are less important that grounding volumetric efficiencies. This is a major reason why the integration of a rebar-reinforced concrete foundation (Concrete Encased Electrode/CEE) as primary EES is an important design criteria.

Equipotential grounding is mandatory. It is achieved when all grounded equipments and all grounded structure are referenced to a common earth potential, similar to Bonding described above.

Generally this would include electrical grounds, lightning grounds, single point grounds, multi-point grounds, single reference grounds, computer grounds, etc. Where a case of a "clean (isolated) ground" is required, an isolating spark gap (gas tube arrestor) can be installed for this purpose. Earth loops and consequential differential rise times (GPR) can be avoided by attention to equi-potential grounding and bonding of all structures on the property. The use of buried bare linear or radial wire conductors can lower impedances since they allow lightning energy to diverge as each buried conductor shares voltage gradients. Bare wire Ground Ring designs connected around structures are more useful than ground rods: they are a requirement for explosives storage facilities per NFPA-780 section 8.4.1. Proper use of concrete footings and foundations (CEE) increases electrode volume.

Where high resistance soils or poor moisture content or absence of salts or freezing temperatures are present the treatment of soils with carbon, Coke Breeze, conductive cements, natural salts or other low resistance additives may be useful. These should be deployed on a case-by-case basis where lowering grounding impedances are difficult and/or expensive by traditional means.

5. Concrete Encased Electrode (CEE)

6. Unnecessary Impedances

4.0 Surge Protection Devices (SPD). Ordinary circuit breakers, fuses and UPSs are not suitable defenses from lightning-induced transients. By definition, “Arrestors” are employed for protection on high voltage circuits such as 1000VAC and above. SPDs should be installed at 480/380VAC circuits (Primary Panels) and other lower voltage circuits such as 220/240 VAC (Secondary Panels) as well as all communications/data/signal circuits including AC, DC and RF power and coaxial/twin lead/Cat 5/Cat 6/RG-58 and other antenna signal circuits.

A layered (cascaded) defense strategy is recommended. By example, an 800 MHZ Radio Network should have SPDs on the AC circuit as well as the antenna circuit. Other examples would include SPD protection at MCC PLCs, SCADA circuits, the lightning detection system, security areas such as CCTV and FLIR, etc. etc.

Internal SPD circuitry most responsive to the lightning waveform would suggest that staged components (example: Diodes/MOVs/Gas Tubes in combination) provide a highly effective defense.

A comprehensive analysis of electrical schematics is necessary to identify “critical” operations where SPDs will be required. We recommend the following protection levels for cases of direct and indirect lightning attacks:

Primary (Main) Panels	Minimum 250kA
Secondary (Branch) Panels	Minimum 125kA
Plug-in (Wall Outlets)	Minimum 3500 Joules

Selection of vendors for DIN-rail and NEMA-4 cabinet SPDs requires caution. The market abounds with exaggerated claims of perfection. For AC circuits, we suggest MCG, MTL, Dehn, Schneider, Phoenix-Contact or Siemens. For electronic communications and other RF signal circuits, vendors such as EDCO, Polyphaser, Citel, Telebyte, and Nextek are reliable.

7. DIN-Rail Mounted SPD

8. External Mounted SPD

9. Coaxial Cable Signal Lines Showing Improper Installation

5.0 References.

5.1 IEEE STD 1100, Powering and Grounding, IEEE NY NY

5.2 IEEE STD 142, Grounding, IEEE NY NY

5.3 Standler, RB: 1989, Protection of Electronic Circuits from Overvoltages, J. Wiley, NY NY

5.4 Arora, R and Mosch, W: 2011, High Voltage and Electrical Insulation Engineeering, IEEE Press, NY NY

6.0 NLSI Company Mascot (Lola).

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