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Strike Terminations for Lightning Protection Systems

Course No: E03-012
Credit: 3 PDH

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1. Introduction

The course will discuss the details of implementing the Strike Termination Subsystem (STS) which is one of the necessary subsystems of a lightning protection system. No single subsystem, of itself, constitutes complete protection against the effects of lightning. Each subsystem works in a complimentary fashion.

An overview of the complete lightning protection systems and its functioning is given in the CED course #E02-009, Fundamentals of Lightning Protection Systems. Completing this course is recommended as a prerequisite to this course but is not necessary.

The STS intercepts the lightning event. Specifications are given in the lesson to describe the arrangement of the receptors of the strike, called strike terminations, in such a fashion that protects a structure and adjacent areas. These specifications are based on the guidance of well-accepted design standards commonly used for lightning protection. The standard that is used for guidance in this lesson is the National Fire Protection Association's *Standard for the Installation of Lightning Protection Systems*, NFPA 780, 2011 edition. This reference has been in use since 1904 and remains the definitive guidance for lightning protection systems. In this lesson, a reference to NFPA 780 will be given in brackets to correlate to a specific paragraph in that standard. The information in this lesson is intended to explain the material in the standard. This lesson is not intended to replace or supersede the requirements of the standard. You are encouraged to obtain a copy of the NFPA 780 for advanced study and/or use.

2. Lightning Protection System Overview

It is important to understand that lightning protection systems (LPS) have five distinct subsystems. They are:

- Strike Termination Subsystem
- Conductor Subsystem
- Grounding Electrode Subsystem
- Equipotential Bonding Subsystem
- Surge Protection Subsystem

These subsystems function in a complimentary fashion to protect a structure from the damaging effects of lightning. No single subsystem provides overall protection against lightning, they all work in concert. Figure 1 illustrates a simple representative LPS that might be installed on a small structure.

This lesson concentrates on the details associated with the implementation of the Strike Termination Subsystem (STS.)

3. Introduction to the Strike Termination Subsystem

a. Purpose

The purpose of the strike termination subsystem is to intercept the lightning event and course it harmlessly into the conductor subsystem. The STS can take many forms specified by the various engineering standards available. In general, it is a metal device that is connected in an electrically and mechanically robust fashion to the conductor subsystem. A common specific type of strike termination is an air terminal. The air terminal is a device listed for the purpose by a Nationally Recognized Testing Laboratory (like Underwriter's Laboratories, for example)

consisting of a metal rod protruding above a structure. These are commonly known as ‘lightning rods’ but this term is generally not used in the lightning protection industry. Other types of strike terminations are commonly used consisting of overhead wires and structural steel parts of a building.

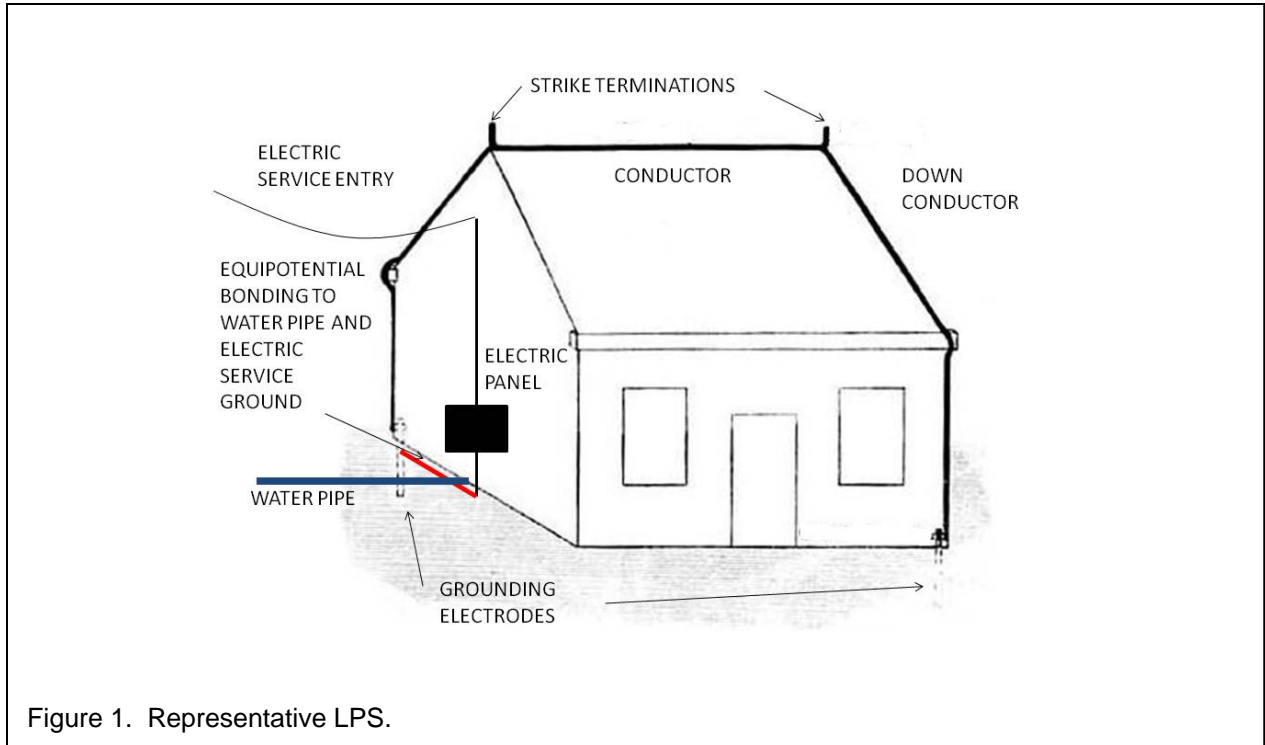


Figure 1. Representative LPS.

b. Operation of the Strike Termination [B.1 – B.3]

The strike termination is a device that responds to the electric field of an approaching thunderstorm. When thunderstorm conditions emerge, electric charge is lowered from the cloud, generally in the form of a line charge. This is called the downward leader and is the precursor of a lightning strike. These may be several of these at any given time and could have a range measured in kilometers. Polarity of the downward leader is negative approximately 90% of the time but ‘positive strikes’ do occur. However, the behavior of negative and positive strikes are identical, as far as we are concerned in this course. As the downward leader approaches the ground, the electric field under it becomes very intense.

In response to the heightened electric field intensity, the strike terminations emit an upward streamer. It is important to point out that any object can emit an upward streamer of charge under the conditions of high electric field intensity. Trees, power lines, buildings without lightning protection systems and even people can emit upward streamers and can,

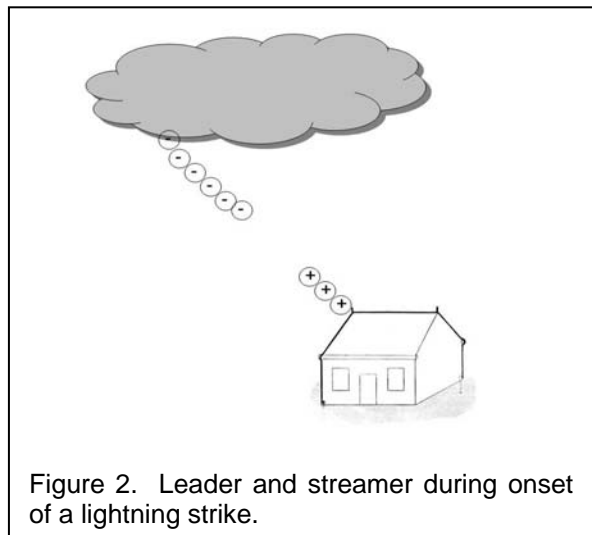


Figure 2. Leader and streamer during onset of a lightning strike.

consequently, be struck by lightning. However, the strike termination is designed to receive lightning current intentionally, unlike other parts of a structure. These upward streamers have a maximum range of some tens of meters but their range is generally shorter as it depends on the amount of charge present in the downward leader. Because this range is limited, having strike terminations and a lightning protection system does not increase the chances that a structure will be struck by lightning, as is sometimes thought.

The upward and downward streamers are of opposite charge and are therefore attractive. (See Figure 2.) When they connect, the lightning channel is completed and a large amount of charge stored in the thundercloud flows to earth, to the strike termination, through the lightning protection system, to equalize charge in the earth. A large amount of current flows and we hear the characteristic noise of thunder when this occurs.

c. Types of Strike Terminations [4.6.1]

The following types of strike terminations are recognized for use:

- Permanent metal parts of structures
- Air terminals
- Metal masts
- Overhead ground wires

Combinations of different strike termination devices are permitted within the entire STS for a structure. [4.6.1.2] Later in the lesson, we will see how to arrange the strike termination devices to afford protection.

4. Construction of Strike Termination Devices

a. Materials

A variety of materials are permitted for the STS. [4.2] Generally, copper, aluminum and copper alloys are used for items constructed specifically for the purpose as strike terminations (air terminals.) Structural parts of buildings are permitted for use in the STS. These could consist of steel or similar structural materials. Similarly, masts could consist of metals commonly used in construction, most commonly steel. In the case of overhead ground wires (OGW) a variety of materials are permitted.

b. Corrosion Prevention

It is necessary to prevent corrosion in the STS. Since aluminum is a common material used in lightning protection systems, its use requires special consideration for the prevention of accelerated corrosion through the electrolytic coupling created by these materials. [4.2.2.3 & 4.5] Aluminum and copper cannot contact each other for this reason. In fact, when water runoff from copper materials (like gutters or roofing) may deluge aluminum lightning protection components, accelerated corrosion may occur. Consequently installation of aluminum components in these locations is avoided. [4.5.1] In addition, aluminum cannot be used in wet locations where the components would be immersed or embedded in concrete or masonry, or attached to a surface coated with alkali-based paint. [4.5.3]

To couple dissimilar metal lightning protection components, special bimetallic (usually bronze) components are used. For example, in the context of the STS, one could use aluminum air terminals with bimetallic bases connected to copper conductors.

c. Thickness

Metals 3/16 in. and greater can be used for a strike termination device. [4.6.1.4] Metals that are thinner increase the risk of burn through as a result of the lightning event. Should this occur, there is a risk of fire from molten metal droplets.

d. Air Terminals

Air terminals are items specifically constructed as strike terminations. They are listed for their purpose (under Underwriter Laboratories Standard 96A) and built to exacting material standards.

1) Air terminal materials. Air terminals are constructed of copper, aluminum or copper alloy.

2) Classes of air terminals. The construction standards for air terminals are divided into two classes, I and II. Class I materials are used for structures that do not exceed 75 ft. in height above grade. Class II materials are used for structures in excess of 75 ft. in height above grade. Mixing is permitted. If a structure has intermediate roofs above and below the 75-foot limit, Class I may be used on the lower roof and Class II on the higher roof. (Class II materials must then be used consistently to grade on the Class II sections of the structure.) Dimensions for the air terminals are given in Tables 1 & 2 below.

Table 1: Minimum Class I Air Terminal Dimensions.

Material:		Copper		Aluminum	
Terminal type	Parameter	SI	US	SI	US
Air terminal, Solid	Diameter	9.5 mm	3/8 in.	12.7 mm	1/2 in.
Air terminal, Tubular	Diameter	15.9 mm	5/8 in.	15.9 mm	5/8 in.
	Wall thickness	0.8 mm	0.033 in.	1.63 mm	0.064 in.

Table 2: Minimum Class II Air Terminal Dimensions.

Material:		Copper		Aluminum	
Terminal type	Parameter	SI	US	SI	US
Air terminal, Solid	Diameter	12.7 mm	1/2 in.	15.9 mm	5/8 in.
Air terminal, Tubular	Not permitted for class II.				

e. Lightning Protection Masts [4.6.3]

Lightning protection masts and/or overhead ground wires can be used to provide a zone of protection. There are a number of requirements for implementing a mast for this purpose.

1) Metal masts must have sufficient material properties (e.g., the top of the metallic mast must have a metal thickness of 3/16 in. or greater) for use as a strike termination. Otherwise, it must have a strike termination device. Such a mast can serve as the down conductor, provided it is electrically continuous and has a minimum wall thickness of 0.064 in.

2) Nonmetallic masts must have at least one strike termination device.

f. Overhead Ground Wires [4.6.4]

Overhead ground wires can provide a zone of protection, under the following conditions.

1) Overhead ground wire material can use aluminum, copper, stainless steel, galvanized steel, or protected steel such as copper-clad, aluminum-clad, or aluminum conductor steel reinforced (ACSR).

2) The overhead ground wire material must minimize corrosion from conditions at the site.

3) The overhead ground wire must have at least the same cross-sectional area as a main lightning conductor.

4) It must have minimal sag under all conditions.

g. Sideflash from Masts and Overhead Ground Wires.

Despite the formation of a 'zone of protection,' sideflashes, essentially an electric arc, can occur under lightning conditions. (More on this topic is presented in CED Course No. E02-009, Fundamentals of Lightning Protection Systems.) To prevent sideflash hazards, the minimum distance between a mast or overhead ground wire and the structure needs to be calculated and considered in overall system design.

1) Sideflash distance from a mast is calculated from the following formula:

$$D = h/6$$

where:

D = sideflash distance from a mast

h = height of mast

2) The sideflash distance from an overhead ground wire is calculated as follows:

$$D = l/(6n)$$

where:

D = sideflash distance from a mast or overhead ground wire.

l = length of lightning protection conductor between its grounded point and the point being calculated.

$n = 1$ where there is a single overhead ground wire that exceeds 60 m (200 ft) in horizontal length.

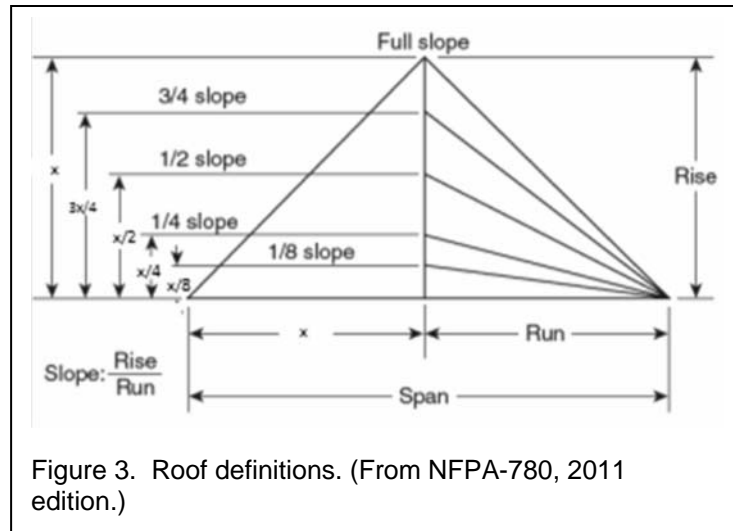
$n = 1.5$ where there is a single overhead wire or more than one wire interconnected above the structure to be protected, such that only two down conductors are located greater than 6 m (20 ft) and less than 30 m (100 ft) apart.

$n = 2.25$ where there are more than two down conductors spaced more than 7.6 m (25 ft) apart within a 30 m (100 ft) wide area that are interconnected above the structure being protected.

The general relationship to minimize the sideflash distance is to minimize the conductor length to the grounded point and to maximize paths to ground. Having several paths to ground divides the current on the overhead ground wire system and consequently minimizes sideflash.

h. Roof definitions.

In order to go further, it is necessary to define some terms for roofs. Roof slope is defined as the rise or increase in vertical height divided by the run, which is the horizontal distance between the roof edge to the apex, as illustrated in Figure 3. [4.1.2] Note that the run is different than the span and that the slopes can be different for each run. Further, the slope is denoted by the fraction of the rise over the run as illustrated. For example, if the rise equals the run, the roof is called 'full slope.' If it rises 1/8 of the run, it is 1/8 slope and so on.



For the purposes of lightning protection the additional definitions apply:

Pitched roofs: Roofs with a span of 12 m (40 ft) or less and a slope 1/8 or greater; or roofs having a span of more than 12 m (40 ft) and a slope 1/4 or greater.

Flat or gently sloping roof: A roof with a slope less than a pitched roof.

5. Zones of Protection Formed by Strike Terminations.

a. Zone of Protection Defined [4.7]

Since the strike termination is intended to intercept the downward leader, it implies a region of protection. This is called the 'Zone of Protection' (ZOP) and is based on models of lightning behavior. The design objective for the STS is to enclose a structure in a ZOP. The ZOP is defined as 'the space adjacent to a lightning protection system that is substantially immune to direct lightning flashes.' [3.3.39] Additionally, one can consider the space, or volume, under the lightning protection system to be substantially immune to lightning flashes. There are generally three different methods to determine this volume or space.

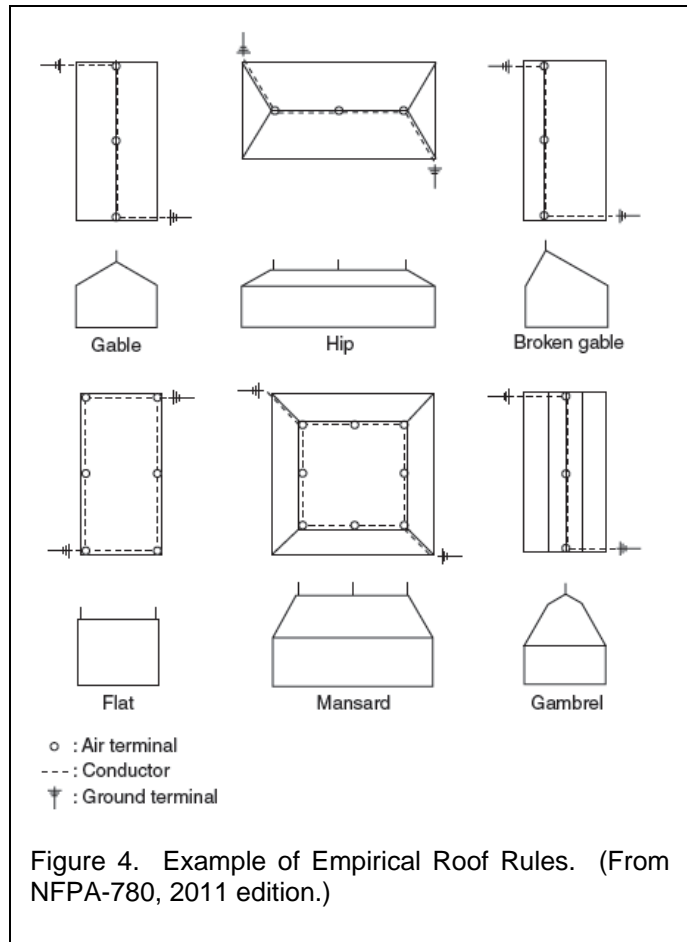
Three models are used for the determination of the ZOP. They are the 'roof rule' method, rolling sphere method and the protective angle method. These methods are ways to determine placement of strike terminations and to find a ZOP.

b. Empirical ‘Roof Rules’

For some simple structures, the NFPA 780 standard lists empirical roof rules that may be applied to protect structures from direct lightning strike. [4.1.2.4] Figure 4 illustrates these rules. In the application of these rules, a height limitation of 50 ft. from grade to eave (the distance above grade to the lower edge of the roof, where it joins the vertical wall) applies.

Implementing roof rules requires correct spacing of the strike terminations that will be discussed in detail in one of the upcoming sections.

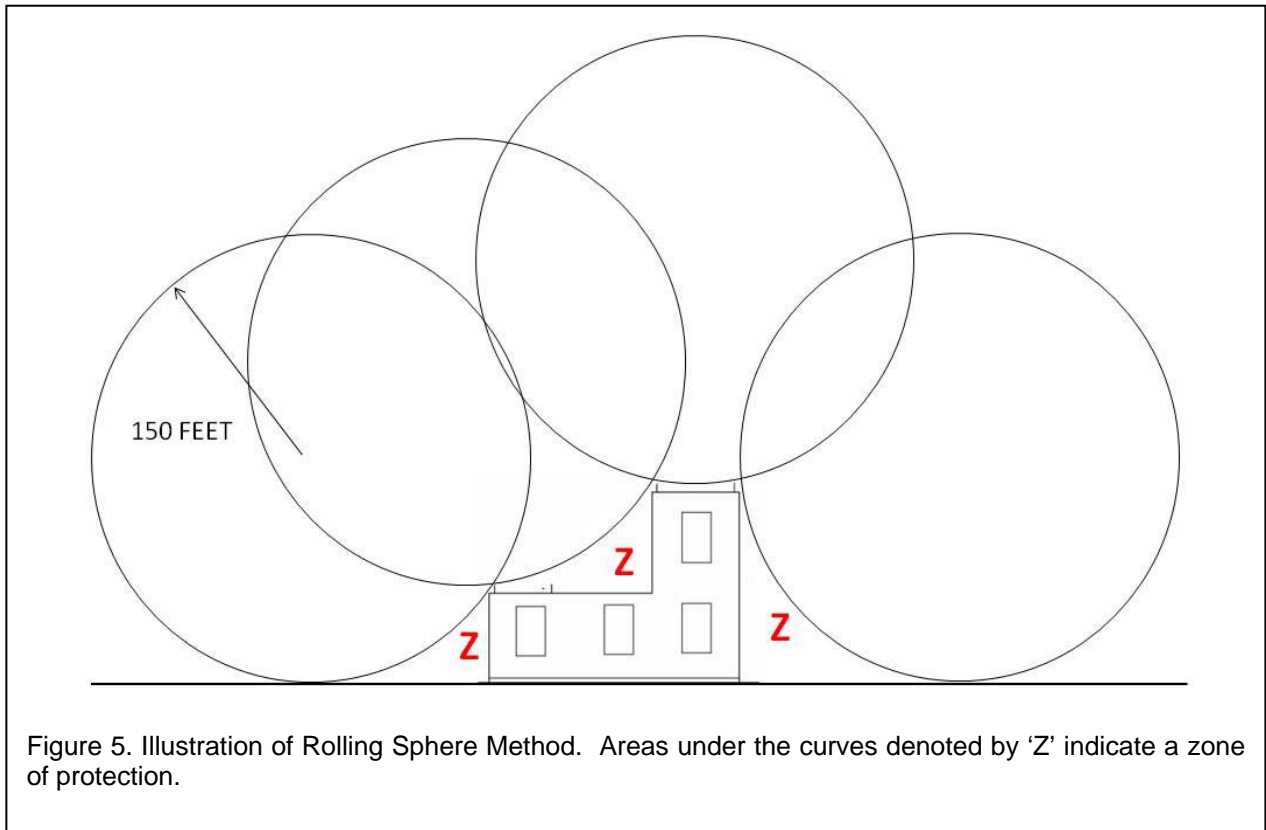
In the application of the roof rules, the ZOP is considered to be the volume extending under the roof vertically from where the eave extends. The implication of the ‘roof rules’ is that the extent of the roof and the structure below it is within the zone of protection. It is recognized that there is a volume extending about the roof that is also considered within the zone of protection. The ‘roof rules’ only apply to the simplest structures and is somewhat limited. Fortunately, models to account for more complicated structures are available.



c. Rolling Sphere Method [4.7]

The Rolling Sphere Method (RSM) is one way to determine strike termination placement and the ZOP of lightning protection systems. It is the most general of the methods. It is formulated by correlating the radius of the sphere with the average amount of charge present in the downward lightning leader. For most applications, the radius of the sphere is 150 ft. (46 m). This correlates to the ‘striking distance’ of over 90% of all lightning events. For more critical applications, a smaller sphere of 100 ft. (30 m) is used, correlating to over 97% of all lightning events.

How this method is applied is to begin with an imaginary sphere of the desired diameter (usually 150 ft.) and ‘roll’ it over the affected structure. Areas under the exterior of the sphere between points of contact become the ZOP. This method is illustrated in Figure 4. It is assumed that strike terminations are needed wherever the sphere contacts the structure and installed in accordance with accepted engineering standards. The sphere must consider all directions of approach to the building although we have really just illustrated two directions (from the left and right) of the building in Figure 5. In addition, there are analytical methods to apply RSM.

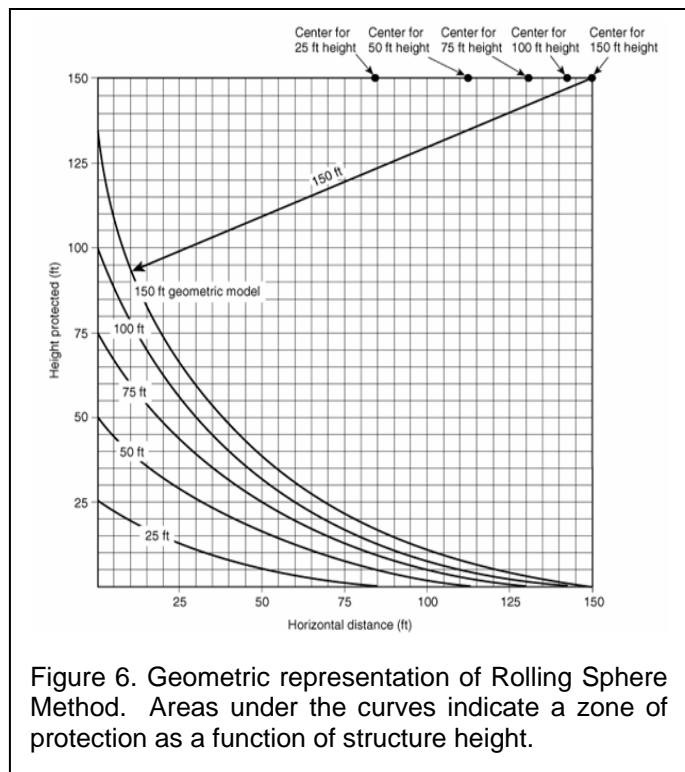


1) Geometric

Using the chart in Figure 6, one can plot the area under the curve for the respective structure height to graphically determine a zone of protection using the rolling sphere method. Selecting a center point for the sphere depending on the height desired (heights from 25 ft. to 150 ft. are shown) the 150 ft. radius is drawn to show the zone of protection curve. A volume under this curve (assuming a dimension out of or into the page) describes a zone of protection adjacent to a strike termination at the height selected.

2) Analytical

The horizontal protected distance can be calculated. This technique is useful to determine the protection profile on intermediate flat roofs.



Using the following formula, you can find the horizontal protected distance, d .

$$d = \sqrt{[h_1(2R-h_1)]} - \sqrt{[h_2(2R-h_2)]}$$

where:

d = horizontal protected distance (m or ft.)

h_1 = height of the higher roof (m or ft.)

R = rolling sphere striking distance radius (m or ft.)

h_2 = height of the lower roof (top of the object)(m or ft.)

(Use consistent units, m or ft.)

To examine the range of the zone of protection, you can apply the following procedure:

STEP 1: Determine roof surface where you want to determine the extent of the zone of protection.

STEP 2: Determine h_1 = height from grade of the higher roof in ft..

STEP 3: Determine h_2 = height from grade of the lower roof in ft..

STEP 4: Calculate to find d . This will be the range from the vertical surface of h_1 that the zone of protection will extend.

STEP 5: Let $h_1 = h_1 - h_2$ and $h_2 = 0$ (Not necessary if h_2 is at grade.) Find d . This value is the maximum extent of the zone of protection used to check if intermediate protection is necessary.

This procedure is illustrated in Figure 7. Given a 75-foot tall (h_1) building, with a 40-foot tall intermediate roof (h_2) that extends 40 ft. horizontally (annotated in red) as an example, the values can be calculated.

Using the formula to find d , the result is (for the B region) approximately 28 ft., annotated in blue in Figure 7. If we then replace h_1 (75 ft.) with ($h_1 - h_2$) (35 ft.) and set h_2 to zero, we find a value of approximately 96 ft., annotated in green in Figure 7. Since the horizontal extent of the roof is less than 96 ft., strike terminations will only be needed at the roof edge. If the horizontal extent of the roof was greater than the second (green) value, an intermediate row of strike terminations would be needed on the flat roof surface.

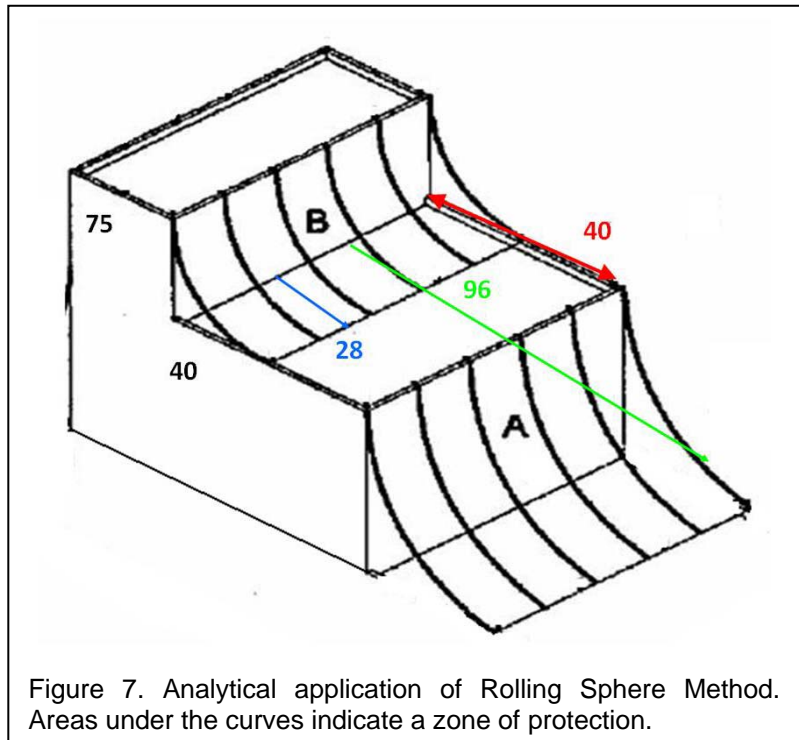


Figure 7. Analytical application of Rolling Sphere Method. Areas under the curves indicate a zone of protection.

If the horizontal extent of the zone of protection is calculated for the A region, ($h_1 = 40$ ft., $h_2 = 0$ ft.) one would find that it is approximately 102 ft. While one would not be concerned with an

intermediate strike termination on the ground, there may be awnings or other projections from the building where knowledge of the zone of protection might be useful.

d. Tall Structures

In the cases where the structure height exceeds the radius of the Rolling Sphere Method, the vertical wall extending under the roof is considered protected, provided that there are strike terminations installed on that roof. This situation is illustrated in Figure 8.

It is widely accepted that the probability of a strike connecting to a vertical surface is very low; consequently, strike terminations are not usually installed on them. Projections from the vertical surface may need strike terminations, however.

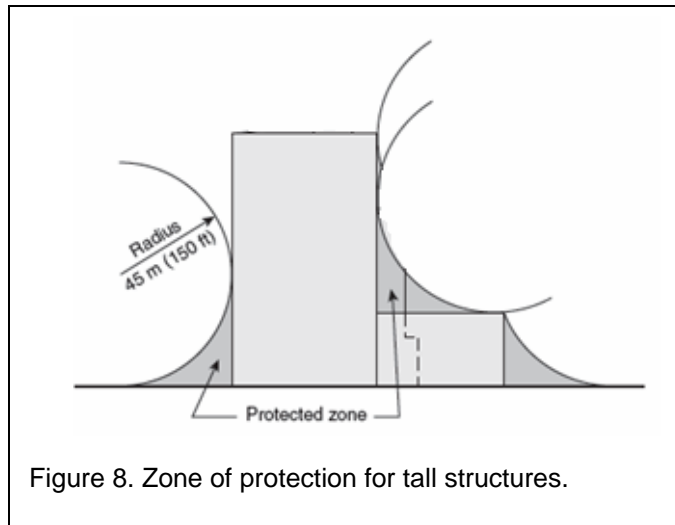


Figure 8. Zone of protection for tall structures.

e. Protective Angle Method

An older and simpler way to determine placement of strike terminations is the Protective Angle Method (PAM). This method is a simplification of the RSM for structures that do not exceed 50 ft. in height. For structures less than 25 ft. in height, a 60 degree, or 1:2, angle is permitted. For structures over 25 ft. but not in excess of 50 ft., a 45 degree, or 1:1, angle is used. This is illustrated in Figure 10.

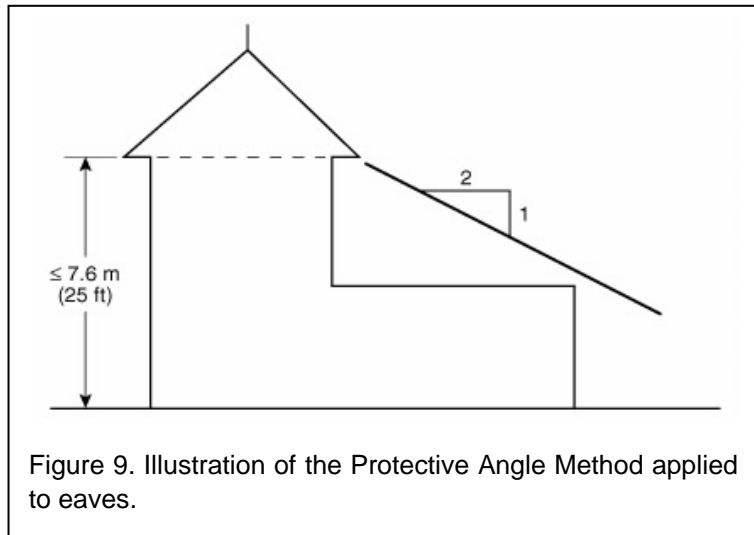


Figure 9. Illustration of the Protective Angle Method applied to eaves.

The protected angle method is construed in the NFPA 780 as 'Protection for Lower Roofs' so one can protect lower attached roofs using the empirical roof rules within these limits. For pitched roofs in the case of the empirical roof rules, the height of the building is considered to be the eave height above grade and the protected angle is drawn from the eave as illustrated in Figure 9. Also, a 1:2 angle is illustrated with a 25-foot eave height above grade. If this eave were to extend up to 50 ft. above grade, then a 1:1 angle would be permitted. Additional placement rules apply if the eave is between 50 ft. and 150 ft. Alternatively, rolling sphere method can always be employed instead.

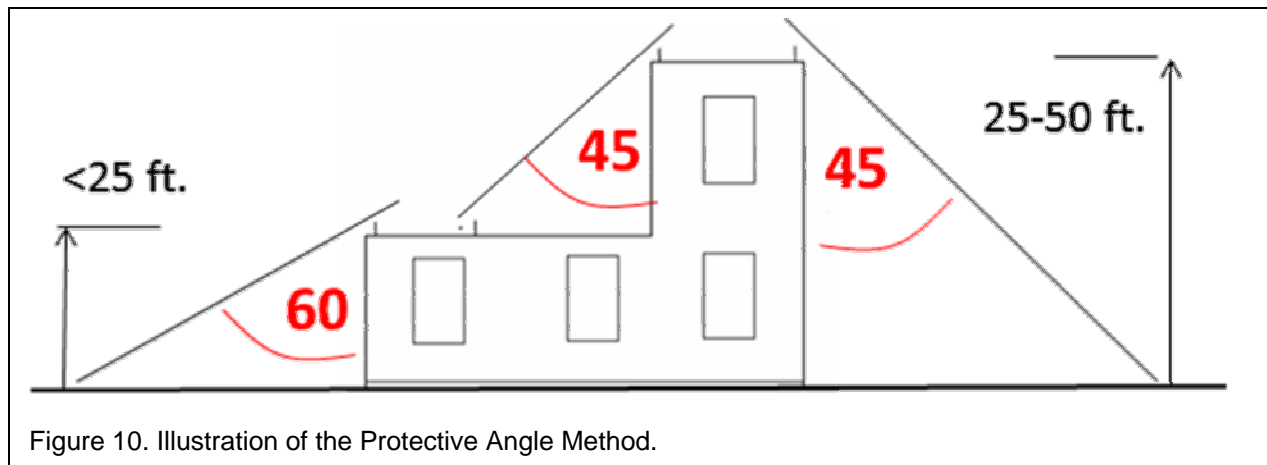


Figure 10. Illustration of the Protective Angle Method.

6. Placement of Strike Terminations

While these methods dictate the placement of the strike terminations to determine zones of protection, other design rules for specific placement apply depending on the type of strike terminations. More details will be found in the engineering standards documents commonly used for lightning protection. For example, if air terminals (a common form of strike termination, sometimes termed 'lightning rods') are used, they have to be placed so that they extend 10 in. above the protected structure, within 2 ft. of the edge and no more than 20 ft. apart. Generally, all strike terminations must have two paths for the lightning current to exit, although there are some specific exceptions. In addition, other strike terminations may be needed to protect objects that are typically installed on roofs, such as Heating, Ventilation and Air Conditioning (HVAC) equipment. Alternatively, some structural metal components commonly used in buildings may serve as strike terminations. It is essential to have a thorough understanding of these details to emplace an effective lightning protection system.

A common mistake is to try to use the rolling sphere method to space the strike terminations. This does not work correctly in most cases, especially in the case of interior strike terminations on flat roofs. This is because the strike termination has some small range of effect (the extent of which depends on the amount of charge in the downward leader) from which the upward leader extends under the influence of an approaching downward leader. While this is accounted for in the development of the methods to determine the zone of protection, it is not illustrated by them. Correct placement rules follow.

a. Strike Termination Spacing [4.8.1]

Strike terminations, most commonly embodied in the form of air terminals, are placed on the ridges of pitched roofs as well as on the perimeter AND interior of flat or gently sloping roofs. They must be placed within 2 ft. of an edge or corner of the roof.

Placing them closer together may need to occur in some cases where there are irregular roof perimeters, crenellations, etc. Closer placement won't provide marked increase in protection. However placing strike terminations farther apart than the specified amount increases the risk of a bypass and direct lightning connection to the protected structure.

For air terminals which must extend at least 10 in. above the structure they are mounted on, the spacing along the ridge or perimeter must not exceed 20 ft. If the air terminal extends 2 ft. or more above the structure, the spacing along the ridge or perimeter must not exceed 25 ft.

If the eave of the roof is less than 50 ft. above grade, the rules already discussed in the earlier section on 'zone of protection' apply. [4.7] If the eave of the roof exceeds 50 ft. above grade, air terminals are placed by different rules based on rolling sphere method.

b. Pitched Roofs. [4.8.1]

For a pitched roof with eave heights over 50 ft. but less than 150 ft. above grade, strike termination devices can be omitted at the eaves if the slope of that roof is equal to or steeper than the tangent of the arc at the eave elevation of a 150 ft. radius rolling sphere. Any projection of the building that extends beyond that tangent needs a strike termination, except for gutters. This situation is illustrated in Figure 11. For a roof where the eave is 75 ft. above grade, (denoted by the red arrow) a tangent (red line) is drawn from 150 ft. rolling sphere (dashed line.) Since the slope of the roof (blue line) does not intersect the tangent (red line) below the eave, strike protection installed only on the ridge is permitted. If the slope was less steep, such that the blue and red lines intersected below the eave, strike terminations are required on the eave.

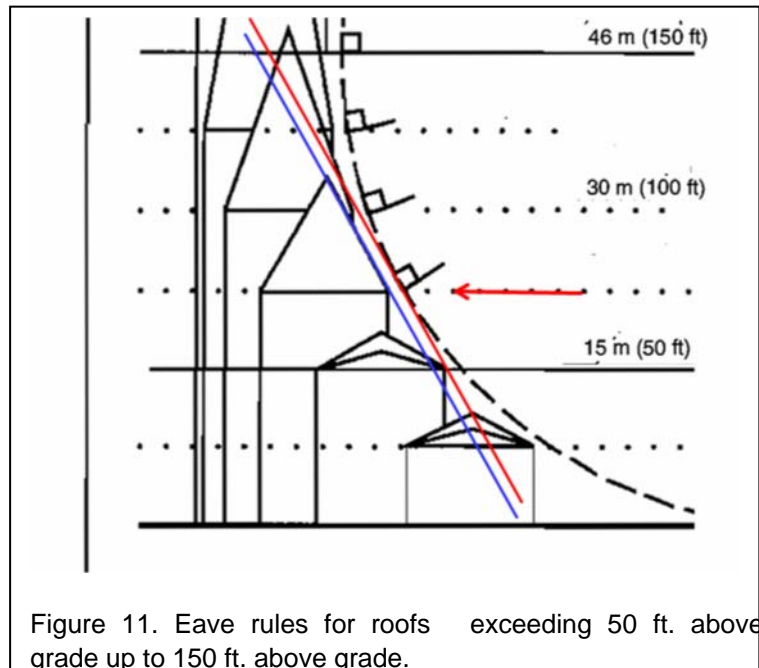


Figure 11. Eave rules for roofs exceeding 50 ft. above grade up to 150 ft. above grade.

Eaves over 46 m (150 ft) above grade shall be protected using the rolling sphere method. As discussed, the tangent of the rolling sphere is essentially a vertical line 150 ft. above grade.

c. Flat and Gently Sloping Roofs [4.8.3]

Recall the definition of flat roof depends on the width of the roof.

Pitched roofs: Roofs with a span of 12 m (40 ft) or less and a slope 1/8 or greater; or roofs having a span of more than 12 m (40 ft) and a slope 1/4 or greater.

Flat or gently sloping roof: A roof with a slope less than that for a pitched roof.

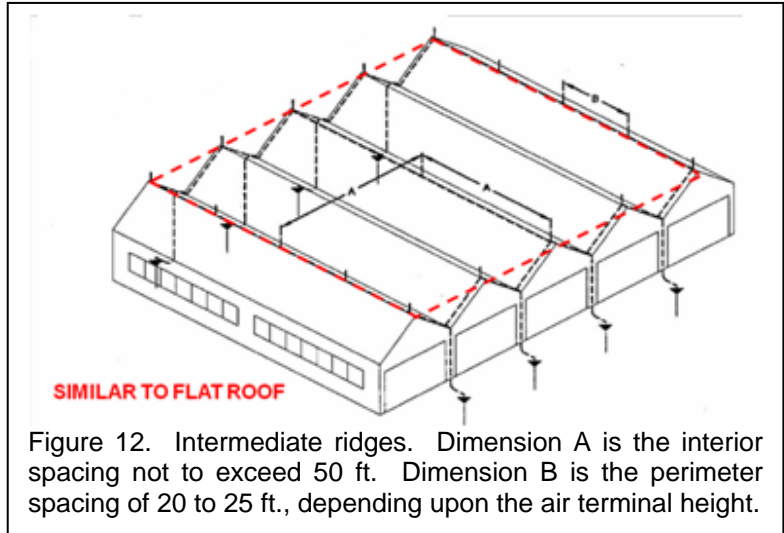
While the spacing of the air terminals or other strike terminations on the flat or gently sloping roof perimeter is defined above (20 ft. or 25 ft.), the interior spacing is relaxed. 50 ft. spacing is permitted between interior strike terminations or air terminals. However, if there is an isolated 'string' of air terminals or strike termination greater than 150 ft. (and for every multiple of 150 ft.), a conductor must be cross run to another 'string.' This requirement helps to divide the current from a lightning strike to prevent arcing and other damage to the system.

d. Dormers and Other Structural Projections [4.8.4]

Any projection outside of the zone of protection, such as but not limited to dormers, need to have a strike termination affixed to it.

e. Roofs with Intermediate Ridges.

Strike termination devices shall be located along the outermost ridges of buildings that have a series of intermediate ridges with the same spacing already discussed. For intermediate ridges, one treats it as flat or gently sloping roofs, as if an imaginary flat roof surface were drawn touching the ridge of the intermediate roofs. Figure 12 illustrates the concept with the 'imaginary flat roof surface' outlined in red.



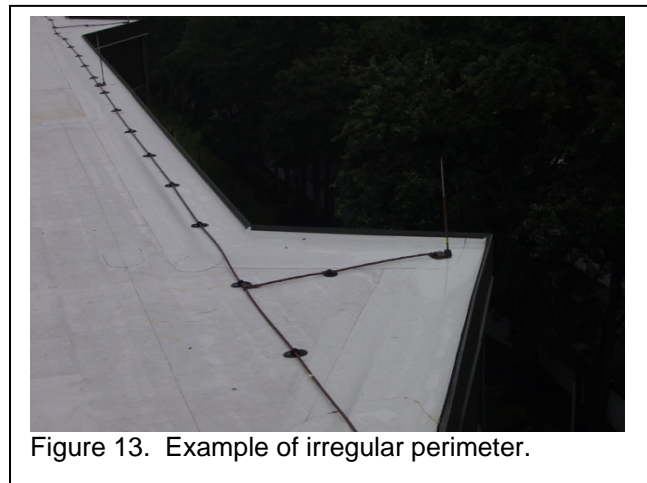
However, if any intermediate ridge is higher than the other ridges, it needs to have the air terminals spaced as a perimeter or single ridge (e.g. 20 to 25 ft. spacing).

f. Flat or Gently Sloping Roofs with Irregular Perimeters. [4.8.6]

Exterior wall designs could result in irregular roof perimeters. Should this occur, the fundamental principles of maximum spacing (20 to 25 ft.) and edge proximity (within 2 ft.) apply. One can use an 'imaginary roof edge' formed by the outermost projections to locate the strike termination devices, similar to the procedure for roofs with multiple intermediate ridges.

Figure 13 provides an example of an irregular roof perimeter. In this particular case, the use of a single conductor to connect the strike termination to the rest of the system is permitted if:

- 1) The length of the vertical or horizontal run does not exceed 16 ft., and
- 2) The connection is made by a T-splice connection or other connector listed for this purpose.



g. Open Areas in Flat Roofs [4.8.7]

Likewise, it is possible to have an open area in a flat roof for a courtyard or similar outdoor space. If it is small enough it might not need any strike terminations. However, if the open area perimeter exceeds 300 ft. with both rectangular dimensions in excess of 50 ft., strike terminations are applied and spaced along the perimeter.

h. Domed or Rounded Roofs [4.8.8]

Many variations are possible for roofs. In these cases, the Rolling Sphere Method is used to place strike terminations.

i. Chimneys and Vents. [4.8.9]

If any chimney or vent is located outside a zone of protection, it will need a strike termination. Alternatively, if the chimney or vent is metal with thickness greater than 3/16 in., it may serve as the strike termination. In this case, it can be connected directly to the lightning protection system using main-size lightning conductor with the contact area of the bond greater than 3 in². Like any other strike termination, it must have two or more paths to ground.

Affixing strike terminations to chimneys and vents follow the same general rules discussed; that is, within 2 ft. of an outside corner. More than one strike termination may be needed.

j. Metal Roof Top Units. [4.8.10]

Roof top units, such as air-conditioning/heating units, metal air intake/exhaust housings, and cooling towers are prominent features on many roofs. If not located within the zone of protection, strike termination devices are needed.

In general, the same rules apply as for chimneys and vents. If the roof top unit metal thickness is 3/16 in. or greater, it may only need connection to the lightning protection system. Otherwise, it will need strike terminations/air terminals. In any case, some rules for making these connections apply.

1) The air terminals need mounting on bases having a minimum contact area of 2 in². Bases need to be secured to bare metal of the housing or mounted by drilling and tapping to the unit's frame. Most lightning protection installers will avoid drilling and tapping, as this interferes with maintenance and could void warranties of the roof-top equipment. However, if the unit is drilled and tapped, the threaded device needs at least five threads fully engaged and secured with a jam nut or equivalent. Further, the threaded portion of the connector needs to be at least 1/2 in. in diameter.

2) At least two main-size conductors connect the unit to the lightning protection system. The connection is made to bare metal at the base or lower edges of the unit using main-size lightning conductors and bonding devices that have a surface contact area of not less than 3 in². As usual, the connection must provide two or more paths to ground, just like any other strike termination device.

3) The two bonding plates are located as far apart as practical at the base or lower edges of the unit's electrically continuous metal housing, and connected to the lightning protection system.

7. Structural Strike Terminations. [4.16]

Substantial metal framing can be used as a strike termination, or as the conductors of the lightning protection system for that matter.

In general, metal framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system, if it is equal to or greater than 3/16 in. in thickness and is electrically continuous, or it is made electrically continuous by methods.

Strike termination devices can be connected directly to the structural metal framing or by any other method permitted for strike termination devices.

8. Standards for Lightning Protection

A few lightning protection standards are available for use. These standards provide the details for the installation and implementation of the components of the LPS. Typically one or more of these standards will be specified for the installation of lightning protection systems in the United States.

- National Fire Protection Association's (NFPA) Standard for the Installation of Lightning Protection Systems (NFPA 780.)
- Underwriter's Laboratory Installation Requirements for Lightning Protection Systems (UL 96A)
- Lightning Protection Institute's Standard of Practice for the Design - Installation - Inspection of Lightning Protection Systems (LPI 175)

All of these standards provide detailed guidance for the selection of materials and installation requirements for the lightning protection system. Additional topics are discussed such as personnel protection as well as protection for various special occupancies, which includes large smokestacks or structures housing flammable and explosive materials. Inspection methods and maintenance topics are also discussed. In the first document, NFPA 780, risk assessment methods are offered to better understand and quantify if any particular structure is at significant risk from lightning.

9. Specifying and Certifying Lightning Protection Systems

Lightning protection systems are not necessarily required by state, municipal or regulatory agencies. Specification of lightning protection systems is often a design choice by the architect, engineer, owner representative or the equivalent. Similarly, most regulatory bodies do not perform inspection or certification of LPS. It is highly recommended that an inspection or certification is specified when a LPS is part of the project. Underwriter's Laboratories and Lightning Protection Institute offer certification programs.

10. Summary

In this course, we discussed the implementation of the Strike Termination Subsystem of a lightning protection system in detail. Once the strike termination intercepts the lightning event, it is then directed into the conductors that are part of the system which is covered under a separate course.

In closing, a list of commonly used engineering standards for the implementation of the LPS was provided. Detailed guidance for the installation of lightning protection systems are contained in these standards. Adherence to these engineering standards is essential for an effective LPS. While this course is intended to provide instruction on the requirements and installation methods of these standards, it does not replace or supersede those requirements and/or methods described in an authoritative standard.

Using this knowledge, you will better understand how to implement lightning protection systems based on one of these engineering design standards.