Lightning Protection for Homes and Farm Buildings

By: Jon Althouse

Lightning strikes to the ground can endanger people, animals, and property. It is important to know what to do during a thunderstorm. The best protection is to be inside a steel framed building. When inside a wood framed building, stay away from plumbing and metal appliances. If caught outside in the open, crouch down near the ground away from any lone tall object such as a tree. An automobile with a metal roof offers good protection. The probability of damage to buildings can be reduced while increasing the effectiveness of the building as a lightning shelter by installing proper lightning protection for the building, (Figure 1.)

Ground lightning is an electrical discharge between a thundercloud and the earth. The purpose of a lightning protection system is to provide a good path from the high point of an object to the earth, preferably on the outside of the building. Lightning can cause damage from a direct hit to a structure and it can cause transient surges in wiring leading to buildings. A properly installed lightning protection system should protect from both sources of lightning damage.

Figure 1. Attach air terminals (lightning rods) to the roof ridge to intercept a lightning strike to the building.

Causes of Lightning: Turbulence and wind shears within a cloud can lead to a separation of electrical charges. Generally, the lower portion of a thunder cloud develops a negative charge and the upper portion develops a positive charge. Normally, air is a good insulator, but with high voltage, air ionizes and becomes electrically conducting and the

current flows to equalize the charge. When the current flows the bolt may strike the highest object, such as a tree, tower, or building. A lightning protection system gives the lightning an easy path. If a path is not provided, the lightning will seek a path that may cause considerable damage to property or cause harm to people and animals. Lightning current can enter a building in search of a path. People standing near metal objects or plumbing may become part of the lightning's current path.

When an electrical charge builds up, leaders begin to develop. The charge usually travels in 150 foot segments downward from the cloud. The lightning process is illustrated in Figure 2. The lightning is a narrow path of air that has become ionized. Every few micro-seconds (a micro-second is one millionth of a second) another segment is added to the leader. Sometimes the leader branches out in several directions. When the leader is within a few hundred feet of the earth, tall objects on the ground often begin to send out another leader to join the one coming down from the cloud. The air above these objects can actually glow, an effect called corona. When the leaders join, an electrically conducting path has been established between the cloud and the earth and a massive return stroke of current follows. The current rapidly peaks then decreases slowly taking one ten-thousandth of a second. If one stroke does not deplete the cloud of it's charge, several strokes may follow the same path. There are usually several strokes per lightning event. They occur so rapidly that they appear as one. Occasionally there is enough time between strokes that a flashing effect can be observed. Lightning typically reaches peak levels in the tens-of-thousands of amperes. Ground materials that are in the path must be capable of conducting high levels of lightning current or damage will occur.

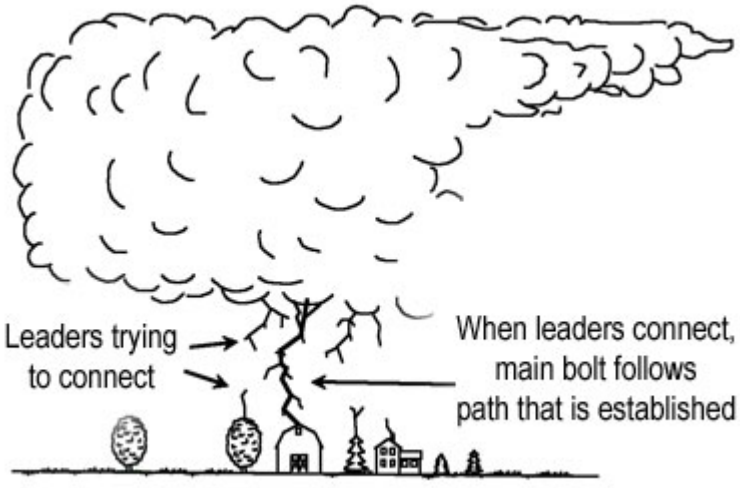

Figure 2. A leader extends down from the cloud to an object on the ground to complete a path followed by a return stroke of tens-of-thousands of amperes.

Protecting Buildings: Lightning protection for a building includes air terminals (lightning rods) on its highest points, properly sized and installed connecting cables, and a grounding electrode system that makes low resistance connection to the earth. For

lightning protection, the building's electrical system must have good grounding and be connected to a separate grounding system. In addition, a surge arrester connected to the home's electrical wires entering a building helps prevent surges from entering that would cause damage to appliances and equipment.

Air terminals should extend a minimum of 10 inches above objects they protect (figure 3). An air terminal should be installed on all high projections, such as silos, roofs, and chimneys. For continuous roof ridges, air terminals should be spaced 25 feet. The diameter of an air terminal is 5/8 inch. When installed on a flat surface, the height should be increased to 12 inches, not to exceed 24 inches.

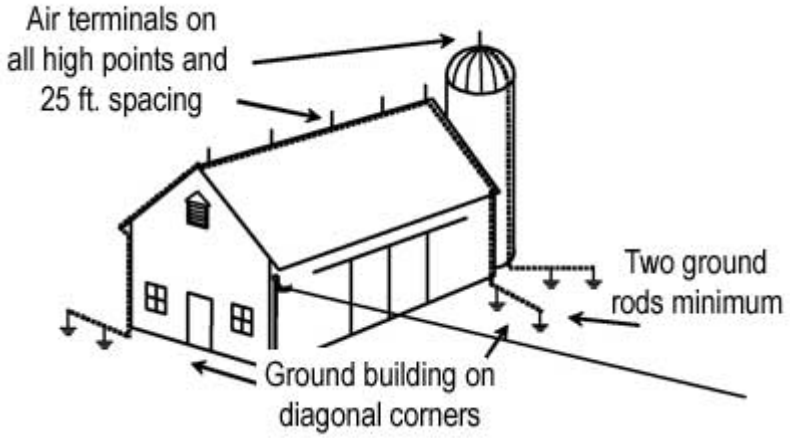

Figure 3. Attach air terminals to the roof ridge and other high points and connect them to grounding electrodes on opposite corners of the building with a main connecting wire.

A grounding connection to earth should be provided at diagonal corners of the structure. Larger buildings (more than 250 feet in perimeter) should have additional grounding connections to the earth. A grounding connection to the earth every 100 feet along a building is recommended. A main wire should be run from the earth ground on one corner, over the building connecting each air terminal and terminating at the other earth ground. If the building is served with a metal underground water piping system, it should be connected to the lightning system grounds. The electrical system ground should be connected to the lightning system grounds. If ground rods are to be used to make the connection to the earth, standard ground rods are 8 feet in length. Ground rods should be driven to their full depth and a wire attached with a suitable clamp for direct burial. It is recommended that each earth connection consist of two ground rods spaced at least 8 feet apart.

If a building is previously equipped with a lightning protection system, check to see if the connections to the grounding electrodes are in good condition. It is common to find wires corroded at the point of entry or somewhere below the earth. If an existing earth ground consists of one ground rod, it is recommended another be added spaced not closer than 8 feet from the original ground rod.

Connecting wires are used to join the air terminals together and connect to the earth ground. All of the components of a lightning protection system for a building should be connected together to form one complete system. Do not connect some air terminals to one earth ground and some to another earth ground. There should be at least two independent paths from every air terminal to an earth ground. An exception is an isolated air terminal tapped to a main line conductor. The connecting wires are typically solid copper, copper coated steel, or galvanized steel. These connecting wires need to be corrosion resistant and of adequate size to carry the current of the lightning bolt. A good reason for having multiple earth grounds and multiple paths is to divide the lightning current so it can be directed to earth more easily. It is recommended that the main line wires be no smaller than copper with a weight of 187 pounds per 1000 feet. This translates into a size 2 AWG copper wire. Radial that runs off the main wire to individual isolated air terminals should be size 6 AWG copper wire, not exceeding 15 feet.

It is important that isolated metal objects exposed on the surfaces of buildings be connected to the lightning protection system. Metal gutters and down spouts are one example. Another might be a metal track for a barn door especially if the barn door is metal. When lightning strikes a building a "side flash" can occur between the wires of the lightning protection system and an adjacent metal object. This side flash can harm a person standing close to the object or ignite a fire. It is not practical to bond all metal objects to the lightning system, but give consideration to metal objects that may become part of a lightning path to earth. A size 6 AWG copper wire can be used to bond the isolated metal objects.

What is a Zone of Protection? It may not be necessary to provide a lightning protection system on all buildings if they are located next to a tall object that has been provided with lightning protection. Figure 4 illustrates the distances and heights that are considered to be protected by an adjacent object. If a building or tall object is properly protected, the zone of protection extends out from the base of the object in all directions equal to the height of the building or object. The probability of a lightning strike is low for a distance of two times the height of the building. This does not mean a person or animal is safe within this zone. A side flash from the protected building or current in the earth can create a hazard for people and animals.

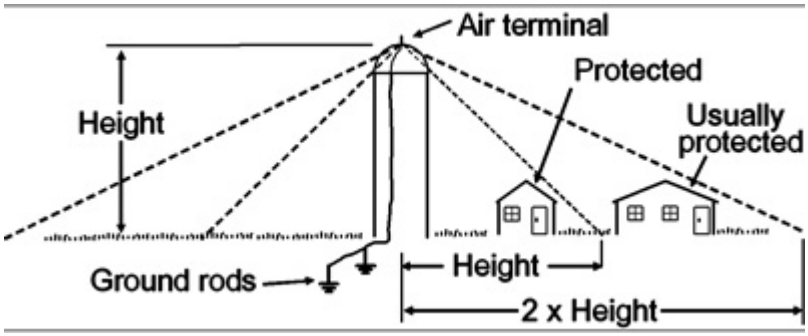

Figure 4. Tall objects with a lightning protection system provide a zone of protection to some adjacent buildings and objects.

Surge Protection: Lightning can strike an electrical power wire travel down the wire in all directions searching for a path to earth. These surges can enter buildings and damage wiring and equipment. Individual pieces of equipment may be equipped with it's own surge protection, but that protection may not be adequate to handle a major surge entering the building through the wiring. An electrician can install a surge protector where the electrical wires enter the building (Figure 5.) A common type of surge protector used for this purpose is called an MOV (metal oxide varistor). The surge protector is connected to each of the ungrounded (hot) wires that enter a building and to the grounded conductor (neutral). A surge approaching a building through the wiring will be a voltage pulse of very short duration and carry a much higher power voltage. The metal oxide in the protector is sensitive to high voltage, but not to the normal voltage. When this metal oxide is exposed to extremely high voltage, it changes from an insulator to a conductor and shortens the surge directly to earth. As soon as the voltage returns to normal the metal oxide returns to an insulator. A good earth ground for electrical systems is essential for proper operation of a surge arrester. If a surge arrester is installed, make sure the adequacy of the electrical system earth ground is checked and improved if necessary.

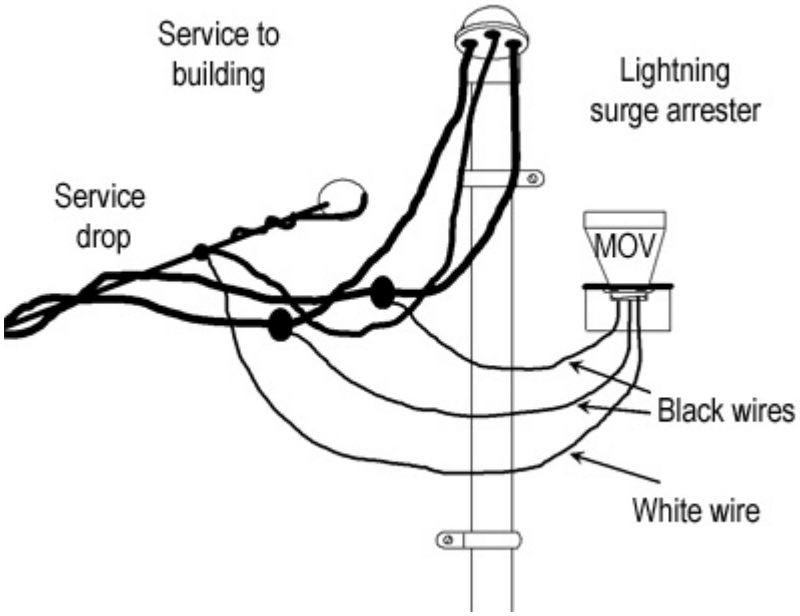

Figure 5. A surge arrester installed at a service entrance to a building provides a direct path to ground.

Conclusion: Lightning is an important and essential part of the earth's ecosystem, but can be destructive at times. It is sometimes hard understand why some places seem to be prone to lightning. Very tall objects are frequent targets because they represent the shortest path from a cloud to earth. Injury, damage, and fires are usually the result of lightning not being able to find a quick and easy path. A good lightning protection system helps provide that path, thus reducing the probability that damage will occur to people or animals.

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