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Lightning Protection for Telecommunications Facilities

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1.0 Summary. In 2004-5 a major national insurance company was receiving lightning-related claims and paying compensation in the six figures to E911 Emergency Radio Operations customers across the USA. Why were losses seemingly unrelated to lightning distribution, times of year, latitudes, elevations, ages of equipment and the like? NLSI was engaged to visit sites in CO, TX, TN, AL, LA, GA, MI and IL to investigate cause, effect, and remediation subjects. The purpose of this paper is to describe findings together with application of known mitigation defenses in general terms for application to telecommunications facilities.

2.0 The Matrix of Lightning Protection Sub-Systems. A hierarchy of recognized application methods should be applied according to site realities. This Matrix is depicted as:

	DIRECT STRIKE	INDIRECT STRIKE	EXTERIOR LOCATION	INTERIOR LOCATION	PEOPLE SAFETY	STRUCTURE SAFETY
AIR TERMINALS	YES	NO	YES	NO	NO	YES
DOWN-CONDUCTORS	YES	NO	YES	YES	NO	YES
BONDING	YES	YES	YES	YES	YES	YES
GROUNDING	YES	YES	YES	YES	YES	YES
SHIELDING	YES	YES	YES	YES	YES	YES
SURGE PROTECTION	YES	YES	YES	YES	YES	YES
DETECTION	YES	YES	YES	YES	YES	YES
POLICIES & PROCEDURES	YES	YES	N/A	N/A	YES	YES

3.0 The practical use of the Matrix where relevant for telecomm sites is presented in a generalized form below.

3.1 Air Terminals. Lightning usually terminates on grounded objects sticking up in the air. Franklin rods are air terminals. Old Ben's designs developed in 1752 divert lightning from rods in the air via conductors to rods in the ground, protecting important assets. This part of a LPS is based upon the Path of Least Impedance principles. Nowadays, some vendors are promoting unconventional air terminal designs (Charge Transfer Array/Early Streamer Emitter, etc.) seeking to gain advantage over competitors. *Caveat Emptor*. Of course, should lightning strike across the street from a telecomm center and couple into its sensitive electronics via underground wiring/water pipes/buried conduits/etc., then no type air terminal sub-system has performed and it has no value. On telecomm towers, ordinary sacrificial rods can protect sensitive antennae. In the main, the tower is the air terminal.

3.2 Bonding. Without proper bonding, all other elements of the LPS are useless. Bonding of all metallic conductors in a telecom facility assures everything is at equal potential. When lightning strikes, all electrical equipment voltages will rise and fall at the same potentials. This protects against unequal voltages in separate sensitive signal and data systems. Bonding should connect all conductors to the same "Mother Earth." A partial listing includes: antenna towers, shields on incoming coaxial cables, cable trays, cabinets and racks, computer room signal reference grids, telephone room equipment, conduits carrying various AC power and low voltage DC current conductors, AC power bus bars, etc. etc. Not convinced bonding is important? Check out NEC 250.90 through 250.104 for more details.
A recent inspection revealed a bare copper ground wire in contact with an interior electrical conduit. Result: a visible arcing mark caused by lightning's "flashover" with resulting destruction of nearby low voltage equipment. Solution: Either bond the two adjacent grounds together, or (better) use only insulated, not bare, wire for interior bonding.

3.3 Grounding. Low resistance grounding provides an efficient destination for the Lightning Beast. If site soils are composed of sand or rock they are resistive, not conductive. If surrounding soils are clays or dirt with moisture present, they likely are conductive. "Good Grounds" are achieved by volumetric efficiencies. We recommend buried bare 4/0 copper wire – the so called ring electrode or ring ground. Cadwelding© all ground references adjacent to buildings should include security fences, tower legs, and all other adjacent metallic objects. The National Electrical Code Section 250 describes the perimeter ring concept as well as other grounding designs such as rods, plates, water pipes (beware plastic pipes underground), metal frame of buildings, and concrete-encased electrodes. Choose your grounding design based upon localized conditions and the amount of available real estate at your location. Good grounding largely is a function of volumetric efficiencies. NEC 250.56 suggests a target earth resistivity number of 25 ohms for one ground rod. Lower is better. Yet some times 50+ ohms will be OK.

Another recent inspection, using an AEMC 3730 Ground Resistance Tester, showed grounding measurements of 450 ohms at a power pole ground wire drop. Result: lightning bypassed this high resistance ground and instead went into the telecomm building via the overhead phase lines. Solution: Re-work power pole grounds to achieve lower ohms target resistance.

3.4 Surge Suppression. Surge suppression devices (SPDs aka TVSS) all function either by absorbing the transient as heat or crowbaring the transient to ground (or some combination thereof). They should be installed at main panel entries and at critical branch or secondary panels and at plug-in outlets where low voltage transformers convert AC power to DC current and voltage. SPDs also should be installed at signal and data line building entry points for critical electronic equipment Included here are Cat. 5/6, coaxial lines, twin lead and other copper wire circuits. Telephone punch blocks should be SPD-protected. Beware the junk SPDs which proliferate the marketplace. Beware counterfeit or false UL and IEEE labeling. Beware of the "it sounds to good to be true" marketing hype employed by some vendors. Consider Panel SPDs which have capabilities to remotely signal their operational performance. SPDs rank right behind Bonding in the hierarchy of important steps to mitigate the lightning hazard.

Surge suppression is a complex subject. Where and how to install SPDs? What SPD internal technologies are important? Which SPD codes and standards are important and which are vendor-influenced? How do UPS-protected circuits play into surge protection? What about fibreoptic conductor vulnerabilities? For these and other considerations, find an Authority not employed by SPD vendors for impartial and verifiable guidance. Feeling lucky and want to play the odds that lightning or power company surges never will enter your telecom facility? Just wait and Mother Nature will do the testing for you!

3.5 Codes and Standards. There aren't any specific lightning protection guidelines for the telecomm industry. It is important that the wireless community consider adopting a contemporary lightning protection recipe. Taking a few topics from NFPA 99 and NFPA 780, also adding in Motorola R56, stirring in some ingredients from IEEE 142 and IEEE 1100, mixing well with FAA-STD-019d and NASA-KSC-E0012E, and sprinkling on top some NEC 250 & 517 information would result is a very good final product for a pragmatic lightning protection standard. Some leadership is needed here. Please step forward…

4.0 Conclusion. Lightning is arbitrary, capricious and stochastic with Odds of a Strike approaching 1: 1,000,000. A detailed and professional Risk Assessment exercise may produce meaningless guidance Most people when confronted with a conundrum of Very Low Risk vs Very High Consequences will chose to take no actions (Path of Least Resistance?) towards lightning protection. With emergency radio networks the equation is different. When the communications net goes off-line, for whatever reason, the result is that ambulance, fire and police resources and responses are compromised. This is an untenable situation which demands lightning protection for telecommunications facilities.

5.0 References.

5.1 Scopes of Work with Reports to Client, NLSI 2004-2005.

5.2 Going Beyond the Codes, An Expanding List of On-The-Job Tips, NLSI 2006. See this at:
www.lightningsafety.com/nlsi_lhm/on-the-job-tips.html

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