PERC$

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Administered by the Michigan Municipal League

A Service of the Michigan Municipal League Liability and Property Pool and the Michigan Municipal League Worker's Compensation Fund

LIGHTNING PROTECTION FOR YOUR MUNICIPALITY

Lightning protection technology and lightning safety awareness are important components of every municipality's public safety program. Lightning protection systems are designed to protect not only life, but also critical emergency communications including police, fire and 911. Municipalities commonly protect high-risk facilities such as hospitals, schools, public utilities, public landmarks, as well as hazardous waste and materials storage facilities and industrial sites.

In addition to protecting public buildings, facilities such as stadiums, pools, golf courses, etc. incorporate lightning protection systems into the design of on-site structures.

LIGHTNING FACTS

Clouds store both positive and negative electrical charges. Updrafts in the clouds separate the charges. Positive charges accumulate at the top of the cloud. Negative charges accumulate in the lower portion of the cloud and interact with charges in the ground. When sufficient charges accumulate so that release is imminent, the condition creates a lightning bolt. A lightning bolt is a spark that carries the charges stored in the clouds. The separation of charges in the ground acts as an amplifier. It allows a release of charges and a lightning strike to the ground.

Many people believe a lightning strike is a single bolt; however, it is actually a string of several bolts. On average, up to 25 strokes may occur in a strike. Typical lightning strikes carry the equivalent of 2.9 billion kilowatts of power. This amount is six times the total generating electric capacity of the United States.

The Lightning Protection institute conducted a study that demonstrates that:

- 32% of lightning strikes hit roofs and projections such as satellite dishes or chimneys;
- 29 % of lightning strikes hit overhead power lines and phone lines;
- 29% of lightning strikes hit television antennas; and
- 10% of lightning-strikes hit trees near structures.

On average, lightning strikes cause 30% of the church fires and at least 18% of lumberyard fires in the United States annually. They also cause significant losses to more than 18,000 houses and 12,000 other buildings.

In addition, according to the Lightning Protection Institute, lightning...

- Packs between 35,000 to 40,000 amperes of current.
- Can generate temperatures as high as 50,000 degrees Celsius.
- Falls somewhere on earth every second.
- Travels as far as 40 miles.
- Kills nearly 100 people each year in the United States and injures hundreds of others.
- Can and does strike the same place twice.
- Causes billions of dollars in property damage each year and many times results in fire and total property loss.

In addition to direct losses such as property damage to buildings, a lightning strike may result in the indirect losses that often accompany the destruction or damage of buildings and their contents. For example, municipalities rely upon the integrity of their structures as they provide services to their communities. A stroke of lightning to an unprotected building that houses the police or fire station may result in an interruption of vital services to the community. The consequences of such an interruption can range from the public's loss of confidence to a citizen's death when a department is unable to respond to an emergency call.

NFPA 780

Since lightning frequently causes property damage, municipalities should evaluate the need for lightning protection. They should consult the National Fire Protection Association Code 780 (NFPA 780) to determine the need for lightning protection for each municipal structure. NFPA 780 includes a Risk Assessment Guide (Appendix H) to assist in this determination. Municipalities should provide lightning protection for those structures having a risk index of four or greater according to the NFPA 780 Risk Assessment.

Municipalities located in geographic areas that are subject to frequent or to severe thunderstorms need lightning protection. Being in an area with few but extremely severe thunderstorms may be more significant than being in an area with more frequent, but milder storms. Other factors you should consider are:

- Topography – the type of land on which a building is located -- flat, hillside or hilltop, mountaintop.
- Relative location – the structure's position in relation to taller buildings or short buildings in the area as well as to adjacent structures or terrain.
- Type of structure -- single family dwelling, municipal services building, library, etc.
- Building height, construction, and design.
- Occupancy -- the building's use and how many people typically are in it.
- Contents -- residential furnishings, flammable liquids or gases, historical contents, etc.
- The presence of highly sensitive solid state electronics such as monitors, computers, and fax machines.
- Special Risks such as the use, handling or storage of hazardous or flammable materials.

LIGHTNING PROTECTION

Lightning protection focuses on providing a means by which a lightning discharge may enter or leave the earth without damaging the property protected. The three major components of a lightning protection system are:

1) Air terminals,
2) Conductors, and
3) Grounding.

The installation of lightning-protection systems can take place on the exterior of a building, or can be partially or fully concealed within the structure. A qualified contractor should design and install the system.

ELECTRICAL PROTECTION SYSTEMS

A lightning protection system installed to protect a structure from direct strokes does not protect against possible voltage surges on electric service conductors and TV or radio antenna systems. Municipalities should consider surge arrestors or electrical protection systems to protect the electrical services to the buildings. Article 280 of NFPA 70, National Electrical Code, covers the installation of surge arrestors on power and communication lines.

MAINTENANCE AND INSPECTION

Proper maintenance of lightning-protection systems is essential. Municipalities should give attention to ground connections, as rods may break or become corroded at or just below the ground level where the damage is not apparent. Damage may occur to the components of the system due to additions or repairs to the building. Roofers and other general contractors have been known to disable the protection unit during construction activities. Deterioration or mechanical damage to the components of the lightning protection system that go undetected and do not get repaired result in an unprotected structure.

NFPA 780 recommends periodic inspections of lightning protection systems to assure their integrity. At a minimum, municipalities should conduct inspections:

- After installation.
- Annually - Visual Inspection, including points and grounding connections.
- Every five years -- Thorough inspection.
- Whenever the municipality alters the structure.
- After a known lightning discharge to the system.

The frequency of such inspections may vary and depends upon such factors as:

- The classification of structure or area protected.
- The level of protection the systems provide.
- The immediate environment (corrosive atmospheres).
- The materials from which the components of the protection system are made.
- The type of surface to which system components are attached.

In addition, NFPA 780 recommends that inspections and testing take place at differing times of year to assure the effectiveness of the system during various seasons.

Suggested Municipal Structures to Evaluate:

Service buildings such as fire, police, water & sewer	Power generating stations
Playgrounds, picnic areas, ball parks & other open areas	Hangars
Libraries, museums, & historical structures	Water towers & cooling towers
Golf & other recreational shelters	Places of assembly such as schools & recreational facilities

DO:

1. Install UL-listed, properly rated transient surge protection at all levels (not just the service entrance) of the electrical power and exterior lighting systems (especially those that originate or terminate outside the facility), and monitor/test regularly for degradation or failures.
2. Install transient surge protection for all data, control, and communications circuits coming into or going out of the facility, whether overhead or underground. Also monitor/test regularly for degradation or failures.
3. Use multiple, properly installed and bonded, grounding electrodes per the NEC (more is better, if properly bonded together) to obtain no more that 5 - 10 ohms impedance to earth ground (even less for sensitive electronic systems). Ensure building steel and all metal underground metal piping entering the building, including gas pipelines, are bonded to the electrode system.
4. Bond all electrodes, metal enclosures, metal raceways, ground busses, and cable shields together at a single point, and then to the grounding electrodes, using low-impedance bonding jumpers of appropriate materials and types for the frequencies of the different systems (reference UL-96A).
5. Bond together the grounding systems of all the out structures of multi-structure facilities, to create an equi-potential ground plane, especially if the structures share hard-wired power, control, data, or communications links.
6. Record weather data whenever an apparent lightning strike occurs, or whenever suspected transient damage to equipment is discovered. Try to obtain written documentation from a local weather station for the day or period when the event occurred.
7. Whenever apparent transient surge damage is suspected, contact the serving electric utilities (telephone, CATV, and power) and obtain documentation on whether an anomaly might have occurred, including a lightning strike, on any of the utility's service lines.
8. Keep ALL parts that appear to have been damaged by a transient event, for review by the insurance appraiser. Take photographs of all damage and damaged parts before starting any repairs or replacing parts.
9. Test grounding and bonding systems regularly for damage, deterioration, increased impedances, open circuits, and multiple grounds that are not bonded.
10. If equipment is damaged or ceases to operate, due to an apparent or possible transient event, test it and all other related circuits and equipment for hidden damage before attempting to re-energize or operate the affected equipment.
11. For lightning protection systems, use appropriately sized and types of copper conductors as down leads in lieu of the building's or tower's (relatively) high-impedance structural steel.
12. Have your facility evaluated per NFPA 780 or LPI-175 to determine if a lightning protection system is recommended for the type, size, and use of your facility.
13. Consider using properly designed and installed dedicated circuits, with dedicated neutrals and isolated ground conductors, for sensitive electronics equipment, especially if recommended by the manufacturer. Consider shielded isolation transformers if appropriate.

DON'T:

1. Install multiple and separate isolated grounding systems, regardless of what system vendors recommend.
2. Install ground rods so the spacing between them is less than their length – this reduces their effectiveness.
3. Use non-listed and ineffectual mechanical clamps, lugs, etc., for bonding grounding wires to metal structures, piping, and metallic enclosures.
4. Rely on building or tower structural frames as grounding "conductors", in lieu of copper down leads, for lightning protection.
5. Mix transient surge device leads in the same raceways with, or adjacent to, data, communications or critical power circuits.

6. Operate or attempt to operate/restart equipment after it has experienced possible transient damage to itself or to its controls without first testing ALL related circuits and equipment for obvious and hidden damage – this could lead to increased or collateral damage, which may not be covered by insurance.
7. Rely on the normal transient surge protection, installed by some utilities (e.g., telephone, CATV, etc.) on their incoming services, to protect your equipment.
8. Buy transient voltage surge suppressors that guarantee energy savings.
9. Install transient surge protective device leads that exceed the manufacturer's recommended lengths (shorter is better), or with kinks or sharp bends.
10. Double-lug TVSS leads with power wiring – use dedicated and approved connectors/circuit breakers.

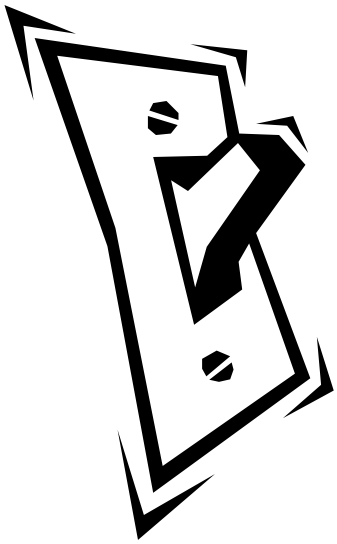
Important Phone Numbers:

MML Risk Management Services (800) 653-2483
The League's Loss Control Services (800) 482-0626.

Note:

This document is not intended to be legal advice. It does not identify all the issues surrounding the particular topic. Public entities are encouraged to review their procedures with an expert who is knowledgeable about the topic.

Specifications for Lightning Protection — ASAE Engineering Practice



ASAE safety standards are not laws. They are recommended voluntary standards used by designers, engineers, manufacturers and users of the equipment, systems and products. However, in the absence of laws, rules and regulations, ASAE standards can be considered "best safety management practices," and failure to implement and enforce these standards could be interpreted as NOT providing a safe and healthy workplace. Manufacturers, employees and others have been found to be negligent when injury or death has resulted from noncompliance with a recognized ASAE Standard.

The standard is not included in its entirety in this document, but rather those safety and health concepts most pertinent to agricultural owners, managers, supervisors and workers have been selected. Complete copies of the ASAE Standards are available from ASAE Order Department, 2950 Niles Road, St. Joseph, MI 49085–9659, Telephone: (616) 429–0300, FAX: (616) 429–3852.

Introduction

This is a condensation of American Society of Agricultural Engineers (ASAE) Standard EP381.1. It contains safety recommendations for lightning protection on farms. This document is not intended to be totally inclusive, but rather to highlight the information that owners and managers of agricultural businesses should understand.

This document is IFAS publication DH 806.

Adapted by UF/IFAS from: *Fact Sheet AE-277* (Department of Agricultural and Biological Engineering, Institute of Food and Agricultural Sciences, University of Florida). Developed by the Florida Cooperative Extension Service for the benefit of Florida's citizens.

Purpose and Scope

This Engineering Practice is intended as a guide for specifying farm lightning protection systems, and for checking existing, new or proposed lightning protection systems against accepted standards of design, materials and installation.

This Engineering Practice is applicable to protection of farm homes, barns, sheds, silos, slatted floors, fences, trees, barn

equipment and other sizable bodies of conductance or inductance. Included are ordinary structures up to 75 feet high.

Common assemblies on typical buildings are detailed to show current practices under normal conditions. Examples cannot cover the wide range of structural variations existing on farms. It is recommended that when a condition is not covered herein, the owner or his agent obtain engineering consultation by an engineer experienced in lightning protection principles, theories and installation requirements, or from an established and recommended manufacturer or distributor of lightning protection materials and equipment.

In areas not covered by this Engineering Practice, refer to the National Fire Protection Association Standard No. 78, Lightning Protection Code; Underwriters' Laboratories Standard, Requirements for Master Label Lightning Protection; or Lightning Protection Institute Standard LPI-175, Installation Code.

"Materials for lightning protection shall be inherently resistant to corrosion or properly protected against corrosion."

Materials

Materials for lightning protection shall be inherently resistant to corrosion or properly protected against corrosion. No materials shall be combined which form an electrolytic coupling that accelerates corrosion, such as copper-aluminum couplings.

Copper commonly required for commercial electrical work, with 98% conductivity when annealed, is the preferred material for farm lightning protection. Alloyed metals used shall be substantially as resistant to corrosion and have the same conductivity as copper under similar conditions.

Copper-clad steel shall have a copper covering permanently and effectively welded to the steel core, in such proportions that conductance is not less than 30% of the conductance of an equivalent cross section of solid copper.

Aluminum is acceptable as a substitute for copper in lightning protection, with the stipulations that (a) aluminum shall not be used underground, in contact with ground or where air may be laden with corrosive elements, such as ocean air; (b) when an aluminum system is joined with copper or copper-clad grounds, the union shall be made with approved bimetal connectors; (c) precautions be taken at connections with dissimilar metals; and (d)

cable conductors be of electrical conductor grade aluminum.

Material such as galvanized steel is not acceptable except as specified elsewhere in this Engineering Practice.

Materials shall be used in those forms and sizes specified in the following Sections, Air Terminals, Conductors, Grounding, and Connectors and Other Fittings.

Air Terminals

Air terminals are the topmost elements of the lightning protection system and are designed to intercept a direct lightning strike.

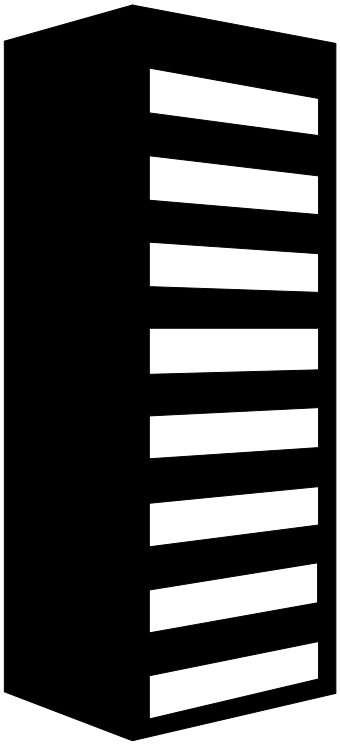
Air terminals shall be $\frac{3}{8}$-inch minimum diameter for solid copper or $\frac{1}{2}$-inch minimum for solid aluminum. Air terminals shall extend above the protected object at least 10 inches but no more than 36 inches. If over 24 inches high, air terminals shall be suitably braced.

Air terminals up to 24 inches high shall be spaced at intervals of 20 feet or less; those 24 inches or higher shall be spaced 25 feet or less. Terminals shall be placed on the ridges of gable, gambrel and hip roofs of ordinary or high slopes, and at the perimeters of flat or low-slope roofs. A shed roof with a high or normal slope shall be considered as half of a gable roof. There shall be an air terminal within two feet of the end of each ridge or each corner of a flat or low-slope roof.

Air terminals shall be placed within two feet of the edge along the perimeter of a flat or low-slope roof. A low-slope roof is one which is 40 feet wide or less and has a pitch of 1 in 8 or less; or is over 40 feet wide and has a pitch of 1 in 4 or less. The center of such a roof shall have intermediate air terminals at intervals not exceeding 50 feet.

Chimney air terminals may be anchored directly, or secured by an acceptable metal band around the chimney. No outside corner of a chimney shall be more that two feet from an air terminal. Copper chimney air terminals and all related components shall be hot-dip lead coated to prevent corrosion. Aluminum points, cable and fittings on chimneys need not be lead coated.

Conductors



Main conductors are those used to (a) interconnect air terminals in a direct or closed-loop roof system; (b) serve as downleads from the roof system to the ground system; (c) connect metal bodies of inductance or conductance to the main conducting system; and (d) serve as ground electrodes in some cases, or to connect ground rods in certain other cases.

When there is no alternative to coursing a conductor through the air, this may be done without support for a distance of three feet or less, or with support of a ⅝-inch copperclad ground rod or its equivalent. A conductor may be coursed through the air for a distance of up to 6 feet.

Roof conductors shall be coursed through or around obstructions in a horizontal plane with the main conductor. Conductors shall maintain a horizontal or downward course, free from U or V (down and up) pockets. No bend of a conductor shall form an angle of less than 90 degrees, or have a radius of bend less than 8 inches.

Metal roofing and siding, eave troughs, downspouts and other metal parts are not acceptable as substitutes for lightning conductors. A lightning conductor system shall be applied to the metal siding of a metal-clad building in like manner as on buildings without such metal coverings.

Down conductors, which are continuations of roof conductors, shall be as widely separated as possible at diagonal corners of rectangular buildings, and diametrically opposite on cylindrical structures.

No less than two down conductors with a proper ground for each shall be provided on any structure. Buildings with perimeters exceeding 200 feet shall have one additional down conductor for each 100 feet or fraction thereof.

Down conductors located in cattle yards, driveways or other vulnerable locations shall be guarded in such a manner as to prevent physical damage or displacement, to a distance not less than 6 feet above ground level. If run through conducting pipe or tubing (of compatible metal), the conductor should be bonded to the conduit at top and bottom.

Grounding

Proper grounds are critical to assure dissipation of a lightning discharge without damage. Extent of grounding will depend on the character of the soil, ranging from two simple 10 foot grounds for a small building located on deep conductive soil, to an elaborate network of cables and rods or plates buried in soil that is dry or rocky and of poor conductivity.

Minimum acceptable standard for each ground electrode shall be a copper-clad steel rod at least ½ inch in diameter and 10 feet long. Rods of solid copper ½ inch in diameter may be used in lieu of copper-clad steel. Stainless steel ground rods are also acceptable where acid soil conditions exist or other conditions warrant substitution of stainless steel.

"Proper grounds are critical to assure dissipation of a lightning discharge without damage."

Wherever practicable, connections to ground electrodes shall be made at points not less than one foot below grade and two feet out from the foundation. Grounds shall be distributed and placed at corners and other locations in a manner to direct the flow of current out from the building rather than under it. Placing of grounding under a building (as in extending a building) shall be kept at a minimum. There shall be a ground at each down conductor.

In moist clay, the ground shall extend vertically not less than 10 feet into the earth, and the earth shall be tamped along the full length of the ground.

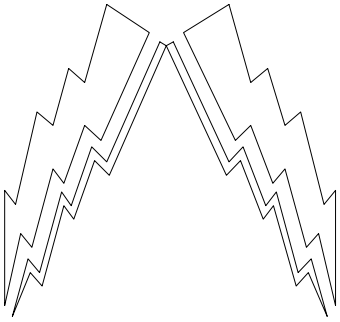
In shallow top soil where bedrock is near the surface, the lightning conductor (extensions of the down conductors) shall be laid in trenches extending away from the building. Trenches shall be at least 12 feet long and one foot deep in clay soil, and at least 24 feet long and 2 feet deep in sandy or gravelly soil.

In moist sandy or gravelly soil of ordinary soil depth, 2 electrodes shall be driven at least 10 feet deep at each ground. The conductor shall be extended out from the building in a trench at least 2 feet from the wall. The two electrodes shall not be spaced more than 6 feet apart.

All underground metallic piping, including water piping, well casings, sewer and septic lines, shall be connected to the grounding system with main size conductors and special fittings with a

minimum contact surface to the pipe 1.5 inches long and 2 square inches area. Water pipe, well casings, sewer and septic line connections are in addition to the required number of regular grounds. If a metal water pipe, well casing, sewer or septic line enters a building, at least one down conductor of the lightning protection system shall be connected to it.

Lightning Arresters



Radio and television masts of metal, regardless of location on a building, shall be bonded to the main conductor of the lightning protection system with a main-size conductor and acceptable fittings.

To protect radio or TV equipment against surges, a lightning arrester shall be installed on the lead-in wire, tape or cable and bonded to the lightning protection system directly or through a common ground. Secondary service arresters shall be installed by the lightning protection contractor, electrical contractor or the electric utility company. Such arresters shall be installed on both overhead and underground services at the electric service entrance, or at the interior service entrance box, depending on local regulations. Before installing a secondary service arrester, it should be determined that the neutral wire is adequately grounded, preferably to a metal water pipe system that enters the ground.

Additional Resources

- Your County Extension office